Rules for the Classification of Inland Navigation Vessels

NR 217

Consolidated edition for documentation only

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This document is for documentation only.

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NR217.B1 DT R06 E	Part B	Hull Design and Construction	Jun. 2021
NR217.C1 DT R06 E	Part C	Machinery, Electricity and Fire	Jun. 2021
NR217.D1 DT R06 E	Part D	Additional Requirements for Notations	Jun. 2021

Rules for the Classification of Inland Navigation Vessels

PART A – Classification and Surveys

Chapters 1 – 2 – 3

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BUREAU VERITAS MARINE & OFFSHORE

GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 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.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of the above listed being relieved from any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 Only the Society is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards ("Applicable Referential"), in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification (or Certification as defined in clause 2.2) is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules and/or to Applicable Referential for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules (available online on veristar.com), guidance notes and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the Rules and/or the Applicable Referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, and/or to the Applicable Referential, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate nor on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisement made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involves, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interest equal to twelve (12) months LIBOR plus two (2) per-cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to resolve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 The Services shall be automatically and immediately terminated in the event the Client can no longer establish any form of interest in the Unit (e.g. sale, scrapping).

9.3 The Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, or immediately in the event of termination under clause 9.2, subject to compliance with clause 4.1 and 6 above.

9.4 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, will be treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, other than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed in accordance with and governed by the laws of England and Wales.

15.2 Any dispute shall be finally settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

15.3 Notwithstanding clause 15.2, disputes relating to the payment of the Society's invoices may be submitted by the Society to the *Tribunal de Commerce de Nanterre*, France, or to any other competent local Court, at the Society's entire discretion.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics and, when applicable, Business Partner Code of Conduct both available at https://group.bureauveritas.com/group/corporate-social-responsibility/operational-excellence.

RULES FOR INLAND NAVIGATION VESSELS

Part A
Classification and Surveys

Chapters **1 2 3**

Chapter 1 **PRINCIPLES OF CLASSIFICATION**

Chapter 2 **CLASSIFICATION**

Chapter 3 **SURVEYS FOR MAINTENANCE OF CLASS**

June 2021

These Rules enter into force on June 1st, 2021.

The English version of these Rules takes precedence over editions in other languages.

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Part A

Classification and Surveys

Chapter 1

PRINCIPLES OF CLASSIFICATION

SECTION 1 GENERAL PRINCIPLES OF CLASSIFICATION

SECTION 2 CLASS DESIGNATION

SECTION 3 CLASSIFICATION NOTATIONS

SECTION 1 GENERAL PRINCIPLES OF CLASSIFICATION

1 Principles of classification

1.1 Purpose of the Rules

1.1.1 These Rules give the requirements for the assignment and the maintenance of class for inland navigation vessels as well as vessels operated in restricted maritime stretches of water.

1.1.2 Class assigned to a vessel reflects the discretionary opinion of the Society that the vessel, for declared conditions of use and within the relevant time frame, complies with the Rules applicable at the time the service is rendered.

1.1.3 General Conditions valid at the time of signing of the contract with the Owner or Prospective vessel Owner, the Building Yard or Other Interested party apply.

1.1.4 The application criteria of the different parts of the present Rules are the following:

- Part A - Classification and Surveys,

  applies to all vessels
- Part B - Hull Design and Construction,

  applies to all vessels, but needs to be complemented by applicable requirements of the Society's Rule Notes:
  - NR561 Hull in Aluminium alloys, for vessels assigned additional service feature **A**
  - NR546 Hull in Composite Materials and Plywood, for vessels assigned additional service feature **C** or **W**
- Part C - Machinery, Systems and Electricity,

  applies to all vessels
- Part D - Additional Requirements for Notations,

  applies to specific vessel types.

The classification of vessels other than those dealt with in the above-mentioned Parts B, C and D is covered by specific Rules published by the Society.

1.1.5 Classification according to these Rules applies primarily to new buildings constructed under survey of the Society. Classification may also be applied to existing vessels by a survey for admission to class after construction, if sufficient documentation is available, see Ch 2, Sec 4, [2].

1.1.6 The Society's Rules for the classification of inland navigation vessels (see [1.1.4]) will be applied for structural elements of the hull and for components of the machinery and electrical installations of vessels, subject to agreement between the Prospective vessel Owner, the Other Interest Party and the Building Yard for the classification order to the Society.

1.2 General definitions

1.2.1 The following general definitions are used in these Rules.

1.2.2 Administration/Authorities

Administration/Authorities means the Government of the state whose flag the vessel is entitled to fly or the state under whose authority the vessel is operating in the specific case.

1.2.3 Building specification

The building specification is part of the building contract between the Prospective vessel Owner, Other Interested Party and the Building Yard which specifies the technical parameters and all other details for the construction of the vessel.

1.2.4 Building Yard

The Building Yard is the contractual partner of the Prospective vessel Owner or Other Interested Party, entrusted with managing the design, construction and equipment of the vessel, generally together with a series of subcontractors and manufacturers.

1.2.5 Hull

The hull is the structural body of a vessel including all strength components, i.e. shell plating, walls, framing, decks, bulkheads, etc. of the main hull, superstructures and deckhouses. The hull also includes:

- all portions of the vessel extending beyond the main hull outline (appendages) such as rudder and rudder stock, shafting pipes, struts, bossing, bilge keels, bowsprit, anchors and anchor chain cables, etc
- river chests
- structures permanently connected by weld to the vessel's hull such as guard rails, bitts, fixed parts of lifting appliances, machinery bedding, etc
- tanks integrated to the hull structure
- independent cargo tanks.

1.2.6 Inland navigation

Inland navigation covers operation of vessels on inland waterways, including estuaries, rivers, tributaries, canals and lakes.

1.2.7 Other Interested Party

Other Interested Party means other ordering subcontractors such as the Broker, the Designer, the Engine and components Manufacturer, or the Supplier of parts to be tested, etc.

1.2.8 Owner or Prospective vessel Owner

Owner or Prospective vessel Owner means the Registered Owner or the Disponent Owner or the Manager or any other party responsible for the definition, purchase and/or operation of the vessel and having the responsibility to keep the vessel seaworthy, having particular regard to the provisions relating to the maintenance of class.

1.2.9 Restricted maritime stretches of water

Inland navigation vessels may operate in coastwise restricted maritime stretches of water complying with the range of navigation specified in Ch 1, Sec 3, [12.2] where allowed by the competent National Authorities. Possible specific requirements of National Authorities for operation in maritime stretches are to be complied with and take precedence on the present Rules in case of conflict.

1.2.10 Significant wave height

The significant wave height considered in the Rules corresponds to $H_{1/3}$ which means the average of 33% of the total number of waves having the greater heights between wave trough and wave crest, observed over a short period.

1.2.11 Society

Society means the classification Society with which the vessel is classed.

1.2.12 Society head office

Society head office means the head office or designated head office department in charge of dealing with Rules and classification particulars.

1.2.13 Statutory Rules

Statutory Rules are the national and international Rules and Regulations which apply to the vessel but which are not covered by the classification.

1.2.14 Survey

Survey means an intervention by the Surveyor for assignment or maintenance of class, or interventions by the Surveyor within the limits of the tasks delegated by the Administrations.

1.2.15 Surveyor

Surveyor means technical staff acting on behalf of the Society to perform tasks in relation to classification and survey duties.

1.2.16 Type approval

Type approval means an approval process for verifying compliance with the Rules of a product, a group of products or a system, and considered by the Society as representative of continuous production.

1.2.17 Date of “contract for construction”

The date of “contract for construction” of a vessel is the date on which the contract to build the vessel is signed between the Prospective vessel Owner or the Other Interested Party and the Building Yard. This date is normally to be declared to the Society by the ordering client applying for the assignment of class to a new building, see Ch 2, Sec 4.

The date of “contract for construction” of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the Prospective vessel Owner or Other Interested Party and the Building Yard.

For the purpose of this definition, vessels built under a single “contract for construction” are considered a “series of vessels” if they are built to the same reviewed plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

- such alterations do not affect matters related to classification, or
- if the alterations are subject to classification requirements, these alterations comply with the classification requirements in effect on the date on which the alterations are contracted between the Prospective vessel Owner or Other Interested Party and the Building Yard or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for review.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

If a “contract for construction” is later amended to include additional vessels or additional options, the date of “contract for construction” for such vessels is the date on which the amendment to the contract is signed between the Prospective vessel Owner or Other Interested Party and the Building Yard. The amendment to the contract is to be considered as a “new contract” to which the above applies.

If a “contract for construction” is amended to change the vessel type, the date of “contract for construction” of this modified vessel or vessels, is the date on which the revised contract or new contract is signed between the Prospective vessel Owner, or Prospective vessel Owners, and the Building Yard.

1.3 Essential service

1.3.1 Essential service is intended to mean a service necessary for a vessel to proceed at waterway, be steered or manoeuvred, or undertake activities connected with its operation, and for the safety of life, as far as class is concerned. Essential service is subdivided in primary and secondary essential services.

1.3.2 Primary essential services

Primary essential services are those which need to be in continuous operation to maintain propulsion and steering.

Examples of equipment for primary essential services:

- steering gear
- actuating systems for controllable pitch propellers
- scavenging air blowers, fuel oil supply pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for the propulsion
- azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps

- electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- electric generators and associated power sources supplying the above equipment
- hydraulic pumps supplying the above equipment
- control, monitoring and safety devices/systems for equipment for primary essential services
- speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion.

The main lighting system for those parts of the vessel normally accessible to and used by personnel and passengers is also considered (included as) a primary essential service.

1.3.3 Secondary essential services

Secondary essential services are those services which need not necessarily be in continuous operation.

Examples of equipment for secondary essential services:

- thrusters
- starting air and control air compressors
- bilge pumps
- fire pumps and other fire-extinguishing medium pumps
- ventilation fans for engine rooms
- services considered necessary to maintain dangerous cargo in a safe condition
- navigation lights, aids and signals
- internal safety communication equipment
- fire detection and alarm systems
- electrical equipment for watertight closing appliances
- electric generators and associated power supplying the above equipment
- hydraulic pumps supplying the above equipment
- control, monitoring and safety for cargo containment systems
- control, monitoring and safety devices/systems for equipment for secondary essential services
- cooling system of environmentally controlled spaces
- windlasses.

Services for habitability are those intended for minimum comfort conditions for people on board.

Examples of equipment for maintaining conditions of habitability:

- cooking
- heating
- domestic refrigeration
- mechanical ventilation
- sanitary and fresh water
- electric generators and associated power sources supplying the above equipment.

1.4 Meaning of classification, scope and limits

1.4.1 The classification process consists of:

- the development of Rules, guidance notes and other documents relevant to the vessel, structure, material, equipment, machinery and other items covered by such documents
- the review of plans and calculations and the surveys, checks and tests intended to demonstrate that the vessel meets the Rules (refer to Ch 2, Sec 1)
- the assignment of class (see Ch 2, Sec 1) and issue of a Certificate of Classification, where compliance with the above Rules is found
- the periodical, occasional and class renewal surveys performed to record that the vessel in service meets the conditions for maintenance of class (see Ch 2, Sec 2).

1.4.2 The Rules, surveys performed, reports, certificates and other documents issued by the Society, are in no way intended to replace or alleviate the duties and responsibilities of other parties, such as Administrations, Designers, Building Yard, Manufacturers, Repairers, Suppliers, Contractors or Subcontractors, actual or Prospective Owners or Operators, Charterers, Brokers, Cargo Owners and Underwriters.

The activities of such parties which fall outside the scope of the classification as set out in the Rules, such as design, engineering, manufacturing, operating alternatives, choice of type and power of machinery and equipment, number and qualification of crew or operating personnel, lines of the vessel, trim, hull vibrations, spare parts including their number, location and fastening arrangements, life-saving appliances, and maintenance equipment, remain therefore the responsibility of those parties, even if these matters may be given consideration for classification according to the type and service of vessel or additional class notation assigned.

1.4.3 Unless otherwise specified, the Rules do not deal with structures, pressure vessels, machinery and equipment which are not permanently installed and used solely for operational activities such as dredging, heavy load lifting or workshops, except for their effect on the classification-related matters, such as the vessel's general strength.

During periods of construction, modification or repair, the vessel is solely under the responsibility of the Builder or the Repair Yard. As an example, the Builder or Repair Yard is to ensure that the construction, modification or repair activities are compatible with the design strength of the vessel and that no permanent deformations are sustained.

Note 1: Refer to [3.3] as regards the Owner's responsibility for maintenance and operation of the vessel in relation to the maintenance of class.

1.4.4 The class assigned to a vessel by the Society following its interventions is embodied in a Certificate of Classification and noted in the Register of vessels.

At a certain date the class of a vessel is maintained or regular when no surveys are overdue, when the conditions for suspension of class are not met and when the class is not withdrawn nor suspended. Otherwise the class is irregular.

Attention is drawn on the fact that a vessel holding a valid Certificate of Classification may be in an irregular class position.

1.5 Limitation of classification to hull

1.5.1 When it is agreed to limit the classification to the vessel's hull only, the parts of the vessel which must comply with the Rules are those mentioned in [1.2.5]. In such a case, the applicable stability requirements must be also complied with and the classification notations defined in Ch 1, Sec 2 will be assigned only to the hull. Machinery, systems and electrical installations which are normally matters for classification must be proven to be in compliance with the applicable relevant Regulations.

1.6 Request for services

1.6.1 Requests for interventions by the Society, such as request for classification, surveys during construction, surveys of vessels in service, tests, etc. are, in principle, to be submitted in writing and signed by the Other Interested Party, the Owner, the Prospective vessel Owner or the Building Yard. Such request implies that the applicant will abide by all the relevant requirements of the Rules and the General Conditions of the Society.

2 Rules

2.1 Effective date

2.1.1 The effective date of entry into force of any amendments to the Rules is indicated on the inside front page of the Rules or in the relevant Section.

2.2 Application

2.2.1 In principle, the applicable Rules for assignment of class to a new vessel are those in force at the date of contract for construction. In the case of admission to class after construction, the Rules in force at the date of the request for classification apply.

2.2.2 Special consideration may be given to applying new or modified rule requirements which entered into force subsequent to the date of the contract for construction, at the discretion of the Society and in the following cases:

- when a justified written request is received from the party applying for classification
- when the keel is not yet laid and more than one year has elapsed since the contract was signed
- where it is intended to use existing previously approved plans for a new contract.

2.2.3 The above procedures for application of the Rules are, in principle, also applicable to existing vessels in the case of major conversions and, in the case of alterations, to the altered parts of the vessel.

2.2.4 The rule requirements related to assignment, maintenance and withdrawal of the class of vessels already in operation are applicable from the date of their entry into force.

2.3 Equivalence

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

2.3.2 As a rule, certification of materials and equipment by the Society in compliance with NR467 Rules for Steel Ships is considered acceptable within the scope of these Rules.

2.4 Novel features

2.4.1 The Society may consider the classification of vessels based on or applying novel design principles or features, to which the Rules are not directly applicable, on the basis of experiments, calculations or other supporting information provided to the Society. Specific limitations may then be indicated on memoranda.

2.5 Disagreement and appeal

2.5.1 Any technical disagreement with the Surveyor in connection with the performance of his duties should be raised by the Interested Party as soon as possible.

The Interested Party may appeal in writing to the Society, which will subsequently consider the matter and announce its decision according to its established procedure.

2.6 Other construction Rules and Regulations

2.6.1 The appraisal of design and construction particulars by the Society will be exclusively based on Rules and Guidelines agreed upon in the specification of the classification contract between the Prospective vessel Owner, the Other Interested Party or the Building Yard and the Society.

2.6.2 In addition, applicable statutory Rules, such as **ADN**, may be applied upon agreement with the relevant Authority and if defined in the specification of the classification contract between the Prospective vessel Owner, the Other Interested Party or the Building Yard and the Society.

2.6.3 The navigation in maritime areas is subject to competent authority agreement which may require the compliance of the vessel design and construction with applicable statutory Regulations.

2.6.4 The compliance to statutory Rules of the respective flag state is the responsibility of the Prospective vessel Owner.

2.7 Industry Codes, Standards, etc.

2.7.1 Internationally recognized Standards and Codes published by relevant organisations, national industry organisations or standardisation institutions may be used upon agreement in particular cases as a design and construction basis.

Examples: ISO, IEC, EN, DIN, NF.

3 Duties of the Interested Parties

3.1 International and national Regulations

3.1.1 The classification of a vessel does not dispense the Owner, Other Interested Party and Building Yard from compliance with any requirements issued by Administrations.

3.2 Surveyor's intervention

3.2.1 Surveyors are to be given free access at all times to vessels which are classed or being classed, Building Yard and manufacturer works, to carry out their interventions within the scope of assignment or maintenance of class, or within the scope of interventions carried out on behalf of Administrations, when so delegated.

Free access is also to be given to experts or/and auditors accompanying the Surveyors of the Society within the scope of the audits as required in pursuance of the Society's internal Quality System or as required by external organizations.

3.2.2 Owners, Other Interested Parties and Building Yard are to take the necessary measures for the Surveyor's inspections and testing to be carried out safely and efficiently under their full responsibility. Owners, Other Interested Parties and Building Yard - irrespective of the nature of the service provided by the Surveyors of the Society or others acting on its behalf - assume with respect to such Surveyors all the responsibility of an employer for his workforce such as to meet the provisions of applicable legislation. As a rule, the Surveyor is to be constantly accompanied during surveys by personnel of the Owner, Other Interested Party or Building Yards.

3.2.3 The certificate of classification and/or other documents issued by the Society remain the property of the Society. All certificates and documents necessary to the Surveyor's interventions are to be made available by the Owner, Other Interested Party or Building Yard to the Surveyor on request.

3.2.4 During the phases of design and construction of the vessel, due consideration should be given to rule requirements in respect of all necessary arrangements for access to spaces and structures with a view to carrying out class surveys. Arrangements of a special nature are to be brought to the attention of the Society.

3.3 Operation and maintenance of vessels

3.3.1 The classification of a vessel is based on the understanding that the vessel is loaded and operated in a proper manner by competent and qualified crew or operating personnel according to the environmental, loading, operating and other criteria on which classification is based.

In particular, it will be assumed that the draught of the vessel in operating conditions according to normal prudent conduct will not exceed that corresponding to the freeboard assigned or the maximum approved for the classification, that the vessel will be properly loaded taking into account both its stability and the stresses imposed on its structures and that cargoes will be properly stowed and suitably secured and that the speed and course of the vessel are adapted to the prevailing wave height and weather conditions.

3.3.2 Any document issued by the Society in relation to its interventions reflects the condition of the vessel as found at the time and within the scope of the survey. It is the Interested Party's responsibility to ensure proper maintenance of the vessel until the next survey required by the Rules. It is the duty of the Interested Party to inform the Surveyor when he boards the vessel of any events or circumstances affecting the class.

3.4 Use of measuring equipment and of service suppliers

3.4.1 General

Firms providing services on behalf of the Interested Party, such as measurements, tests and servicing of safety systems and equipment, the results of which may form the basis for the Surveyor's decisions, are subject to the acceptance of the Society, as deemed necessary.

The equipment used during tests and inspections in workshops, Building Yards and on board vessels, the results of which may form the basis for the Surveyor's decisions, is to be customary for the checks to be performed. Firms are to individually identify and calibrate to a recognised national or international standard each piece of such equipment.

Note 1: Refer to Rule Note NR533 Approval of Service Suppliers.

3.4.2 Simple measuring equipment

The Surveyor may accept simple measuring equipment (e.g. rulers, tape measures, weld gauges, micrometers) without individual identification or confirmation of calibration, provided it is of standard commercial design, properly maintained and periodically compared with other similar equipment or test pieces.

3.4.3 On board measuring equipment

The Surveyor may accept measuring equipment fitted on board a vessel (e.g. pressure, temperature or rpm gauges and meters) and used in examination of on board machinery and/or equipment based either on calibration records or comparison of readings with multiple instruments.

3.4.4 Other equipment

The Surveyor may request evidence that other equipment (e.g. tensile test machines, ultrasonic thickness measurement equipment, etc.) is calibrated to a recognised national or international standard.

3.5 Spare parts

3.5.1 It is the Owner's responsibility to decide whether and which spare parts are to be carried on board.

3.5.2 As spare parts are outside the scope of classification, the Surveyor will not check that they are kept on board, maintained in a satisfactory condition, or suitably protected and lashed.

However, in the case of repairs or replacement, the spare parts used are to meet the requirements of the Rules as far as practicable.

3.6 Quality system audits

3.6.1 Attention is drawn to the possibility that auditors external to the Society may attend surveys and audits carried out by the Society and that this attendance shall not be obstructed.

4 Application of statutory requirements by the Society

4.1 International and national Regulations

4.1.1 When authorised by the Administration concerned, the Society will act on its behalf within the limits of such authorisation. In this respect, the Society will take into account the relevant requirements, survey the vessel, report and issue or contribute to the issue of the corresponding certificates.

4.1.2 The above surveys do not fall within the scope of the classification of vessels, even though their scope may overlap in part and may be carried out concurrently with surveys for assignment or maintenance of class.

In the case of a discrepancy between the provisions of the applicable international and national Regulations and those of the Rules, normally, the former take precedence. However, the Society reserves the right to call for the necessary adaptation to preserve the intention of the Rules.

SECTION 2 CLASS DESIGNATION

1 General

1.1 Purpose of the classification notations

1.1.1 The class of a vessel complying with these Rules is expressed by the "classification notations", assigned for hull and machinery including electrical installations.

1.1.2 There are different kinds of classification notations, describing particular features, capabilities, service restrictions or special equipment and installations included in the classification.

1.1.3 The classification notations give the scope according to which the class of the vessel has been based and refer to the specific rule requirements which are to be complied with for their assignment. In particular, the classification notations are assigned according to the type, service and navigation of the vessel and other criteria which have been provided by the Owner, Building Yard or Other Interested Party, when applying for classification.

The Society may change the classification notations at any time, when the information available shows that the requested or already assigned notations are not suitable for the intended type, service, navigation and any other criteria taken into account for classification.

Note 1: Reference should be made to Ch 1, Sec 1, [1.4] on the limits of classification and its meaning.

1.1.4 The classification notations assigned to a vessel are indicated on the certificate of classification, as well as in the Register of vessels published by the Society.

It will be the decision of the Owner, Building Yard or Other Interested Party to have the notations, together with the whole class designation, included in the published Register of the Society or not.

1.1.5 The classification notations applicable to existing vessels conform to the Rules of the Society in force at the date of assignment of class, as indicated in Ch 2, Sec 1, [4]. However, the classification notations of existing vessels may be updated according to the current Rules, as far as applicable.

1.1.6 At the request of the Owner and as far as applicable, the Society reserves the right to grant other classification notations as defined in other Rules of the Society. The class maintenance surveys for such classification notations are to be performed to the corresponding requirements in the other Rules of the Society.

1.2 Types of notations assigned

1.2.1 The types of classification notations assigned to a vessel are the following:

a) construction mark
b) class symbol
c) class period
d) equipment symbol
e) navigation and operating area notations
f) service notations with additional service features, as applicable
g) additional class notations (optional).

The different classification notations and their conditions of assignment are defined in Articles [2] to [9].

1.2.2 Examples of class designation

Tab 1 shows examples of a class designation for hull and machinery of a vessel covered by these Rules.

Table 1 : Examples of class designation

Vessel type	Class designation
General cargo vessel	**II ✠ HULL • MACH** **3 Z IN** **General cargo vessel /** **Double hull /1R / Heavycargo (Hold, 110 kN/m²)**
Tanker	**I ✠ HULL • MACH** **5 Z IN(1,2)** **Tanker / DG-N closed / Double hull / 2R** **DP = 11,5kPa / TP = 13kPa**
	I ✠ HULL ✠ MACH **5 Z** **IN(1,7) / Estuary Plus / Belgian coast / operating between the Western Scheldt and the Zeebrugge harbour / within 5NM from shore / Beaufort 7** **Tanker / Type C / ADN / 2R / Annual survey** **DP = 57,5kPa / TP = 65kPa**
Passenger vessel	**I ✠ HULL ✠ MACH** **5 Z IN(0,8)** **Passenger vessel / Ferry /** **Fire / With double bottom**
Tug	**I • HULL • MACH** **5 (-) IN(2)** **Tug** **• AUT-UMS**
Note 1: IN corresponds to **IN(0,6)** in the previous Rules version.	

Table 2 : Hull and machinery - Mode of survey and certification

Component	Symbol	Rule requirements
Hull	✠	Vessels built under the supervision of the Society and with certification of components and materials in accordance with the Rules.
	✠̲	Vessels built under the supervision of another classification Society and which have been assigned a class equivalent to the Society's Rules of classification.
	•	Vessels built under the supervision of the Society in accordance with the Rules but, e.g., without inspection by the Society of components and materials which, however, are deemed to be acceptable. It is the responsibility of the Building Yard, Owner or Other Interested Party to ascertain that the materials and equipment used in the vessel's construction satisfactorily meet the Rules requirements. Depending on particular conditions or vessel notations, inspection of materials and components by the Society may be required for essential services.
	•	In the event of admission to class or classification after construction of not classed vessels.
Machinery	✠, etc.	Same symbols followed by **MACH**

2 Construction marks for hull and machinery installations

2.1 General

2.1.1 The construction mark identifies the procedure under which the vessel and its main equipment or arrangements have been surveyed for initial assignment of the class. (see Tab 2). However, the Society may change the construction mark where the vessel is subjected to repairs, conversion or alterations.

The procedures under which the vessel is assigned one of the construction marks are detailed in Ch 2, Sec 1.

2.1.2 One of the construction marks defined below is assigned separately to the hull of the vessel, to the machinery installation, and to some installations for which an additional classification notation is assigned.

The construction mark is placed before the symbol **HULL** for the hull, before the symbol **MACH** for the machinery installations, and before the additional class notation granted, when such a notation is eligible for a construction mark (e.g. **✠ Crane**).

If the vessel has no machinery installations covered by classification, the symbol **MACH** is not granted and the construction mark will be only placed before the symbol **HULL**.

2.2 Symbol ✠

2.2.1 The symbol ✠ will be assigned to the relevant part of the vessel when it has been constructed:

- under the survey of and in accordance with the Rules of the Society at the Building Yard and/or at subcontractors supplying construction components/hull sections, as applicable
- with certification by the Society of components and materials requiring inspection subject to the Society's construction Rules.

2.3 Symbol ✠̲

2.3.1 The symbol ✠̲ will be assigned to the relevant part of the vessel when this latter has been designed and constructed in accordance with the Rules and under supervision of another classification Society and is subsequently - or at a later date - classed with the Society, see Tab 2.

2.4 Symbol •

2.4.1 The symbol • will be assigned to the relevant part of the vessel, where the procedure for the assignment of classification is other than those detailed in [2.2.1] and [2.3.1], but however deemed acceptable, see Tab 2.

3 Class symbol

3.1 General

3.1.1 The class symbol expresses the degree of compliance of the vessel with the rule requirements as regards its construction and maintenance. One class symbol is to be assigned to every classed vessel.

3.1.2 The class symbol **I** is assigned to vessels built in accordance with the Society's Rules or other Rules recognised as equivalent, and maintained in a condition considered satisfactory by the Society.

3.1.3 The class symbol **II** is assigned to vessels which do not meet all requirements for class symbol **I**, but are deemed acceptable to be entered into the Register of vessels. In this case, the class may be maintained for shorter class periods or with shorter survey intervals. See Tab 3.

Table 3 : Class symbol, class period and equipment symbol

Symbol	Description
	Class symbol
I	For vessels found to meet the construction and scantling requirements.
II	For vessels that do not meet in full some construction or scantling requirements, but, however, are deemed acceptable to be entered in the Register of vessels.
	Class period symbol (**p**)
5 **3**	These symbols, preceding the range of navigation character, indicate the duration of the class period in years.
	Equipment symbol
Z	Where the vessel's anchors and chain cables meet the applicable requirements of the Rules.
(Z)	The symbol **Z** is replaced by **(Z)**, if the vessel's equipment does not meet the rule requirements in full, but, however, is deemed acceptable for the intended service. Reference will be made in the classification certificate to the compliance of the equipment with other recognized standards or Regulations such as ES-TRIN or Normam 02.
(-)	Where the Society considers that it is not called upon to form an opinion on the equipment with regard to particular conditions.

4 Class period symbol

4.1 General

4.1.1 The symbol **p** indicates the duration of the nominal class period in years.

The hull, the machinery as well as special equipment and installations classed have, in principle, the same class period.

Normally: **p** = 5

The nominal class period may be extended in compliance with Ch 2, Sec 2, [6.2.1].

The nominal class period can be reduced in exceptional cases and for a limited time, if the vessel does not fully comply with the Rules but has been allowed to operate under restrictions, e.g. regarding the range of navigation and/or weather conditions. See Tab 3.

5 Navigation and operating area notations

5.1 Range of navigation notation

5.1.1 The symbol **IN** indicates a vessel on waters covered by these Rules, i.e.:

- all inland waterways
- all restricted maritime stretches of water up to a significant wave height of 2 m
- other waters showing comparable conditions.

Note 1: The Owner's attention is drawn to the navigation conditions, which on some lakes are very similar to sea navigation conditions. It is up to the Owner to state in each particular case if he wishes that the vessel is assigned a range of navigation according to these Rules or one of the navigation notations listed in the Rules for seagoing vessels.

For operation on estuaries, lakes or restricted maritime stretches of water, the symbol **IN** is completed, between brackets, with the significant wave height for which the vessel has been designed. See also Ch 1, Sec 3, [12.2].

5.2 Estuary plus

5.2.1 The range of navigation notation will be completed by the navigation notation **Estuary plus**, if:

- the significant wave height exceeds 1,2 m, or
- the vessel is operated on restricted maritime stretches of water, or
- the vessel is operated on large lakes.

See also Ch 1, Sec 3, [12.3].

5.3 Operating area notation

5.3.1 The operating area notation expresses the specified area where considered vessel is intended to operate. The operating area notation will be assigned to:

- vessels with the notation **Estuary plus**, or
- vessels operating within specific restrictions which are different from normal navigation conditions, or
- vessels operating in defined river systems or waters only.

See also Ch 1, Sec 3, [12.4].

6 Equipment symbol

6.1 General

6.1.1 The symbol **Z** indicates that the vessel's equipment on anchors and chain cables meet the applicable requirements of the Rules.

6.1.2 Where the vessel's equipment does not meet the rule requirements, but is deemed by the Society acceptable for the intended service, the symbol **Z** is replaced by **(Z)**. Reference will be made in the classification certificate to the compliance of the equipment with other recognized standards or Regulations such as ES-TRIN or Normam 02.

6.1.3 The symbol **Z** is replaced by **(-)**, where the Society considers that it is not called upon to form an opinion on the anchor equipment, with regard to particular conditions, e.g., in the case of a rigid convoy, for:

- Pusher, where the propulsion system is deemed sufficient to ensure a convoy minimum required speed over the ground whatever the maximum expectable stream and wind conditions
- Non propelled cargo vessel operated solely as part of such a convoy.

7 Service notations

7.1 General

7.1.1 The service notations define the type and/or service of the vessel which have been considered for its classification, according to the request for classification signed by the Prospective Owner, Building Yard or Other Interested Party. At least one service notation is to be assigned to every classed vessel.

7.1.2 A vessel may be assigned several different service notations. In such a case, the specific rule requirements applicable to each service notation are to be complied with. However, if there is any conflict in the application of the requirements applicable to different service notations, the Society reserves the right to apply the most appropriate requirements or to refuse the assignment of one of the requested service notation.

7.1.3 Where a vessel part does not meet fully the applicable rule requirements, a service notation between brackets may be assigned provided that the vessel is proven to comply with the applicable statutory Rules, when deemed acceptable by the Society for the intended service and the operation area, e.g.:

(**Passenger vessel)**

Reference will be made in the classification certificate to the compliance of the part with the applicable statutory Rules, together with a mention of any restriction to be observed for the vessel operation.

8 Additional service features

8.1 General

8.1.1 A service notation may be completed by one or more additional service features, giving further precision regarding the type or service of the vessel, for which specific rule requirements are applied, e.g.:

2R

DG-N open

8.1.2 Where a vessel part does not meet fully the applicable rule requirements, an additional service feature between brackets may be assigned provided that the vessel is proven to comply with the applicable statutory Rules, when deemed acceptable by the Society for the intended service and the operation area, e.g.:

Tanker / (DG-C)

Reference will be made in the classification certificate to the compliance of the part with the applicable statutory Rules, together with a mention of any restriction to be observed for the vessel operation.

8.1.3 The requirement [8.1.2] does not apply to the following additional service features:

- **Type G**
- **Type C**
- **Type N closed**
- **Type N open with flame arresters**
- **Type N open**.

9 Additional class notations

9.1 General

9.1.1 An additional class notation expresses the classification of additional equipment or specific arrangement, which has been requested by the Interested Party, e.g.:

Ice

AUT-UMS

9.1.2 The assignment of such an additional class notation is subject to the compliance with additional rule requirements, which are detailed in Part D, Chapter 2.

SECTION 3 CLASSIFICATION NOTATIONS

1 General

1.1 Application

1.1.1 The notations to be assigned for the classification of inland vessels are indicated in Tab 1 together with the reference to their definitions.

Table 1 : List of classification notations

Classification notations	Reference
Construction mark	Ch 1, Sec 2, [2]
Class symbol	Ch 1, Sec 2, [3]
Class period	Ch 1, Sec 2, [4]
Equipment symbol	Ch 1, Sec 2, [6]
Service notations	[1.2]
Additional service features	[1.3]
Additional class notations	[1.4]
Range of navigation	[12.2]
Estuary plus	[12.3]
Operating area	[12.4]

1.2 Service notations

1.2.1 Generally, the service notations will be assigned according to the indications or suggestions of the Prospective vessel Owner, Building Yard or Other Interested Party.

1.2.2 The various service notations which may be assigned to a vessel are defined in [2] to [10], according to the category to which they belong. These notations are also listed in Tab 2, together with corresponding additional service features.

1.2.3 Vessels may be described by service notations which correspond to seagoing vessels or to special type regarding the hull configuration and/or particular kind of propulsion. Such notations may be assigned instead or in addition to the notations referred to, when the applicable rule requirements are met, e.g.:

- **Crew boat**
- **Supply vessel**
- **HSC**

1.2.4 The Society reserves the right to grant other service notations.

1.3 Additional service features

1.3.1 General

Additional service features are defined together with service notations to which they correspond in [2] to [10].

The service notation may be also completed by the additional service features described in [1.3.2] to [1.3.4] depending upon:

- vessel mode of propulsion
- hull structural configuration
- hull materials.

1.3.2 No propulsion

Each non-propelled vessel or unit will be assigned the additional service feature **No propulsion**, added to its service notation.

This service feature does not apply to the following units:

- pontoons
- harbour equipment
- floating establishments.

1.3.3 Hull structural configuration

Based on the different types of the hull structural configuration, the following additional service features may be added to the service notations:

- **Double hull** for vessels and units fitted with inner bottom and inner sides contributing to the hull girder strength and complying with the applicable rule requirements.

  Convenient accesses to all double bottom and side tank spaces are to be provided for inspection.
- **With double bottom** for vessels and units fitted with inner bottom contributing to the hull girder strength and complying with the applicable rule requirements.

  Convenient accesses to all double bottom spaces are to be provided for inspection.
- **With double sides** for vessels and units fitted with inner sides contributing to the hull girder strength and complying with the applicable rule requirements.

  Convenient accesses to all side tank spaces are to be provided for inspection.

1.3.4 Special considerations for hull materials

If vessels are constructed of normal strength hull structural steel, this will not be specially indicated. If other materials are employed for the hull, this will be indicated in the notations in the class certificate, e.g.:

- **HS** for Higher Strength hull structural steel
- **A** for ALuminium
- **C** for Composite materials such as fibre reinforced plastic (FRP)
- **W** for Wood or plywood
- **CR** for Concrete.

Table 2 : Service notations and corresponding additional service features

	Service notation [ref. in Part A]	Additional service feature [ref. in Part A]	Applicable rule requirements
Cargo vessels	**Bulk cargo vessel** [2.1.1]		Pt D, Ch 1, Sec 2
	Container vessel [2.1.2]		Pt D, Ch 1, Sec 4
	General cargo vessel [2.1.3]		Pt D, Ch 1, Sec 1
	RoRo cargo vessel [2.1.4]		Pt D, Ch 1, Sec 5
		1R [2.2.1]	Pt B, Ch 3, Sec 1, [3.1.5]
		2R [2.2.2]	Pt B, Ch 3, Sec 1, [3.1.4]
		Nonhomload [2.2.3]	–
		Ind [2.2.4]	–
		Max. density [2.2.5]	–
		DG1 [2.2.6]	Pt D, Ch 3, Sec 7
		DG2 [2.2.7]	Pt D, Ch 3, Sec 7
		DGD [2.2.8]	Pt D, Ch 3, Sec 9
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W / CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
Carriage of liquid or gaseous cargo in bulk	**Tanker** [3.1.1]		Pt D, Ch 1, Sec 3
		1R [3.2.1]	Pt B, Ch 3, Sec 1, [3.1.5]
		2R [3.2.2]	Pt B, Ch 3, Sec 1, [3.1.4]
		Nonhomload [3.2.3]	–
		Ind [3.2.4]	–
		Max. density [3.2.5]	–
		Max. t° [3.2.6]	–
		TP = x kPa [3.2.7]	–
		DP = x kPa [3.2.7]	–
		Type G [3.2.8]	ADN **(1)**
		Type C [3.2.9]	ADN **(1)**
		Type N closed [3.2.10]	ADN **(1)**
		Type N open with flame arresters [3.2.11]	ADN **(1)**
		Type N open [3.2.12]	ADN **(1)**
		DG-G [3.2.13]	Pt D, Ch 3, Sec 2
		DG-C [3.2.14]	Pt D, Ch 3, Sec 3
		DG-N closed [3.2.15]	Pt D, Ch 3, Sec 4
		DG-N open with flame arresters [3.2.16]	Pt D, Ch 3, Sec 4
		DG-N open [3.2.17]	Pt D, Ch 3, Sec 4
		Oil separator vessel [3.2.18]	Pt D, Ch 3, Sec 5
		Supply vessel [3.2.19]	Pt D, Ch 3, Sec 6
		DGD [3.2.20]	Pt D, Ch 3, Sec 9
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W / CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22

	Service notation [ref. in Part A]	Additional service feature [ref. in Part A]	Applicable rule requirements
Carriage of passengers	**Passenger vessel** [4.1.1]		Pt D, Ch 1, Sec 6
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W / CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
Vessels for dredging activities	**Dredger** [5.1.1] **(2)**		Pt D, Ch 1, Sec 9
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W / CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
	Hopper barge [5.1.2]		Pt D, Ch 1, Sec 9
	Hopper dredger [5.1.3] **(2)**		Pt D, Ch 1, Sec 9
	Split hopper barge [5.1.4]		Pt D, Ch 1, Sec 9
	Split hopper dredger [5.1.5] **(2)**		Pt D, Ch 1, Sec 9
		1R [5.2.1]	Pt B, Ch 3, Sec 1, [3.2.4]
		2R [5.2.2]	Pt B, Ch 3, Sec 1, [3.2.4]
		Nonhomload [5.2.3]	–
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W /CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
Working units	**Launch** [6.1.1]		Pt D, Ch 1, Sec 10
		HS / A / C / W / CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
	Pontoon [6.1.2]		Pt D, Ch 1, Sec 8
	Pontoon-crane [6.1.2]		Pt D, Ch 1, Sec 8
	Pusher [6.1.3]		Pt D, Ch 1, Sec 7
		DGL [6.2.1]	Pt D, Ch 3, Sec 8
		DGD [6.2.2]	Pt D, Ch 3, Sec 9
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22

	Service notation [ref. in Part A]	Additional service feature [ref. in Part A]	Applicable rule requirements
☝	**Tug** [6.1.4]		Pt D, Ch 1, Sec 7
		DGL [6.2.1]	Pt D, Ch 3, Sec 8
		DGD [6.2.2]	Pt D, Ch 3, Sec 9
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
Pleasure vessel	**Pleasure vessel** [7.1.1]		Pt D, Ch 1, Sec 11
		HS / A / C / W /CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22
Harbour equipment	**Floating dock** [8.2.1] **Floating landing dock** [8.2.2] **Floating door** [8.2.3] **Floating bridge** [8.2.4] **Worksite unit** [8.2.5] **Floating Storage** [8.2.6]		NR612
Floating establishment	**Floating establishment** [9.1]		NR580
Special service	**Special service** [10] **(3)**		**(4)**
		Particular service [10.1.2]	–
		No propulsion [1.3.2]	–
		Double hull / With double bottom / With double sides [1.3.3]	–
		HS / A / C / W /CR [1.3.4]	–
		Dualfuel / Gasfuel [1.3.5]	NR529 or NR467, Pt D, Ch 9
		Hydrogencell [1.3.6]	NI 547
		Battery system [1.3.7]	NR467, Pt F, Ch 11, Sec 21
		Electric hybrid [1.3.8]	NR467, Pt F, Ch 11, Sec 22

(1) The applicable requirements of Part D, Chapter 3, not covered by ADN are to be complied with.
(2) This notation may be completed by the type of dredger, e.g. **Suction dredger**.
(3) This notation may be completed by the type of vessel, e.g. **Rescue vessel**. This type of vessel is considered on a case by case basis by the Society, according to its intended mission.
(4) These vessels are considered on a case by case basis according to their additional service feature.

1.3.5 Vessels with gas fuelled propulsion

The service notation will be completed by one of the following additional service features, when the vessel complies with the applicable requirements of NR529 Safety Rules for Gas-Fuelled Engine Installations in Ships, or NR467 Rules for Steel Ships, Part D, Chapter 9, or a combination thereof, as applicable:

- **Dualfuel** for engines using both gas and fuel oil as fuel
- **Gasfuel** for engines using only gas as fuel.

The gas may be either compressed natural gas or liquefied natural gas.

1.3.6 Vessels with hydrogen fuel cell propulsion

The service notation will be completed by the additional service feature **Hydrogencell**, when the vessel complies with NI 547 Guidelines for Fuel Cell Systems Onboard Commercial Ships.

1.3.7 Battery system

The service notation may be completed by the additional service feature **Battery system** when batteries are used for propulsion and/or electric power supply purpose during operation of the vessel. This additional service feature is mandatory when the vessel is only relying on batteries for propulsion and/or electrical power supply for main sources.

The requirements for the assignment of this additional service feature are given in the Rules for the Classification of Steel Ships (NR467, Pt F, Ch 11, Sec 21).

Note 1: when a vessel is assigned the additional service feature **Electric hybrid ( )**, it is not necessary to assign the additional service feature **Battery system**.

1.3.8 Electric hybrid

The service notation may be completed by the additional service feature **Electric hybrid ( )** when vessels are provided with an energy storage system (ESS) used to supply the electric propulsion and/or the main electrical power distribution system of the vessel.

The additional service feature **ELECTRIC HYBRID ( )** is to be completed, between brackets, by at least one of the following notation:

- **PM**, when at least one of the following power management mode is available: load smoothing mode, peak shaving mode, or enhanced dynamic mode
- **PB**, when power backup mode is available
- **ZE**, when zero emission mode is available.

Example:

ELECTRIC HYBRID (PM, ZE)

The requirements for the assignment and maintenance of this additional service feature are given in the Rules for the Classification of Steel Ships (NR467, Pt F, Ch 11, Sec 22).

Table 3 : List of additional class notations

Additional class notation	Ref. in Part A	Applicable rule requirements	Remarks
ADN (1) (5)	[11.4.2]	ADN Regulations	Applies to the following notations: • **Type G**, **Type C**, **Type N closed** • **Type N open with flame arresters** • **Type N open**, **DG1**, **DG2**, **DGL**, **DGD** • **Oil separator vessel**, **Supply vessel**
Annual survey	[11.1]	Pt D, Ch 2, Sec 9	
AUT-UMS (2)	[11.2]	Pt D, Ch 2, Sec 8	
Auxiliary propulsion	[11.3]	Part C	
AWT	[11.15.3]	Pt D, Ch 2, Sec 11	
Cicos (3)	[11.4.3]	Cicos Regulations	
Cleanvessel	[11.15.2]	Pt D, Ch 2, Sec 11	
COMF-NOISE	[11.5.2]	NR467, Pt F, Ch 6	
COMF-VIB	[11.5.3]	NR467, Pt F, Ch 6	
Damage stability	[11.14.1]	Pt D, Ch 2, Sec 6	
Equipped for transport of containers	[11.6]	Pt D, Ch 2, Sec 3	
Equipped for transport of wheeled vehicles	[11.7]	Pt D, Ch 2, Sec 4	
EUR	[11.4.4]	ES-TRIN **(4)**	
Ferry	[11.8]	Pt D, Ch 2, Sec 5	Applies to passenger vessels
Fire	[11.9]	Pt D, Ch 2, Sec 7	
Grabloading	[11.10]	Pt D, Ch 2, Sec 10	Applies to bulk cargo vessels
Green passport	[11.15.4]	NR528	
GWT	[11.15.5]	Pt D, Ch 2, Sec 11	
Heavycargo (AREA$_i$, x$_i$ kN/m^2)	[11.11]	Pt D, Ch 2, Sec 2	
Heavycargo	[11.12]	Pt D, Ch 2, Sec 2	Applies to bulk cargo vessels
Ice	[11.13.5]	Pt D, Ch 2, Sec 1	
Ice-30	[11.13.4]		
Ice-40	[11.13.3]		
Ice-40+	[11.13.2]		
NDO-x days	[11.15.6]	Pt D, Ch 2, Sec 11	
NOX-x%	[11.15.7]	Pt D, Ch 2, Sec 11	
Normam 02	[11.4.5]	Normam 02	
OWS-x ppm	[11.15.8]	Pt D, Ch 2, Sec 11	
SOX-x%	[11.15.9]	Pt D, Ch 2, Sec 11	

(1) ADN means European agreement concerning the international carriage of dangerous goods by inland waterways.
(2) A character of construction is added to this notation.
(3) Cicos means International Commission of the Congo-Oubangui-Sangha Basin.
(4) ES-TRIN means European Standard laying down Technical Requirements for Inland Navigation vessels
(5) Does not apply to the following notations:
- **DG-G**, **DG-C**, **DG-N closed**
- **DG-N open with flame arresters**
- **DG-N open**

1.4 Additional class notations

1.4.1 The additional class notations which may be assigned to a vessel are defined in [11], and listed in alphabetical order in Tab 3.

1.4.2 The Society reserves the right to grant other additional class notations.

1.5 Navigation and operating area notations

1.5.1 The navigation and operating area notations which may be assigned to a vessel are defined in [12] and listed hereafter:

- Range of navigation
- Estuary plus
- Operating area.

1.6 Survey related notations

1.6.1 The survey related notations which may be assigned to a vessel are:

- **Annual survey** as defined in [11.1]
- **Laid-up** where lay-up survey is implemented in compliance with Ch 2, Sec 2, [11].

2 Cargo vessels

2.1 Service notations

2.1.1 Bulk cargo vessel

The service notation **Bulk cargo vessel** applies to vessels intended for the carriage of dry bulk cargo complying with the rule requirements stated under Pt D, Ch 1, Sec 2.

When the maximum cargo density is greater than 1 t/m^3, the service notation **Bulk cargo vessel** is completed with the indication of the maximum density of the cargo that the vessel is allowed to carry, e.g.:

Bulk cargo vessel / Max. density 1.8 t/m^3

2.1.2 Container vessel

The service notation **Container vessel** applies to vessels specially intended for the carriage of containers complying with the rule requirements stated under Pt D, Ch 1, Sec 4.

2.1.3 General cargo vessel

The service notation **General cargo vessel** applies to vessels intended for the carriage of general cargo, dry bulk cargo of density $\rho_B \leq 1$ t/m^3 included, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 1.

2.1.4 RoRo cargo vessel

The service notation **RoRo cargo vessel** applies to vessels specially intended to carry vehicles, trains and loads on wheeled beds, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 5.

2.2 Additional service features

2.2.1 1R

The service notation of cargo vessels will be completed by the additional service feature **1R**, when the vessel's structure is designed for loading and unloading in one run.

2.2.2 2R

The service notation of cargo vessels will be completed by the additional service feature **2R**, when the vessel's structure is designed for loading and unloading in two runs.

2.2.3 Nonhomload

The service notation of cargo vessels will be completed by the additional service feature **Nonhomload**, when the vessel has been designed in such a way that the cargo spaces may be loaded non-homogeneously, including cases where some holds may be empty, at a draught up to the scantling draught and fulfil the appropriate rule requirements for general strength, and when the corresponding loading conditions are listed in the reviewed loading manual. This additional service feature may be completed with the indication of the different maximum loads allowed in each hold and which holds may be empty, if appropriate.

2.2.4 Ind

The service notation of a vessel carrying substances in independent cargo tanks which meet the requirements of the Rules, will be completed by the additional service feature **Ind**.

2.2.5 Max. density

When applicable, the maximum allowed density **Max. density** of the cargo carried may be added to the service notation as an additional service feature.

2.2.6 DG1

The service notation of cargo vessels will be completed by the additional service feature **DG1** when the vessel is designed to carry dry dangerous goods in quantities exceeding those indicated in Pt D, Ch 3, App 2, [1], in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 7.

2.2.7 DG2

The service notation of cargo vessels will be completed by the additional service feature **DG2** when the vessel is designed to carry dry dangerous goods in quantities limited to those indicated in Pt D, Ch 3, App 2, [1], in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 7.

2.2.8 DGD

The service notation of cargo vessels will be completed by the additional service feature **DGD** when the vessel (not carrying dangerous goods) is intended to be a part of a pushed convoy or a side-by-side formation comprising a cargo vessel or a tanker carrying dangerous substances and complies with the applicable rule requirements stated under Pt D, Ch 3, Sec 9.

3 Vessels carrying liquid or gaseous cargo in bulk

3.1 Service notation

3.1.1 Tanker

The service notation **Tanker** applies to vessels specially intended to carry liquid or gaseous cargo in bulk, in compliance with the applicable rule requirements stated under Pt D, Ch 1, Sec 3.

3.1.2 The list of cargoes the tanker is allowed to carry will be issued by the Society, in the case of transport of dangerous goods (see Pt D, Ch 3, Sec 1).

The compatibility of the accepted dangerous goods with all the construction materials of the vessel, including installations and equipment, which come into contact with the cargo, is outside of the classification scope and remains the responsibility of the vessel Owner.

3.2 Additional service features

3.2.1 1R

The service notation of tankers will be completed by the additional service feature **1R**, when the vessel's structure is designed for loading and unloading in one run.

3.2.2 2R

The service notation of tankers will be completed by the additional service feature **2R**, when the vessel's structure is designed for loading and unloading in two runs.

3.2.3 Nonhomload

The service notation of tankers will be completed by the additional service feature **Nonhomload**, when the vessel has been designed in such a way that the cargo spaces may be loaded non-homogeneously, including cases where some holds may be empty, at a draught up to the scantling draught and fulfil the appropriate rule requirements for general strength, and when the corresponding loading conditions are listed in the reviewed loading manual. This additional service feature may be completed with the indication of the different maximum loads allowed in each tank and which tanks may be empty, if appropriate.

3.2.4 Ind

The service notation of a tanker carrying substances in independent cargo tanks which meet the requirements of the Rules, in particular those concerning parallelepiped cargo tanks, or cylindrical pressure tanks, will be completed by the additional service feature **Ind**.

3.2.5 Max. density

When applicable, the maximum allowed density **Max. density** of the cargo carried may be added to the service notation as an additional service feature.

3.2.6 Max. t°

When applicable, the maximum allowed temperature, **Max. t°** of the cargo carried may be added to the service notation as an additional service feature.

3.2.7 TP / DP

In addition to the service notation **Tanker**, the test pressure **TP** and the design pressure **DP** of the cargo tank, measured at the tank top, expansion trunk or dome excluded and expressed in kPa, are added as additional service features. These pressures are to be determined according to Pt B, Ch 3, Sec 4, [5] and first list item of Pt B, Ch 3, Sec 4, [3.1.2] for test pressure and design pressure respectively, taking z equal to z_{TOP}.

3.2.8 Type G

Type G applies to a tanker built and equipped for the carriage in bulk of pressurised or refrigerated gases, in compliance with the applicable provisions of ADN Regulations (see also Note 1). **Type G** will be completed by the additional class notation **ADN**.

Note 1: Items not covered by the ADN provisions shall comply with applicable requirements of Part D, Chapter 3.

3.2.9 Type C

Type C applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable provisions of ADN Regulations (see also Note 1). **Type C** will be completed by the additional class notation **ADN**.

Note 1: Items not covered by the ADN provisions shall comply with applicable requirements of Part D, Chapter 3.

3.2.10 Type N closed

Type N closed applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable provisions of ADN Regulations (see also Note 1). **Type N closed** will be completed by the additional class notation **ADN**.

Note 1: Items not covered by the ADN provisions shall comply with applicable requirements of Part D, Chapter 3.

3.2.11 Type N open with flame arresters

Type N open with flame arresters applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable provisions of ADN Regulations (see also Note 1). **Type N open with flame arresters** will be completed by the additional class notation **ADN**.

Note 1: Items not covered by the ADN provisions shall comply with applicable requirements of Part D, Chapter 3.

3.2.12 Type N open

Type N open applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable provisions of ADN Regulations (see also Note 1). **Type N open** will be completed by the additional class notation **ADN**.

Note 1: Items not covered by the ADN provisions shall comply with applicable requirements of Part D, Chapter 3.

3.2.13 DG-G

DG-G applies to a tanker built and equipped for the carriage in bulk of pressurised or refrigerated gases, in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 2.

3.2.14 DG-C

DG-C applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 3.

The vessel shall be of the flush deck type (see Pt B, Ch 5, Sec 4, [1.1.1]) and double hull type with double hull spaces, double bottoms, but without trunk.

The cargo tanks may be formed by the vessel's inner hull or may be installed in the hold spaces as independent tanks.

3.2.15 DG-N closed

DG-N closed applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 4.

3.2.16 DG-N open with flame arresters

DG-N open with flame arresters applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 4.

3.2.17 DG-N open

DG-N open applies to a tanker built and equipped for the carriage of dangerous liquids in bulk, in compliance with the applicable rule requirements stated under Pt D, Ch 3, Sec 4.

3.2.18 Oil separator vessel

Oil separator vessel applies to Type N open tankers and DG-N open tankers with a deadweight of up to 300 tons built and equipped to accept and carry oily and greasy wastes from the operation of vessels, complying with:

- the ADN provisions, for Type N Open
- the applicable rule requirements stated under Pt D, Ch 3, Sec 5, for DG-N Open.

3.2.19 Supply vessel

Supply vessel applies to Type N open tankers and DG-N open tankers with a deadweight of up to 300 tons built and equipped for the carriage and delivery to other vessels of products intended for the operation of vessels, complying with:

- the ADN provisions, for Type N Open
- the applicable rule requirements stated under Pt D, Ch 3, Sec 6, for DG-N Open.

3.2.20 DGD

The service notation **Tanker** will be completed by the additional service feature **DGD** when the vessel (not carrying dangerous goods) is intended to be a part of a pushed convoy or a side-by-side formation comprising a cargo vessel or a tanker carrying dangerous substances and complies with the applicable rule requirements stated under Pt D, Ch 3, Sec 9.

4 Vessels carrying passengers

4.1 Service notation

4.1.1 Passenger vessel

The service notation **Passenger vessel**, applies to vessels specially intended to carry more than 12 passengers complying with the rule requirements stated under Pt D, Ch 1, Sec 6.

5 Vessels for dredging activities

5.1 Service notations

5.1.1 Dredger

The service notation **Dredger**, applies to vessels specially equipped only for dredging activities (excluding carrying dredged material), complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 9.

5.1.2 Hopper barge

The service notation **Hopper barge**, applies to vessels (self-propelled or non-propelled) specially equipped for carrying spoils or dredged material only, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 9.

5.1.3 Hopper dredger

The service notation **Hopper dredger**, applies to vessels specially equipped for dredging activities and carrying spoils or dredged material, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 9.

5.1.4 Split hopper barge

The service notation **Split hopper barge**, applies to vessels (self-propelled or non-propelled) specially equipped for carrying spoils or dredged material only, and which open longitudinally around hinges in compliance with the applicable rule requirements stated under Pt D, Ch 1, Sec 9.

5.1.5 Split hopper dredger

The service notation **Split hopper dredger** applies to vessels specially equipped for dredging activities and carrying spoils or dredged material, which open longitudinally around hinges, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 9.

5.2 Additional service features

5.2.1 1R

The service notation of vessels intended to carry spoil will be completed by the additional service feature **1R**, when the vessel's structure is designed for loading and unloading in one run.

5.2.2 2R

The service notation of vessels intended to carry spoil will be completed by the additional service feature **2R**, when the vessel's structure is designed for loading and unloading in two runs.

5.2.3 Nonhomload

The service notation of vessels intended to carry spoil will be completed by the additional service feature **Nonhomload**, when the vessel has been designed in such a way that the cargo spaces may be loaded non-homogeneously, including cases where some holds may be empty, at a draught up to the scantling draught and fulfil the appropriate rule requirements for general strength, and when the corresponding loading conditions are listed in the reviewed loading manual. This additional service feature may be completed with the indication of the different maximum loads allowed in each hold and which holds may be empty, if appropriate.

6 Notations for working units

6.1 Service notations

6.1.1 Launch

The service notation **Launch** is assigned to small vessels which are used to provide facilities and assistance for the performance of specified activities, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 10.

6.1.2 Pontoon

The service notation **Pontoon** is assigned to non-propelled units intended to carry cargo and/or equipment on deck only, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 8.

When a crane is permanently fitted on board, the crane is to be certified according to NR526 Rules for the Certification of Lifting Appliances onboard Ships and Offshore Units, and the service notation **Pontoon-crane** is granted.

6.1.3 Pusher

The service notation **Pusher**, applies to vessels specially equipped for pushing, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 7.

6.1.4 Tug

The service notation **Tug**, applies to vessels specially equipped for towing, complying with the applicable rule requirements stated under Pt D, Ch 1, Sec 7.

6.2 Additional service features

6.2.1 DGL

The service notation **Tug** or **Pusher** will be completed by the additional service feature **DGL** when the tug or pusher is part of a pushed convoy or a side-by-side formation comprising a tank vessel carrying dangerous substances and complies with the applicable rule requirements stated under Pt D, Ch 3, Sec 8.

6.2.2 DGD

The service notation **Tug** or **Pusher** will be completed by the additional service feature **DGD** when the tug or pusher is part of a pushed convoy or a side-by-side formation comprising a cargo vessel carrying dangerous substances and complies with the applicable rule requirements stated under Pt D, Ch 3, Sec 9.

7 Notations for pleasure units

7.1 Service notation

7.1.1 Pleasure vessel

The service notation **Pleasure vessel** is assigned to vessels other than passenger vessels, intended for sport or pleasure cruising complying with the requirements stated under Pt D, Ch 1, Sec 11.

8 Harbour equipment

8.1 General

8.1.1 The requirements for harbour equipment design, construction, equipment, assignment and maintenance are developed in NR612 Harbour Equipment.

8.1.2 Applicable additional class notations and additional service features are those defined in NR612 Harbour Equipment.

8.2 Service notations

8.2.1 Floating dock

The service notation **Floating dock** is assigned to harbour equipment intended to lift floating units, complying with the applicable requirements of NR612 Harbour Equipment.

8.2.2 Floating landing dock

The service notation **Floating landing dock** is assigned to harbour equipment intended for drawing alongside vessels allowing operations such as bunkering, cargo loading and unloading, passenger embarking and disembarking, etc., complying with the applicable rule requirements of NR612 Harbour Equipment.

8.2.3 Floating door

The service notation **Floating door** is assigned to watertight box girder harbour equipment fitted with flooding and dewatering systems intended to be operated as movable gate to close or separate water stretch areas, complying with the applicable rule requirements of NR612 Harbour Equipment.

8.2.4 Floating bridge

The service notation **Floating bridge** is assigned to harbour equipment supported by low flat-bottomed boats or pontoons intended to be used as bridge, complying with the applicable rule requirements of NR612 Harbour Equipment.

8.2.5 Worksite unit

The service notation **Worksite unit** is assigned to harbour equipment appropriately built and equipped for use at worksites, complying with the applicable rule requirements of NR612 Harbour Equipment.

8.2.6 Floating Storage

The service notation **Floating Storage** is assigned to harbour equipment intended for storage of products in bulk or in package, complying with the applicable rule requirements of NR612 Harbour Equipment.

9 Floating establishment

9.1 General

9.1.1 The service notation **Floating establishment** is assigned to stationary berthed non propelled floating units equipped for missions such as activities intended for the public, accommodation facilities, etc.

9.1.2 The requirements for floating establishment design, construction, equipment, assignment and maintenance are developed in NR580 Floating Establishments.

9.1.3 Applicable additional class notations and additional service features are those defined in NR580 Floating Establishments.

10 Special service

10.1 General

10.1.1 The service notation Special service is assigned to vessels which, due to the peculiar characteristics of their activity, are not covered by any of the service notations mentioned above. The classification requirements of such units are considered by the Society on a case by case basis.

This service notation may apply, for instance, to vessels engaged in research, expeditions and survey, vessels for training of personnel and other vessels with design features and modes of operation which may be referred to the same group of vessels.

10.1.2 An additional service feature will be specified after the service notation, e.g. **Rescue vessel**, to identify the particular service in which the unit is intended to trade. The scope of classification of such units is indicated into the certificate of classification.

11 Additional class notations

11.1 Annual survey

11.1.1 The additional class notation **Annual survey** is assigned to vessels for which surveys for the maintenance of class include the annual survey performed in compliance with Pt D, Ch 2, Sec 9.

11.2 Automated machinery systems

11.2.1 The additional class notation **AUT-UMS** is assigned to vessels which are fitted with automated installations enabling machinery spaces to remain periodically unattended in all sailing conditions including manoeuvring, complying with the requirements stated under Pt D, Ch 2, Sec 8.

11.2.2 In compliance with Ch 1, Sec 2, [2.1.2], this notation is assigned a character of construction, as defined in Ch 1, Sec 2, [2].

11.3 Auxiliary propulsion

11.3.1 A service notation may be completed by the additional class notation **Auxiliary propulsion**, when the vessel is equipped with an auxiliary propulsion system allowing short moves at a limited speed complying with the applicable requirements of Part C.

11.4 Compliance with statutory Regulations

11.4.1 General

A service notation may be completed by an additional class notation denoting compliance with any specific statutory Regulations, such as those given in [11.4.2] to [11.4.5].

11.4.2 ADN

A service notation may be completed by the additional class notation **ADN**, when the vessel's structure and equipment are examined by the Society and found in compliance with the Regulations Annexed to the European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways, as amended. Assigned class notation **ADN** is, in no way, intended to replace statutory certificate.

A service notation may also be completed by the additional class notation **ADN**, when corresponding certificate has been issued by the Authorities.

11.4.3 Cicos

A service notation may be completed by the additional class notation **Cicos**, when the vessel's structure and equipment are examined by the Society and found in compliance with the Regulations of the International Commission of the Congo-Oubangui-Sangha Basin, as amended. Assigned class notation **Cicos** is, in no way, intended to replace statutory certificate.

A service notation may also be completed by the additional class notation **Cicos**, when corresponding certificate has been issued by the Authorities.

11.4.4 EUR

A service notation may be completed by the additional class notation **EUR**, when the vessel's structure, equipment and systems are examined by the Society and found in compliance with the ES-TRIN, as amended. Assigned class notation **EUR** is, in no way, intended to replace statutory certificate.

A service notation may also be completed by the additional class notation **EUR**, when corresponding certificate has been issued by the Authorities.

Note 1: ES-TRIN means European Standard laying down Technical Requirements for Inland Navigation vessels.

11.4.5 Normam 02

A service notation may be completed by the additional class notation **Normam 02**, when the vessel's structure and equipment are examined by the Society and found in compliance with the Brazilian Flag Regulations for Inland Navigation Vessels, as amended. Assigned class notation **Normam 02** is, in no way, intended to replace statutory certificate.

A service notation may also be completed by the additional class notation **Normam 02**, when corresponding certificate has been issued by the Authorities.

11.5 Comfort on board vessels (COMF)

11.5.1 General

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

The parameters which are taken into consideration for the evaluation of the comfort such as the level of noise, the level of vibration will be indicated in the relevant annex to the certificate of classification.

The requirements for the assignment of these notations are given in NR467 Rules for Steel Ships, Part F, Chapter 6.

11.5.2 Comfort with regard to noise (COMF-NOISE)

The additional class notation **COMF-NOISE** is assigned to vessels satisfying levels of noise defined in NR467 Rules for Steel Ships, Part F, Chapter 6. The assessment of noise levels is carried out through measurements during harbour and river trials.

The notation is completed by a grade **1**, **2** or **3** which represents the comfort level achieved for the assignment of the notation. The lower grade (**1**) corresponds to the higher class of comfort, e.g.:

COMF-NOISE 2

11.5.3 Comfort with regard to vibration (COMF-VIB)

The additional class notation **COMF-VIB** is assigned to vessels satisfying levels of vibration defined in NR467 Rules for Steel Ships, Part F, Chapter 6. The assessment of vibration is carried out through measurements during harbour and river trials.

The notation is completed by a grade **1**, **2** or **3** (evaluation based on overall frequency criteria) which represents the comfort level achieved for the assignment of the notation. The lower grade (**1**) corresponds to the higher class of comfort, e.g.:

COMF-VIB 1

11.6 Equipped for transport of containers

11.6.1 A service notation may be completed with the additional class notation **Equipped for transport of containers**, where the vessel complies with the rule requirements stated under Pt D, Ch 2, Sec 3.

11.7 Equipped for transport of wheeled vehicles

11.7.1 A service notation may be completed with the additional class notation **Equipped for transport of wheeled vehicles**, where the vessel complies with the rule requirements stated under Pt D, Ch 2, Sec 4.

11.8 Ferry

11.8.1 The service notation **Passenger vessel** may be completed by the additional class notation **Ferry**, for vessels specially equipped to load wheeled vehicles, complying with the rule requirements stated under Pt D, Ch 2, Sec 5.

11.9 Fire

11.9.1 The additional class notation **Fire** may be added to the service notation when the vessel's installations comply with the rule requirements stated under Pt D, Ch 2, Sec 7.

11.10 Grabloading

11.10.1 The service notation **Bulk cargo vessel** may be completed with the additional class notation **Grab-loading** if the hold tank is specially reinforced for loading/unloading cargoes by means of grabs or buckets.

The requirements for the assignment of this notation are given in Pt D, Ch 2, Sec 10.

However, this does not preclude vessels not assigned with this notation from being loaded/unloaded with grabs.

11.11 Heavycargo (AREA$_i$, x$_i$ kN/m^2)

11.11.1 A service notation will be completed by the additional class notation **Heavycargo (AREA$_i$, x$_i$ kN/m^2)**, when the double bottom and/or hatch covers and/or other cargo areas designed to support heavy cargoes fulfil the appropriate rule requirements. The value xi indicates the maximum allowable local pressure corresponding to zone **AREA$_i$** where the cargo is intended to be stowed, e.g.:

General cargo vessel / Heavy cargo (Hold, 120 kN/m^2)

The requirements for the assignment of this additional class notation are given in Pt D, Ch 2, Sec 2.

11.12 Heavycargo

11.12.1 When the maximum density of the cargo that the vessel is allowed to carry is greater than or equal to 2,5 t/m^3, the service notation **Bulk cargo vessel** will be completed by the additional class notation **Heavycargo** followed by the indication of the maximum allowable cargo density, when the double bottom structure complies with the rule requirements stated under Pt D, Ch 2, Sec 2, e.g.:

Bulk cargo vessel / Heavy cargo/ Max. density 4.4 t/m^3

11.13 Navigation in ice

11.13.1 Notations dealt with under this Sub-article are relevant to vessels strengthened for navigation in ice in accordance with the rule requirements given in Pt D, Ch 2, Sec 1.

11.13.2 Ice-40+

The additional class notation **Ice-40+** is assigned to vessels with such structure, machinery and other properties that they are capable of navigating in light ice conditions, with the assistance of icebreakers when necessary.

These vessels are to comply with the ice strengthening requirements developed in Pt D, Ch 2, Sec 1, which are equivalent to those corresponding to **ICE CLASS IC** in the "Finnish-Swedish Ice Class Rules 2010 as amended".

11.13.3 Ice-40

The additional class notation **Ice-40** is assigned to vessels whose reinforcements for navigation in ice are different from those required for the assignment of the notation **Ice-40+** defined in [11.13.2] and complying with the specific rule requirements detailed in Pt D, Ch 2, Sec 1.

11.13.4 Ice-30

The additional class notation **Ice-30** is assigned to vessels with such structure, machinery and other properties that they are capable of navigating in broken ice with a thickness not exceeding 30 cm, complying with the applicable rule requirements stated under Pt D, Ch 2, Sec 1.

11.13.5 Ice

The additional class notation **Ice** is assigned to vessels with such structure, machinery and other properties that they are capable of navigating in broken ice with a thickness not exceeding 20 cm, complying with the applicable rule requirements stated under Pt D, Ch 2, Sec 1.

11.14 Stability notations

11.14.1 Damage stability

The additional class notation **Damage stability** may be assigned to vessels for which the intact stability and the damage buoyancy file have been examined by the Society and found to satisfy the specific rule requirements stated under Pt D, Ch 2, Sec 6.

The certificate issued specifies the criteria considered for this examination and is to be annexed to the classification certificate. The damage buoyancy and stability file is to be available on board.

11.14.2 The certificate issued for damage stability remain valid unless:

- the relevant structure, equipment or installations of the vessel are modified or not kept in a satisfactory condition of maintenance and operation
- the conditions of operation of the vessel differ from those taken into consideration for the examination
- the proper applicable documentation examined by the Society is not available on board
- the classification certificate is not valid.

11.15 Pollution prevention

11.15.1 General

The notations dealt with under this heading are assigned to vessels fitted with equipment and arrangements enabling them to control and limit the emission of polluting substances in the water and the air.

The requirements for the assignment of these notations are given in Pt D, Ch 2, Sec 11.

11.15.2 Cleanvessel

The additional class notation **Cleanvessel** is assigned to vessels fitted with equipment and arrangements as given in Pt D, Ch 2, Sec 11.

11.15.3 Advanced wastewater treatment (AWT)

The additional class notation **AWT** is assigned to vessels fitted with an Advanced Wastewater Treatment plant in accordance with the provisions of in Pt D, Ch 2, Sec 11.

11.15.4 Green passport for vessel recycling

The additional class notation Green passport may be assigned to vessels for which requirements intended to facilitate vessel recycling have been applied, encompassing the identification, quantification and localization of materials which may cause harm to the environment and people when the fittings or equipment containing such materials are removed, or when the vessel is recycled.

The requirements for the assignment and maintenance of this notation are given in NR528 Green Passport.

11.15.5 GWT

The additional class notation **GWT** applies to vessels fitted with a grey water treatment plant in accordance with the provisions of Pt D, Ch 2, Sec 11.

11.15.6 NDO-x days

The additional class notation **NDO-x days** applies to vessels having sufficient onboard storage capacity for solid waste and liquid effluents, allowing the fully loaded vessel to operate without discharging any substances into the water during x consecutive days (no discharge period), in accordance with the provisions of Pt D, Ch 2, Sec 11.

11.15.7 NOX-x%

The additional class notation **NOX-x%** applies to vessels fitted with diesel engines having a weighted average NOx emission level not exceeding x% of limit, in accordance with the provisions of Pt D, Ch 2, Sec 11.

11.15.8 OWS

The additional class notation **OWS-x ppm** applies to vessels fitted with an oily water separator (OWS) capable of producing effluents having a hydrocarbon content not exceeding x ppm, in accordance with the provisions of Pt D, Ch 2, Sec 11.

11.15.9 SOX-x%

The additional class notation **SOX-x%** applies to vessels using fuel oils complying with the criteria given in Pt D, Ch 2, Sec 11.

12 Navigation and operating area notations

12.1 General

12.1.1 The assignment of these notations does not absolve the Owner or Other Interested Party from compliance with any international and national Regulations established by the Administrations for a vessel operating in national waters, or a specific area, or a navigation zone. Neither does it waive the requirements in Ch 1, Sec 1, [3.3].

12.1.2 Where it is envisaged for the vessel to proceed temporarily in conditions other than defined by the assigned navigation notations or operating area notations, e.g. for transit, appropriate drawing review and occasional survey are to be carried out to check that the intended voyage and the vessel's specific condition comply with the Society's Rules.

12.2 Range of navigation

12.2.1 The range of navigation which the Society assigns upon examination of plans or any other equivalent procedure does not entirely determine the actual capability of a vessel to operate in a specific area; this capability being dependent on other factors which are not considered in the Rules. Consequently, no comparison should be made between a range of navigation assigned by the Society and a navigation zone or category as defined by national or international Regulations.

12.2.2 IN

The range of navigation **IN** is assigned to a vessel having a structure with scantlings deemed suitable to navigate on stretches of water where there may be strong currents and a certain roughness of the surface on which a maximum wave height of 0,6 m can develop.

Note 1: **IN** corresponds to **IN(0,6)** in the previous Rules version.

12.2.3 IN(x ≤ 2)

The range of navigation **IN(x ≤ 2)** is assigned to a vessel having structure scantlings and other design features deemed suitable to navigate on stretches of water on which a significant wave height x, not exceeding 2,0 m, can develop, e.g. estuaries, lakes and restricted maritime stretches of water.

The definition of significant wave height is given in Ch 1, Sec 1, [1.2.10].

12.3 Estuary plus

12.3.1 The range of navigation notation will be completed by the navigation notation **Estuary plus**, if:

- the significant wave height exceeds 1,2 m, or
- the vessel is operated on restricted maritime stretches of water, or
- the vessel is operated on large lakes.

Vessels assigned with the notation **Estuary plus** shall comply with Pt D, Ch 2, Sec 12.

12.3.2 The navigation notation **Estuary plus** will be completed by the operating area notation as defined in [12.4].

12.3.3 In the class designation, the navigation notation **Estuary plus** will be indicated after the range of navigation.

12.4 Operating area

12.4.1 The operating area notation expresses the specified area where considered vessel is intended to operate. The operating area notation will be assigned to:

- vessels with the notation **Estuary plus**, or
- vessels operating within specific restrictions which are different from normal navigation conditions, or
- vessels operating in defined river systems or waters only.

12.4.2 In the class designation, the operating area notation will be indicated after the navigation notation **Estuary plus** if assigned, or after the range of navigation notation.

12.4.3 The operating area will be completed with:

- the indication of the wind force on Beaufort scale considered for the classification if the navigation notation **Estuary plus** is assigned
- eventual limitations or restrictions in other cases (e.g. current speed, etc.)

Example:

Belgian coast / operating between the Western Scheldt and the Zeebrugge harbour / within 5 NM from shore / Beaufort 7

13 Other notations

13.1 General

13.1.1 When the vessel's hull or essential parts have been constructed in accordance with a design, for which sufficient experience is not available, the Society may also define other notations by means of provisional requirements and guidelines, which may then be published in the form of tentative rules. The Society will decide at what intervals the required periodical surveys will have to be carried out.

13.1.2 Procedures as developed by IMO such as the international convention on load lines used to be noted ILLC 66 and other Codes for seagoing ships may be adopted, as far as practicable, if no equivalent Regulations are available.

Part A
Classification and Surveys

Chapter 2
CLASSIFICATION

SECTION 1	ASSIGNMENT OF CLASS
SECTION 2	MAINTENANCE OF CLASS
SECTION 3	SUSPENSION AND WITHDRAWAL OF CLASS
SECTION 4	CLASSIFICATION PROCEDURES
SECTION 5	HULL SURVEY FOR NEW CONSTRUCTION - STEEL AND ALUMINIUM ALLOYS
APPENDIX 1	REQUIREMENTS FOR THICKNESS MEASUREMENTS

SECTION 1 ASSIGNMENT OF CLASS

1 General

1.1

1.1.1 Class is assigned to a vessel upon a survey, with the associated operations, which is held in order to verify whether it is eligible to be classed on the basis of the Rules of the Society, see Ch 1, Sec 1, [1.4.2].

This may be achieved through:

- the completion of a new building, during which a survey has been performed
- a survey when the vessel changes class between classification Societies, or
- a specific admission to class survey, in cases where a vessel is not classed at all.

2 New building procedure

2.1 Vessel surveyed by the Society during construction

2.1.1 When a vessel is surveyed by the Society during construction, it is to comply with those requirements of the Rules which are in force and applicable depending on the class of the vessel, taking into account the provisions of Ch 1, Sec 1, [2.1], Ch 1, Sec 1, [2.2] and Ch 1, Sec 1, [2.3].

2.1.2 The Society:

- reviews the plans and documentation submitted as required by the Rules, see Ch 2, Sec 4
- proceeds, if required, with the appraisal of the design of materials and equipment used in the construction of the vessel and their inspection at works
- carries out surveys or obtains appropriate evidence to satisfy itself that the scantlings and construction meet the rule requirements in relation to the reviewed drawings
- attends tests and trials provided for in the Rules
- assigns the classification notations, refer to Ch 1, Sec 2.

2.1.3 The Society defines which materials and equipment used for the construction of vessels built under survey are, as a rule, subject to appraisal of their design and to inspection at works, and according to which particulars (a summary of these requirements is given, for easy reference, in NR544 Equipment and Materials Certification for the Classification of Inland Navigation Vessels).

2.1.4 As part of his interventions during the vessel's construction, the Surveyor will:

- conduct an overall examination of the parts of the vessel covered by the Rules
- examine the construction methods and procedures when required by the Rules
- check selected items covered by the rule requirements
- attend tests and trials where applicable and deemed necessary.

2.2 Vessels built under supervision of another classification Society

2.2.1 In this case, vessels will be admitted to the Society's class upon satisfactory surveys and verification of documentation. For the extent and scope of the surveys to be carried out and the list of documentation to be submitted by the Owner or Other Interested Party, reference is to be made to Ch 2, Sec 4.

Supervision of construction tests and trials to be carried out are based on the completion progress of the vessel and the updated current construction/class status as provided by the previous classification Society.

Admission to class may be conditioned by statutory Regulations.

2.2.2 Other vessels may be accepted on a case by case basis.

2.3 Use of materials, machinery, appliances and items

2.3.1 As a general rule, all materials, machinery, boilers, auxiliary installations, equipment, items, etc. which are covered by the class and used or fitted on board vessels surveyed by the Society during construction are to be new and tested by the Society.

Second hand materials, machinery, appliances and items may be used subject to the specific agreement of the Society and the Owner.

2.3.2 The requirements for the selection of materials to be used in the construction of the various parts of a vessel, the characteristics of products to be used for such parts and the checks required for their acceptance are to be as stated in other Parts of the Rules or as specified on reviewed plans. In particular, the testing of products manufactured according to quality assurance procedures approved by the Society or judged equivalent by the Society and the approval of such procedures are governed by the requirements of the Society.

2.4 Defects or deficiencies and their repairs

2.4.1 The Society may, at any time, reject items found to be defective or contrary to rule requirements or require supplementary inspections and tests and/or modifications, notwithstanding any previous certificates issued.

2.4.2 All repairs are subject to the preliminary agreement of the Society. When the limits of tolerance for defects are specified in the Rules concerned or by the manufacturer, they are to be taken into account for repairs.

2.4.3 It is the duty of the Owner, Other Interested Party and Building Yard to notify the Society of any defects or deficiencies noted during the construction of the vessel and/or of any item not complying with the applicable requirements or in any case unsatisfactory.

2.4.4 Proposals regarding remedial actions intended to be adopted to eliminate such defects or deficiencies are to be submitted to the Society and, if accepted, carried out to the Surveyor's satisfaction.

2.5 Equivalence of rule testing under certain conditions

2.5.1 Notwithstanding the provisions of [2.3], the Society may, at its discretion and subject to conditions and checks deemed appropriate, accept certain materials, appliances or machinery which have not been subjected to rule testing.

3 Vessels classed after construction

3.1 General

3.1.1 When an Owner applies to the Society for a vessel already in service to be admitted to class, the order will be processed differently depending on whether the vessel is:

- classed with another Society, or
- not classed at all.

3.1.2 Where appropriate within reasonable limits, a proven service record of satisfactory performance during a period of adequate length may be used as a criterion of equivalence. Special consideration will be given to vessels of recent construction.

3.1.3 For installations or equipment covered by additional class notations, the Society will determine the documentation to be submitted.

3.1.4 In addition, the Society may base its judgement upon documentation such as certificates issued or accepted by the former classification Society, if any, and statutory certificates issued by the flag Administration or by a recognised organisation on its behalf; moreover, other documents and/or plans may be specifically required to be supplied to the Society in individual cases.

3.2 Vessels classed with another Society

3.2.1 In this case, vessels will be admitted to the Society's class upon satisfactory surveys and verification of documentation. For the extent and scope of the surveys to be carried out and the list of documentation to be submitted by the Owner or Other Interested Party, reference is to be made to Ch 2, Sec 4, [2].

3.2.2 Surveys to be carried out are based on the age of the vessel and the updated current class status of the previous classification Society, as provided by the Owner.

3.3 Not classed vessels

3.3.1 In this case, the class of the vessel will be assigned upon a preliminary review of the documentation listed in Ch 2, Sec 4, [2.1.5] and subsequent satisfactory completion of the surveys.

3.3.2 The extent and scope of the admission to class survey are to be not less than those required at the class renewal survey of a vessel of the same age and type; in addition, all other periodical surveys should be performed together with those inspections which are linked to specific service notations and/or additional class notations and/or special installations the vessel is provided with.

4 Date of classification - Definitions

4.1 Date of build

4.1.1 For a new building the date of build is the year and month on which the new construction survey process is completed. Where there is a substantial delay between the completion of the construction survey process and the vessel commencing active service, the date of commissioning may be also specified.

If modifications are carried out, the date of build remains assigned to the vessel. Where a complete replacement or addition of a major portion of the vessel (e.g. forward section, after section, main cargo section) is involved, the following applies:

- the date of build associated with each major portion of the vessel is to be indicated on the classification certificate and in the Register, where it has been agreed that the newer structure shall be on a different survey cycle
- survey requirements are based on the date of build associated with each major portion of the vessel.

4.2 Date of classification for new buildings

4.2.1 As a general rule, for new buildings the date of initial classification coincides with the date of build.

4.3 Date of classification for existing vessels

4.3.1 In principle, for existing vessels, the date of classification is the date of completion of the admission to class survey.

5 Reassignment of class

5.1 General

5.1.1 At the request of the Owner, a vessel which was previously classed with the Society, subsequently withdrawn from class and has not been classed since may have the class reassigned subject to an admission to class survey. If applicable and appropriate, account may be taken of any periodical surveys held in the former period of class with the Society.

5.1.2 Where, after suspension or withdrawal of class, the repairs required by the Society have been carried out and the vessel has been subjected to a survey for readmission to class, the original class may be reassigned starting with a new period of class. Such surveys are generally to be carried out in accordance with the requirements for a class renewal survey.

5.1.3 Depending on the duration of the interruption period, parts of the machinery installation may have to be dismantled and river trials or function tests have to be carried out in excess of the requirements mentioned above. For parts and installations replaced or added in the meantime, the scope of examinations and tests to be carried out for admission to class shall be as for newbuildings.

SECTION 2 MAINTENANCE OF CLASS

1 General principles of surveys

1.1 Survey types

1.1.1 Classed vessels are submitted to surveys for the maintenance of class. These surveys include the class renewal survey, intermediate and eventual annual survey, bottom survey (either survey in dry condition or in-water survey), propeller shaft survey, pressure equipment survey, and surveys for the maintenance of additional class notations, where applicable. Such surveys are carried out at the intervals and under the conditions laid down in this Section.

1.1.2 The different types of periodical surveys are summarized in Tab 1. The intervals at which the periodical surveys are carried out are given in the items referred to in the second column of Tab 1. The relevant extent and scope are given in Ch 3, Sec 1 to Ch 3, Sec 9 for all vessels.

Where there are no specific survey requirements for additional class notations assigned to a vessel, equipment and/or arrangements related to these additional class notations are to be examined, as applicable, to the Surveyor's satisfaction at each class intermediate or renewal survey for the class.

The surveys are to be carried out in accordance with the relevant requirements in order to confirm that the hull, machinery, equipment and appliances comply with the applicable Rules and will remain in satisfactory condition based on the understanding and assumptions mentioned in Ch 1, Sec 1, [3.3].

Where the conditions for the maintenance of service notations and additional class notations are not complied with, the service notation and/or the additional class notations as appropriate will be suspended and/or withdrawn in accordance with the applicable rule requirements given in Ch 2, Sec 3.

Note 1: It is understood that the requirements for surveys apply to those items that are required according to the Rules or, even if not required, are fitted on board.

1.1.3 Unless specified otherwise, any survey other than bottom survey and propeller shaft survey may be effected by carrying out partial surveys at different times to be agreed upon with the Society, provided that each partial survey is adequately extensive. The splitting of a survey into partial surveys is to be such as not to impair its effectiveness.

1.1.4 The periodical surveys listed in the following are to be conducted for the hull, machinery including electrical installations as well as special equipment and installations included in the classification of the vessel (see Tab 1).

If, for some obvious reason, e.g. a temporary out-of-service condition of certain equipment, parts included in the classification cannot be surveyed, this will be noted in the survey statement/certificate.

1.1.5 Where flag state Regulations are applicable which impose inspection intervals deviating from the class related intervals, the intervals will be harmonized in the individual case to reduce the number of single surveys, where possible.

1.2 Change of periodicity, postponement or advance of surveys

1.2.1 The Society reserves the right, after due consideration, to change the periodicity, postpone or advance surveys, taking into account particular circumstances.

When a survey becomes due, the requirements of [1.2.2] to [1.2.4] apply.

1.2.2 Class renewal survey

In the case of a class renewal survey, the Society may grant an extension provided there is documented agreement to such an extension and class extension surveys are performed prior to the expiry date of the class certificate, and the Society is satisfied that there is justification for such an extension.

1.2.3 Annual and intermediate surveys

In the case of annual and intermediate surveys, as a rule, no postponement is granted. The surveys are to be completed within their prescribed windows.

1.2.4 All other periodical surveys and recommendations

In the case of all other periodical surveys and conditions of class, extension or postponement may be granted, provided there is sufficient technical justification for such an extension or postponement.

1.3 Extension of scope of survey

1.3.1 The Society may extend the scope of the provisions in Ch 3, Sec 1 to Ch 3, Sec 9, which set forth the technical requirements for surveys, whenever and so far as considered necessary, or modify them in the case of special vessels or systems.

1.3.2 The extent of any survey also depends upon the condition of the vessel and its equipment. Should the Surveyor have serious doubts as to the maintenance or condition of the vessel or its equipment, or be advised of any deficiency or damage which may affect the class, then further examination and testing may be conducted as considered necessary.

Table 1 : List of periodical surveys

Type of survey	Reference in this Section	Reference to scope of survey
Class renewal - hull	[4]	Ch 3, Sec 3, Ch 3, Sec 7 and Ch 3, Sec 8 **(1)**
Class renewal - machinery	[4]	Ch 3, Sec 3, Ch 3, Sec 7 and Ch 3, Sec 8 **(1)**
Class renewal - additional class notations		Ch 3, Sec 9 **(2)**
Annual	[5.2]	
Annual - additional class notations		Ch 3, Sec 9 **(2)**
Intermediate - hull	[5.3]	Ch 3, Sec 2, Ch 3, Sec 7 and Ch 3, Sec 8 **(1)**
Intermediate - machinery	[5.3]	Ch 3, Sec 2, Ch 3, Sec 7 and Ch 3, Sec 8 **(1)**
Intermediate - additional class notations		Ch 3, Sec 9 **(2)**
Bottom - dry condition	[5.4]	Ch 3, Sec 5, [2]
Bottom - in water	[5.4]	Ch 3, Sec 5, [3]
Propeller shaft - complete	[5.5]	Ch 3, Sec 4, [1]
Propeller shaft - modified	[5.5]	Ch 3, Sec 4, [2]
Pressure equipment	[5.6]	Ch 3, Sec 6

(1) As applicable, according to the service notation and additional service feature assigned to the vessel.
(2) As applicable, according to the additional class notations assigned to the vessel.

1.4 General procedure of survey

1.4.1 The general procedure of survey consists in:

- an overall examination of the parts of the vessel covered by the rule requirements
- checking, at random, of selected items covered by the rule requirements
- attending tests and trials where applicable and deemed necessary by the Surveyor.

1.4.2 When a survey results in the identification of significant corrosion, structural defects or damage to hull, machinery and/or any piece of its equipment which, in the opinion of the Surveyor, affect the vessel's class, remedial measures may be required to be implemented before the vessel continues in service.

1.4.3 The Society's survey requirements cannot be considered as a substitute for specification and acceptance of repairs and maintenance, which remain the responsibility of the Owner.

2 Definitions and procedures related to surveys

2.1 Definitions

2.1.1 Period of class

Period of class means the period starting either from the date of the initial classification or from the credited date of the last class renewal survey, and expiring at the limit date assigned for the next class renewal survey.

2.1.2 Anniversary date

Anniversary date means the day of the month of each year in the period of class which corresponds to the expiry date of the period of class.

2.1.3 Survey time window

Survey time window, or more simply window, means the fixed period during which annual and intermediate surveys are to be carried out.

2.1.4 Overdue surveys

Each periodical survey is assigned a limit date specified by the relevant requirements of the Rules (end of survey interval or end date of window) by which it is to be completed.

A survey becomes overdue when it has not been completed by its limit date.

2.1.5 Conditions of class

A defect and/or deficiency to be dealt with in order to maintain class, within a specific period of time, is indicated as a condition of class. A condition of class is pending until it is cleared, through a survey by the attending Surveyor or upon evidence that requirements have been completed, to the satisfaction of the Society. Where it is not cleared by its limit date, the condition of class is overdue.

Conditions of class may be imposed in other cases, which, in the Society's opinion, require specific consideration.

2.1.6 Memoranda

Those defects and/or deficiencies which do not affect the maintenance of class and which may therefore be cleared at the Owner's convenience and any other information deemed noteworthy for the Society's convenience are indicated as memoranda. Memoranda are not to be regarded as condition of class.

2.2 Terminology related to hull survey

2.2.1 Ballast tank

A ballast tank is a tank that is being primarily used for water ballast. A tank which is used for both cargo and water ballast will be treated as a ballast tank when substantial corrosion has been found in such tank, see [2.2.7].

2.2.2 Spaces

Spaces are separate compartments such as holds and tanks.

2.2.3 Overall survey

An overall survey is a survey intended to report on the overall condition of the hull structure and determine the extent of additional close-up surveys.

2.2.4 Close-up survey

A close-up survey is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. normally within reach of hand.

2.2.5 Transverse section

A transverse section includes all longitudinal members contributing to longitudinal hull girder strength, such as plating, longitudinals and girders at the deck, side shell, bottom, inner bottom, longitudinal bulkheads, and plating in side tanks, as well as relevant longitudinals, as applicable for the different vessels. For a transversely framed vessel, a transverse section includes adjacent frames and their end connections in way of transverse sections.

2.2.6 Representative tanks or spaces

Representative tanks or spaces are those which are expected to reflect the condition of other tanks or spaces of similar type and service and with similar corrosion protection systems. When selecting representative tanks or spaces, account should be taken of the service and repair history on board and identifiable suspect areas.

2.2.7 Substantial corrosion

Substantial corrosion is an extent of corrosion such that assessment of the corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits.

2.2.8 Pitting corrosion

Pitting corrosion is defined as scattered corrosion spots/areas with local material reductions which are greater than the general corrosion in the surrounding area.

2.2.9 Coating condition

Coating condition is defined as follows:

- good: condition with only minor spot rusting
- fair: condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for poor condition
- poor: condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

2.2.10 Critical structural area

Critical structural areas are locations which have been identified from calculations to require monitoring or from the service history of the subject vessel or from similar vessels or sister vessels, if applicable, to be sensitive to cracking, buckling or corrosion which could impair the structural integrity of the vessel.

2.2.11 Suspect areas

Suspect areas are locations showing substantial corrosion and/or considered by the Surveyor to be prone to rapid wastage.

2.2.12 Cargo area for vessels carrying liquid cargo in bulk

The cargo area is that part of the vessel which contains cargo tanks, slop tanks and cargo/ballast pump rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the vessel over the above-mentioned spaces.

2.2.13 Cargo area for dry cargo vessels

The cargo area is that part of the vessel which includes all cargo holds and adjacent areas including fuel tanks, cofferdams, ballast tanks and void spaces.

2.2.14 Prompt and thorough repair

A “Prompt and thorough repair” is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of class. See also [2.2.11].

2.3 Procedures for thickness measurements

2.3.1 When required as per the scope of surveys, thickness measurements are normally to be carried out under the responsibility of the Owner, and in the presence of the Surveyor, by a service supplier independent from the Owner.

Thickness measurements are to be carried out in compliance with Ch 2, App 1.

2.3.2 For all vessels, the following applies:

- thickness measurements required in the context of surveys of hull structure are to be witnessed by a Surveyor. This requires the Surveyor to be on board while the gaugings are taken, enabling him at any time to intervene and to control the process
- prior to commencement of the survey, a meeting is to be held between the attending surveyor(s), the Owner representative(s) in attendance and the thickness measurement firm’s representative(s) so as to ensure the safe and efficient execution of the surveys and thickness measurements to be carried out on board.

2.3.3 In any kind of survey, i.e. class renewal, intermediate, annual or other surveys having the same scope, thickness measurements of structures in areas where close-up surveys are required, are to be carried out simultaneously with close-up surveys.

2.3.4 Thickness measurement is normally to be carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven to the Surveyor as required. The thickness measurements are to be carried out by a company authorised by the Society.

The Society reserves the right to limit the scope of authorisation of the Company.

Note 1: Rule Note NR533 Approval of Service Suppliers gives details about the authorisation.

2.4 Thickness measurements acceptance criteria

2.4.1 Hull structural elements

Acceptance criteria applicable to hull structural elements are given in Ch 2, App 1.

2.4.2 Anchor equipment

Maximum permissible reduction of the mean diameter of chain links: 12%.

Maximum permissible reduction in weight of anchors: 10%.

2.4.3 Piping system

The maximum permissible large-surface reduction of piping thickness shall not exceed the values of corrosion allowance defined in Pt C, Ch 1, Sec 10, [2.4.4].

2.5 Agreement of firms for in-water survey

2.5.1 The in-water surveys referred to in the Rules are to be carried out by a certified company accepted by the Society.

Note 1: Rule Note NR533 Approval of Service Suppliers gives details about the certification.

2.6 Preparations and conditions for surveys

2.6.1 Surveys required for maintenance of class, e.g. in the case of repairs of, or modifications to any parts subject to classification, are to be agreed with the Society's head office or the local Society representations in due time, so that the measures envisaged may be assessed and supervised as required.

2.6.2 The Surveyors are to be given access at any time to the vessel and/or to the workshops, so that they may perform their duties. The Owner is to provide the necessary facilities for the safe execution of the surveys.

For their internal examination, tanks and spaces are to be safe for access, i.e. cleared, cleaned, gas freed, ventilated, etc.

For survey of the vessel's internal structure including close up survey, means are to be provided to enable the Surveyor to examine the structure in a safe and practical way.

Tanks and spaces are to be sufficiently illuminated, clean and free from water, scale, dirt, oil residues, etc. to reveal significant corrosion, deformation, fractures, damage or other structural deterioration.

Adapted rescue and safety equipment is to be available.

In this connection all areas to be surveyed have to be cleared, cleaned and are to be made gas-free, as deemed necessary by the Surveyor.

The class certificate and other documents related to classification and carried on board are to be made available to the Surveyor.

2.6.3 When examination of solid ballast spaces are required, the solid ballast is to be partially removed for examination of the condition of the structure in way. Should doubts arise, the Surveyor may require more extensive removal of solid ballast.

2.6.4 The Society will inform the Owner about the status of class, indicating the last recognized surveys and the next due dates. However in principle it remains the responsibility of the Owner to comply with the class conditions and to observe the dates for the prescribed surveys.

2.6.5 Upon request the Society may agree to testing, monitoring and analysis procedures as a supplement to or equivalent substitute for conventional survey methods.

2.6.6 The Society reserves the right to extend the scope of a survey and/or inspection for given reasons, e.g. in case of suspected damage or other negative experience gained, possibly on board of similar vessels or vessels with similar components.

Likewise, the Society reserves the right to demand surveys to be held between the due dates of regular periodical surveys.

2.7 Equipment for surveys

2.7.1 One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

- radiographic equipment
- ultrasonic equipment
- magnetic particle equipment
- dye penetrant.

2.8 Selection of Surveyors

2.8.1 On principle, the acting Surveyors will be chosen by the Society. However, the Owner is free to have any findings of surveys and decisions resulting there from, which deem to be doubtful, checked by other Society's Surveyors upon special request to head office.

2.9 External service suppliers

2.9.1 Personnel or firms engaged in services affecting classification and statutory work are subject to approval by the Society.

The inspection, measuring and test equipment used in workshops, Building Yards and on board vessels, which may form the basis for Surveyor's decisions affecting classification or statutory work, shall be appropriate for the services to be performed. The firms shall individually identify and calibrate each unit of such equipment to a recognized national or international standard.

2.10 Repairs

2.10.1 Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the vessel's structural, watertight or weathertight integrity, is to be promptly and thoroughly (see [2.2.14]) repaired.

Areas to be considered include, as applicable for the different vessel types:

- side structure and side plating; side shell frames, their end attachments and adjacent shell plating; inner side structure and inner side plating

- deck structure and deck plating
- bottom structure and bottom plating; inner bottom structure and inner bottom plating
- longitudinal bulkheads structure and longitudinal bulkheads plating, where fitted
- watertight or oiltight bulkheads structure and plating
- hatch covers or hatch coamings, where fitted
- weld connection between air pipes and deck plating
- air pipe heads installed on the exposed decks
- ventilators, including closing devices, if any; bunker and vent piping systems.

2.10.2 For locations where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage.

2.10.3 Additionally, when a survey results in the identification of structural defects or corrosion, either of which, in the opinion of the Surveyor, will impair the vessel's fitness for continued service, remedial measures are to be implemented before the vessel continues in service.

2.10.4 Where the damage found on structure mentioned in [2.10.1] is isolated and of a localised nature which does not affect the vessel's structural integrity, consideration may be given by the Surveyor to allow an appropriate temporary repair to restore watertight or weathertight integrity and impose a condition of class in accordance with the Rules, with a specific time limit.

3 Certificate of Classification: issue, validity, endorsement and renewal

3.1 Issue of Certificate of Classification

3.1.1 A Certificate of Classification, bearing the class notations assigned to the vessel and an expiry date, is issued to any classed vessel.

3.1.2 A Provisional Certificate of Classification may serve as a Certificate of Classification in some cases, such as after an admission to class survey, after a class renewal survey, or when the Society deems it necessary.

The period of validity for the Provisional Certificate of Classification is not to exceed 6 months from the date of issuance.

3.1.3 The Certificate of Classification is to be made available to the Society's Surveyors upon request.

3.2 Validity of Certificate of Classification, maintenance of class

3.2.1 According to Ch 1, Sec 1, [2.5], the Society alone is qualified to confirm the class of the vessel and the validity of its Certificate of Classification.

3.2.2 During the class period, a Certificate of Classification is valid when it is not expired.

The class is maintained during a certain period or at a given date, when during the said period or at such date the conditions for suspension or withdrawal of class are not met.

Refer also to Ch 1, Sec 1, [1.4.4].

3.2.3 At the request of the Owner, a statement confirming the maintenance of class may be issued by the Society based on the information in its records for that vessel at the time.

This statement is issued on the assumption that the Owner has complied with the Rules, in particular with [6].

Should any information which would have prevented the Society from issuing the statement and which was not available at the time subsequently come to light, the statement may be cancelled.

Attention is drawn to Ch 2, Sec 3, [2], whereby the Society, upon becoming aware of a breach of the Rules, is empowered to suspend class from the date of the breach, which may be prior to the date of the statement.

3.2.4 According to the same conditions as in [3.2.3], a statement declaring that the class is maintained "clean and free from condition of class" may be issued by the Society when there is no pending condition of class at that date.

3.2.5 Classification-related documents and information are liable to be invalidated by the Society whenever their object is found to differ from that on which they were based or to be contrary to the applicable requirements. The Owner is liable for any damage which may be caused to any third party from improper use of such documents and information.

3.3 Endorsement of Certificate of Classification

3.3.1 Text of endorsement

When surveys are satisfactorily carried out, the Certificate of Classification is generally endorsed accordingly, with the relevant entries.

3.3.2 Possible modifications to endorsements

The Society reserves the right to modify the endorsements made by Surveyors.

3.4 Status of surveys and conditions of class

3.4.1 Information given in the Certificate of Classification, vessel survey status, Rules and other vessel specific documents made available to the Owner, enables the Owner to identify the status of surveys and conditions of class.

3.4.2 The omission of such information does not absolve the Owner from ensuring that surveys are held by the limit dates and pending conditions of class are cleared to avoid any inconvenience which is liable to result from the suspension or withdrawal of class; see Ch 2, Sec 3.

4 Class renewal survey

4.1 General principles

4.1.1 Class renewal survey - also called special survey - is to be carried out at the intervals **p** indicated by the character of class period.

4.1.2 In principle elements covered by the classification and submitted to a class renewal survey on a date different from the date of the periodical class renewal survey of the vessel, are to be re-examined **p** years after the previous survey.

4.1.3 Upon request, extension of the class period may be granted by the Society, see [6.2].

4.1.4 Class renewals for hull are numbered in the sequence I, II, III, etc., depending upon the age of the vessel, in years, at time of class renewal survey:

I	:	Age ≤ 5
II	:	5 < Age ≤ 10
III	:	10 < Age ≤ 15
IV	:	15 < Age

Regarding their scope, see Ch 3, Sec 3, [2].

4.1.5 A class renewal survey may be carried out in several parts. The survey may be commenced at the last year during the class period. Considering [4.1.3], the total survey period of the class renewal survey must not exceed 12 months, except under special circumstances and by prior agreement from the Society.

4.1.6 The new period of class will commence:

- with the following day, after which the previous class expires, provided that the class renewal survey has been completed within the 3 months preceding that date. In case of extension of validity of class certificate, the period of class will commence the following day after which the last classification certificate has expired.
- with the date on which the class renewal survey has been completed, if this is the case more than 3 months before expiry of the previous class.

4.1.7 The class renewal survey is in principle to be held, in addition to the inspections and checks to be carried out on occasion of the intermediate surveys, when the vessel is in dry dock or on a slipway unless a dry docking survey has already been carried out within the admissible period, see [4.1.5] and Ch 3, Sec 5.

5 Other periodical surveys

5.1 General

5.1.1 The different types of periodical surveys are summarised in Tab 1.

5.2 Annual surveys

5.2.1 Where required, annual surveys are to be carried out within three months before or after each anniversary date.

5.2.2 The Society may require a vessel to be submitted to an annual survey, depending on:

- its service notation
- its range of navigation and frequency of operations in restricted maritime stretches of water or lakes, and
- its age.

As a rule, annual survey is required when the vessel is granted with a range of navigation **IN(1,2 < x ≤ 2)** or operated more than 40% of the time in salt waters.

5.3 Intermediate surveys

5.3.1 The intermediate survey falls due at half the nominal time interval between two class renewal Surveys, i.e. every **p**/2 years.

The survey has to be carried out within a time interval of 6 months before to 6 months after the date corresponding to **p**/2.

5.4 Bottom survey

5.4.1 Bottom survey means the examination of the outside of the vessel's bottom and related items. This examination may be carried out with the vessel either in dry dock (or on a slipway) or afloat: in the former case the survey will be referred to as dry-docking survey, while in the latter case as in-water survey.

5.4.2 The Owner is to notify the Society whenever the outside of the vessel's bottom and related items can be examined in dry dock or on a slipway.

5.5 Survey of propeller shafts, propellers and other propulsion systems

5.5.1 General

For maintenance of class, periodical surveys and tests of propeller shafts, propellers as well as other propulsion systems of the vessels are to be carried out.

5.5.2 Propeller shaft normal survey

The propeller shaft normal survey is a complete propeller shaft survey whose scope is given in Ch 3, Sec 4, [1].

Where the propeller shaft is:

- fitted with continuous liners, or
- protected against corrosion, or
- mechanically grease-lubricated, or
- fitted with approved oil sealing glands, or
- made of corrosion-resistant material, or
- of increased corrosion allowance to the Society satisfaction,

the interval of survey is to be **p** years, possibly in connection with the dry dock survey, in any of the following three cases:

- the propeller is fitted to a keyed shaft taper the design details of which comply with the applicable requirements in Pt C, Ch 1, Sec 7, and a non-destructive examination of the after end of the cylindrical part of the shaft (from the after end of the liner, if any), and of about one third of the length of the taper from the large end is performed at each survey by an approved crack-detection method
- the propeller is fitted keyless to the shaft taper, the shaft is protected from river water, the design details are approved, and a non-destructive examination of the forward part of the aft shaft taper is performed at each survey by an approved crack-detection method
- the propeller is fitted to a solid flange coupling at the aft end of the shaft, the shaft and its fittings are not exposed to corrosion, the design details are approved. Non-destructive examination of the fillet radius of the aft propeller shaft flange may be required if the visual examination of the area is not satisfactory.

Propeller shafts and tube shafts are to be sufficiently drawn to permit entire examination.

For oil lubricated arrangement, the shaft need not be drawn at the occasion of the normal survey, provided that all exposed areas of the after shaft area are examined by an approved crack-detection method and:

- the clearances and wear down of the bearings
- the records of lubricating oil analysis, oil consumption
- the visible shaft areas,

are found satisfactory.

Periodicity of propeller shaft normal survey is summarized in Fig 1.

5.5.3 Propeller shaft modified survey

A modified survey of the propeller shaft is an alternate way of examination whose scope is given in Ch 3, Sec 4, [2]. It may be accepted for propeller shafts described in [5.5.2] provided that:

- they are fitted with oil lubricated bearings and approved oil sealing glands, or they are mechanically grease-lubricated
- the shaft and its fittings are not exposed to corrosion
- the design details are approved
- the clearances of the aft bearing are found to be in order
- the oil and the oil sealing arrangements prove effective
- lubricating oil analyses are carried out regularly at intervals not exceeding six months and oil consumption is recorded at the same intervals.

The modified survey is to be carried out at interval of **p** years from the last normal survey with a window period of plus or minus six months.

The next normal survey is to be carried out 2 **p** years from the last normal survey.

Periodicity of propeller shaft modified survey is summarized in Fig 1.

5.5.4 Propellers

During normal or modified surveys of the propeller shafts, the propellers as well as the remote and local control gear of controllable pitch propellers are to be surveyed at the Surveyor's discretion, depending on the findings.

5.5.5 Other propulsion systems

Other propulsion systems such as rudder and steering propellers, pod propulsion systems, pump jet units, etc., are submitted to periodical surveys at intervals not exceeding **p** years.

5.6 Pressure equipment survey

5.6.1 Boiler survey

There are to be two internal examinations of boilers in each period of class of five years.

In all cases, the interval between any two such examinations is not to exceed 36 months.

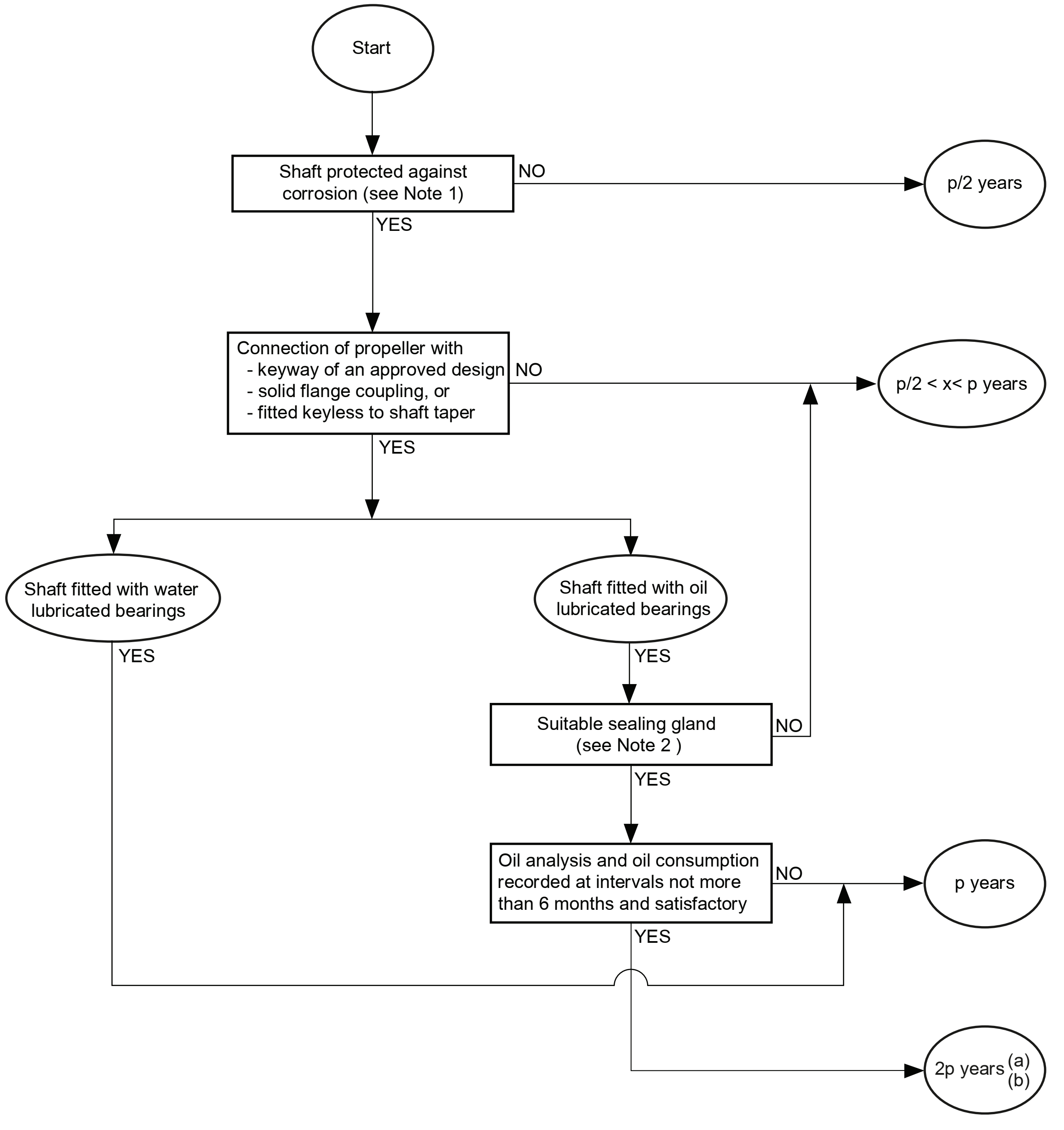
5.6.2 Thermal oil heater survey

There is to be one internal examination of thermal oil heaters in each period of class of five years.

5.7 Links between anniversary dates and intermediate surveys and class renewal surveys

5.7.1 The link between the anniversary dates, the class renewal survey (when carried out according to the normal system), and the intermediate surveys is given in Fig 2, considering class period **p** = 5.

Figure 1 : Periodicity of propeller shaft survey



(a): with shaft withdrawn, subject to modified survey at p years plus or minus 6 months.

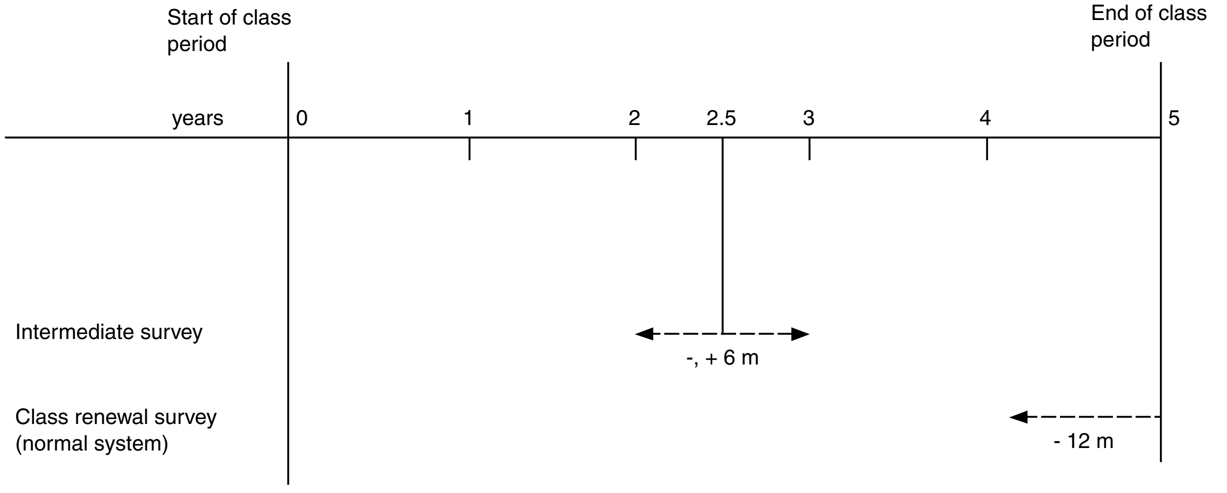
(b): the periodicity cannot exceed the maximum recommended by the designer and manufacturer of the propeller shaft and bearing system.

Note 1: Shafts protected against corrosion are those:

- made of corrosion resistant material, or
- fitted with continuous liners or systems considered as equivalent, or
- fitted with oil lubricated bearings and oil sealing glands

Note 2: Suitable sealing glands are glands which are type-approved by the Society with regard to protection of the sterntube against ingress of water.

Figure 2 : Links between anniversary dates and intermediate surveys and class renewal surveys



6 Occasional surveys

6.1 General

6.1.1 An occasional survey is any survey which is not a periodical survey. The survey may be defined as an occasional survey of hull, machinery, boilers, refrigerating plants, etc., depending on the part of the vessel concerned.

Where defects are found, the Surveyor may extend the scope of the survey as deemed necessary.

6.1.2 Occasional surveys are carried out at the time of, for example:

- updating of classification documents, e.g. change of the Owner, name of the vessel, flag
- damage or suspected damage
- repair or replacement work
- alterations or conversion
- quality system audits
- postponement of surveys or of conditions of class.

6.2 Class extension surveys

6.2.1 On Owner's special request and following surveys of hull and machinery including shaft arrangement afloat, the Society may extend the class by no more than 12 months in total, provided that the surveys in the scope of an intermediate survey at least, show that hull and machinery including electrical installations are in unobjectionable condition.

The class extension surveys are to be performed within one month before of the certificate of classification.

6.3 Damage and repair surveys

6.3.1 Damage and repair surveys fall due whenever the vessel's hull and machinery, including electrical installations, as well as special equipment and installations covered by the classification have suffered a damage which might affect validity of class, or if damage may be assumed to have occurred as a consequence of an average or some other unusual event, see also [10.1.2].

6.3.2 Where damage has occurred to the vessel's hull, machinery including electrical installations or special equipment and installations, the automatic/remote-control systems, etc., the damaged parts are to be made accessible for inspection in such a way that the kind and extent of the damage can be thoroughly examined and ascertained, see also [10.1.2].

In the case of grounding, dry docking, see Ch 3, Sec 5, [2] or, alternatively, in-water survey, see Ch 3, Sec 5, [3], is required.

6.3.3 The repair measures are to be agreed with the Surveyor such as to render possible confirmation of the class without reservations upon completion of the repairs. In general, a class confirmation with conditions of class, e.g. in the case of a preliminary repair ("emergency repair"), requires to be approved by the Society's head office or Society's representative.

6.3.4 Surveys conducted in the course of repairs are to be based on the latest experience and instructions by the Society. In exceptional cases advice is to be obtained from the Society's head office or Society's representative, in particular where doubts exist as to the cause of damage.

6.3.5 For older vessels, in the case of repairs and/or replacement of parts subject to classification, as a matter of principle, the construction Rules in force during their period of construction continue to be applicable.

This does not apply in the case of modifications required to the structure in the light of new knowledge gained from damage analyses, with a view to avoiding recurrence of similar damages.

6.3.6 Regarding the materials employed and certificates required, the requirements for newbuildings are applicable. See [10.2].

6.3.7 Regarding corrosion damages or excessive wastage beyond allowable limits that affect the vessel's class, see Ch 2, App 1.

6.4 Conversion surveys

6.4.1 In case of conversion and/or major changes of the vessel's hull, machinery, as well as special equipment and installations with effect to the class designation including notations, the Society's approval is to be requested as in the case of newbuildings and surveys are to be carried out, as described in [10.2].

A new or amended class designation will be assigned, where necessary.

6.5 Quality system audits

6.5.1 The Society reserves the right to require extraordinary surveys to be held independently of any regular surveys. Such surveys may become necessary for examining the vessel's technical condition and are understood to be a part of Society's quality assurance system.

6.6 Survey for towage or voyage over sea

6.6.1 In compliance with the provisions of the General Conditions, a certificate regarding towage or voyage over sea may be issued upon satisfactory survey the scope of which is fixed in each particular case by the Society according to the towing or voyage over sea.

7 Surveys in accordance with flag state Regulations

7.1 General

7.1.1 All activities outlined in [7.2] and, where applicable, issuance of relevant certificates/attestations are likewise subject to the respective latest edition of Society's General Conditions.

7.2 Society's intervention

7.2.1 Where surveys are requested by the Owner on account of international conventions and/or of corresponding laws and Regulations of a flag state, the Society will carry them out by order or within the framework of official order, acting on behalf of the Authorities concerned, based on the respective provisions. This includes surveys according to e.g. ADN Regulations, European Directive, etc.

Where possible, such surveys will be carried out simultaneously with the class surveys.

8 Surveys relative to classification notations from other Rules of the Society

8.1 General

8.1.1 The surveys requested for granting of classification notations defined in other Rules of the Society have to be performed according to corresponding requirements for maintenance of class.

9 Change of ownership

9.1

9.1.1 In the case of change of ownership, the vessel retains its current class with the Society, provided that:

- the Society is informed of the change in due time and able to carry out any survey deemed appropriate, and
- the new Owner expressively requests to keep the current class, involving acceptance of the Society's General Conditions and Rules. This request covers inter alia the condition of the vessel when changing ownership.

9.1.2 The vessel's class is maintained without prejudice to those provisions in the Rules which are to be enforced in cases likely to cause suspension or withdrawal of the class such as particular damages or repairs to the vessel of which the Society has not been advised by the former or, as the case may be, new Owner.

10 Validity of class

10.1 General

10.1.1 The class continues to be valid, provided that the hull, machinery as well as special equipment and installations classed are subject to all surveys stipulated, see Part A, Chapter 3 and that any repairs required as a consequence of such a survey are carried out to the satisfaction of the Society.

If some special equipment classed is not subjected to the prescribed surveys or is no longer intended to be carried on board, the notation for that equipment only will be suspended or withdrawn.

10.1.2 The Society's head office or one of its representations are to be immediately informed about any average, damage or deficiency to the hull, machinery or equipment classed, where these may be of relevance to the vessel's class and safety. A survey will have to be arranged immediately.

If the survey reveals that the vessel's class has been affected, it will be maintained only on condition that the repairs or modifications demanded by the Society are carried out within the period and under the operating conditions specified by the Surveyor. Until full settlement of these demands the class will be restricted.

10.1.3 Any damage or excessive wastage beyond allowable limits to side shell frames, their end attachments and/or adjacent shell plating, the deck structure and deck plating, the bottom structure and bottom plating, the watertight or oiltight bulkheads and the hatch covers or coamings that affect a vessel's class, is to be permanently repaired immediately.

For locations where adequate repair facilities are not available, consideration may be given to allow a vessel to proceed directly to a Repair Yard. This may require temporary repairs for the intended voyage.

Damages or excessive wastage at the areas noted above and not immediately affecting the vessel's structural or watertight/weathertight integrity may be temporarily repaired for a period to be defined.

10.1.4 Where defects are found further to an inspection by an Administration in pursuance of Port State Control or similar programs, Owners are to:

- immediately report the outcome of this inspection to the Society, and
- ask the Society to perform a survey in order to verify the deficiencies, when related to the class of the vessel.

10.1.5 Apart from the class certificate, any other documentation of significance for classification, such as:

- reports on surveys previously performed
- maintenance schedules to be observed by vessel owner, as agreed with the Society
- reviewed drawings and other documentation handed out to the vessel owner and containing particulars or instructions of significance in respect of the classification requirements, e.g. use of special steel grades,

is to be kept on board and made available to the Surveyor on request.

10.1.6 Systems for special use may be exempted from classification. However, any changes in such systems that may affect the safety of operations and hence validity of the vessel's class, including its classified installations, shall be notified to the Society in due course. This applies particularly to cases, where system changes lead to structural conversions or important changes in the machinery and electrical installation.

10.1.7 The Society provides a notification system to remind the vessel owner of surveys becoming due, or of any other matters of interest or urgency in connection with the classification of the vessel. However, it remains the responsibility of the vessel Owner to comply with the class conditions and to observe the dates for the prescribed surveys.

10.2 Repairs, conversions

10.2.1 Where parts or components are damaged or worn to such an extent that they no longer comply with the class requirements, they are to be repaired or replaced. The damaged parts shall be made accessible for inspection so that the kind and extent of the damage can be thoroughly examined.

During repairs or maintenance work, the Owner has to arrange so that any damage, defects or non-compliance with the rule requirements are reported to the Surveyor during his survey.

10.2.2 Repairs and conversions of the vessel's hull, machinery as well as special equipment and installations classed have to be carried out under the supervision of the Society to ensure compliance with the Rules and continued validity of class. The repair measures are to be agreed with the Surveyor such as to render possible confirmation of the class, without reservations and conditions of class, upon completion of the repairs.

Where necessary, documentation is to be submitted to the Society and/or made available to the attending Surveyor.

Generally, a confirmation of class with conditions of class, e.g. in case of temporary repairs, requires to be approved by the Society's head office.

10.2.3 The areas affected by repairs or conversion shall be treated in the same way as for new buildings. However, experience and technical knowledge gathered since the vessel was built shall be taken into account.

Materials and equipment used for conversions, alterations or repairs are generally to meet the requirements of the Rules for new vessels built under survey; see Ch 2, Sec 4.

10.2.4 If, following major conversions, new classification notations are assigned so that the class certificate has to be reissued, commencement of a new period of class may be agreed upon.

11 Lay-up and recommissioning

11.1 General principles

11.1.1 The period of class of hull and machinery will not be interrupted throughout the lay-up period. This means that periodical and non-periodical surveys will have to be carried out as before; surveys due, for which dry-docking is required, may be postponed until recommissioning.

11.1.2 Upon expiry of the class, a survey substituting the class renewal survey will have to be performed. When the lay-up survey is applied, this is indicated in the Certificate of Classification and the notation **Laid-up** is entered in the Register.

11.1.3 A vessel put out of commission may be subject to specific requirements for maintenance of class, as specified below, provided that the Owner notifies the Society of the fact.

If the Owner does not notify the Society of the lay-up of the vessel or does not implement the lay-up maintenance program, the vessel's class will be suspended and/or withdrawn when the due surveys are not carried out by their limit dates in accordance with the applicable requirements given in Ch 2, Sec 3.

11.1.4 The lay-up maintenance program provides for a “lay-up survey” to be performed at the beginning of lay-up and subsequent “lay-up condition surveys” which are required to be carried out as long as the vessel remains laid-up. The minimum content of the lay-up maintenance program as well as the scope of these surveys are given in Ch 3, App 1. The other periodical surveys which become overdue during the lay-up period may be postponed until the recommissioning of the vessel.

11.1.5 Where the vessel has an approved lay-up maintenance program and its period of class expires, the period of class is extended until it is recommissioned, subject to the satisfactory completion of the lay-up condition surveys as described in [11.1.4].

11.1.6 The periodical surveys carried out during the lay-up period may be credited, either wholly or in part, at the discretion of the Society, having particular regard to their extent and dates. These surveys will be taken into account for the determination of the extent of surveys required for the recommissioning of the vessel and/or the expiry dates of the next periodical surveys of the same type.

11.1.7 When a vessel is recommissioned, the Owner is to notify the Society and make provisions for the vessel to be submitted to the following surveys:

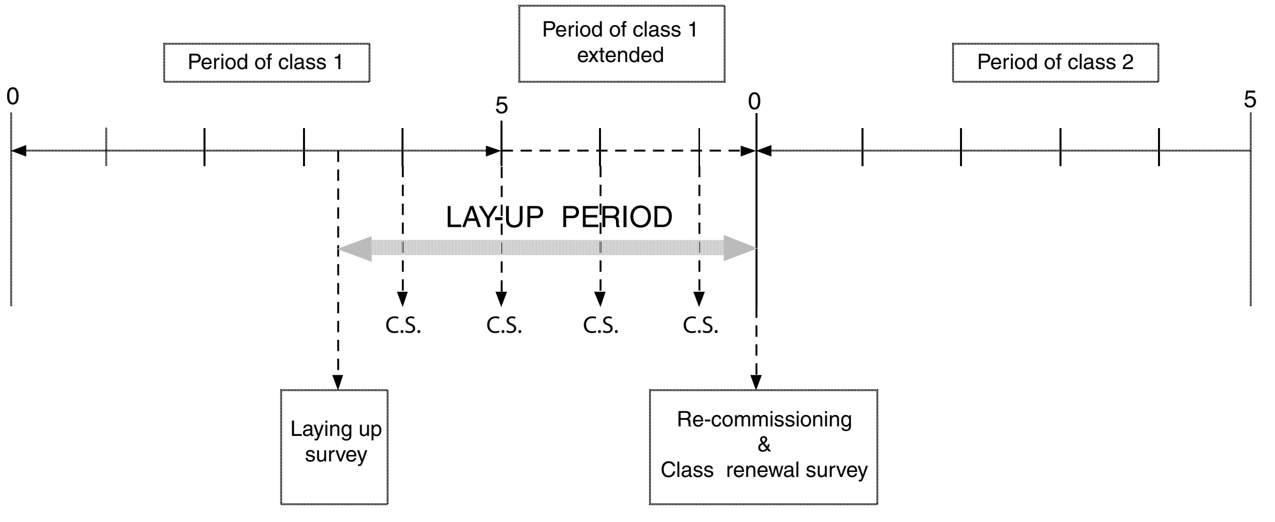
- an occasional survey prior to recommissioning, the scope of which depends on the duration of the lay-up period
- all periodical surveys which have been postponed in accordance with [11.1.2], taking into account the provisions of [11.1.4].

11.1.8 Where the previous period of class expired before the recommissioning and was extended as stated in [11.1.5], in addition to the provisions of [11.1.4] a complete class renewal survey is to be carried out prior to recommissioning. Items which have been surveyed in compliance with the class renewal survey requirements during the 12 months preceding the recommissioning may be credited. A new period of class is assigned from the completion of the class renewal survey.

11.1.9 The principles of intervals or limit dates for surveys to be carried out during the lay-up period, as stated in [11.1.1] to [11.1.7], are summarised in Fig 3. The interval between successive lay-up condition surveys are to be agreed with the Society.

11.1.10 The scope of the laying-up survey and lay-up condition surveys are described in detail in Ch 3, App 1.

Figure 3 : Survey scheme of a case of a lay-up going beyond the expiry date of the period of class



Note 1: C. S. means lay-up condition survey.

SECTION 3 SUSPENSION AND WITHDRAWAL OF CLASS

1 Discontinuance of class

1.1 General

1.1.1 The class may be discontinued either temporarily or permanently. In the former case it is referred to as "suspension" of class, in the latter case as "withdrawal" of class. In both these cases, the class is invalidated in all respects.

If, for some reason, the class has expired or has been withdrawn or suspended by the Society, this fact may be indicated in the Register.

1.1.2 If the vessel Owner is not interested in maintenance of class of the vessel or any of its special equipment and installations classed, or if conditions are to be expected under which it will be difficult to maintain class, the Society will have to be informed accordingly. The Society will decide whether the certificate will have to be returned and class suspended or withdrawn. Where only special equipment and installations are concerned, the corresponding notation will be withdrawn and the certificate amended accordingly.

1.1.3 Class may also be suspended if a vessel is withdrawn from active service for a longer period.

2 Suspension of class

2.1 General

2.1.1 The class may be suspended either automatically or following the decision of the Society. In any event, the vessel will be considered as not retaining its class from the date of suspension until the date when class is reinstated.

2.1.2 The class may be automatically suspended when one or more of the following circumstances occur:

- when a vessel is not operated in compliance with the rule requirements, such as in cases of services or conditions not covered by the service notation, or trade outside the navigation restrictions for which the class was assigned
- when a vessel proceeds with less freeboard than that assigned, or has the freeboard marks placed on the sides in a position higher than that assigned, or, in cases of vessels where freeboards are not assigned, the draught is greater than that assigned
- when the Owner fails to inform the Society in order to submit the vessel to a survey after defects or damages affecting the class have been detected
- when repairs, alterations or conversions affecting the class are carried out either without requesting the attendance of the Society or not to the satisfaction of the Surveyor.

Suspension of class with respect to the above cases will remain in effect until such time as the cause giving rise to suspension has been removed. Moreover, the Society may require any additional surveys deemed necessary taking into account the condition of the vessel and the cause of the suspension.

2.1.3 In addition, the class is automatically suspended:

- when the class renewal survey has not been completed by its limit date or within the time granted for the completion of the survey, unless the vessel is under attendance by the Society's Surveyors with a view to completion prior to resuming trading
- when the annual survey, if relevant, or the intermediate survey has not been completed by the end of the corresponding survey time window.

Suspension of class with respect to the above cases will remain in effect until such time as the class is reinstated once the due items and/or surveys have been dealt with.

2.1.4 In addition to the circumstances for which automatic suspension may apply, the class of a vessel may also be suspended following the decision of the Society:

- when a condition of class is not dealt with within the time limit specified, unless it is postponed before the limit date by agreement with the Society
- when one or more surveys are not held by their limit dates or the dates stipulated by the Society also taking into account any extensions granted in accordance with the provisions of Ch 1, Sec 2, [4]
- when, due to reported defects, the Society considers that a vessel is not entitled to retain its class even on a temporary basis, pending necessary repairs or renewals, etc
- in other circumstances which the Society will consider on their merits, e.g. in the event of non-payment of fees or when the Owner fails to render the vessel available for the occasional surveys as listed in Ch 2, Sec 2, [6.1.2].

2.1.5 Suspension of class decided by the Society takes effect from the date when the conditions for suspension of class are met and will remain in effect until such time as the class is reinstated once the due items and/or surveys have been dealt with.

3 Withdrawal of class

3.1 General

3.1.1 The Society will withdraw the class of a vessel in the following cases:

- at the request of the Owner
- when the causes that have given rise to a suspension currently in effect have not been removed within six months after due notification of suspension to the Owner
- when the vessel is reported as a constructive total loss
- when the vessel is lost
- when the vessel is reported scrapped.

Withdrawal of class takes effect from the date on which the circumstances causing such withdrawal occur.

3.1.2 When the withdrawal of class of a vessel comes into effect, the Society will:

- forward the Owner written notice
- delete the vessel from the Register Book
- notify the flag Administration, if needed
- make the information available to the Underwriters, at their request.

4 Suspension/withdrawal of additional class notations

4.1 General

4.1.1 If the survey requirements related to maintenance of additional class notations are not complied with, the suspension or withdrawal may be limited to the notations concerned.

The same procedure may apply to service notations of vessels which are assigned with more than one service notation.

4.1.2 The suspension or withdrawal of an additional class notation or a service notation (where a vessel is assigned with more than one service notation) generally does not affect the class.

SECTION 4 CLASSIFICATION PROCEDURES

1 Classification of new building

1.1 Order for classification

1.1.1 The written order for classification is to be submitted to the Society by the Building Yard, the Other Interested Party or by the Prospective vessel Owner, using the form provided by the Society. It should be clearly agreed between the parties concerned, e.g. in the building contract, which party will be responsible for compliance with the Society's Rules and Guidelines and other Rules and Regulations to be applied.

1.1.2 Where orders for the production of components are placed with subcontractors, the Society will have to be advised accordingly indicating the scope of the subcontract. The Building Yard, Prospective Owner and Other Interested Party are responsible for observance of the Rules, Guidelines and Regulations by subcontractors.

1.1.3 When particulars already approved by the Society for previous vessels built under supervision of the Society are incorporated in the design of the new building, this should be specifically stated in the order for classification. Amendments to the construction Rules having been introduced meanwhile shall be taken into account.

1.2 Examination of design and construction particulars

1.2.1 Particulars/documents for review such as construction plans, calculations, details on materials, type designation of standard equipment, etc. are to be submitted to the Society, in English or other language agreed upon with the Society in due time prior to commencement of construction/manufacturing.

The particulars submitted shall contain all details required to verify compliance with the construction Rules. The Society reserves the right to request additional information and particulars to be submitted, according to the specific nature of the vessel to be classed.

Design calculations are to be provided, when called for, as supporting documents to the submitted plans.

1.2.2 After examination by the Society, the documents subject to review will be returned in one copy with a mark/stamp of review. One copy of each document, with remarks related to the compliance with the rule requirements should the need arise, will be forwarded for verification to the Society's inspection office(s) in charge of construction supervision.

1.2.3 Any deviations from the reviewed documents e.g. due to requirements of the vessel Owner or alterations suggested by the Building Yard, require to be approved by the Society prior to being realized.

1.3 Documentation

1.3.1 The design data, calculations and plans to be submitted for review are listed in applicable requirements of Part B, Part C and Part D.

1.3.2 The documentation submitted to the Society is examined in relation to the class requested in the order for classification.

1.3.3 Should the Other Interested Party, Building Yard or Prospective Owner subsequently wish to have the class, in particular the service notations or additional class notations, granted to the vessel modified, plans and drawings are generally to be re-examined.

1.3.4 As a rule, modifications of the reviewed plans regarding items covered by classification are to be submitted for review.

1.3.5 The plans and design data to be submitted to the Society are to incorporate all information necessary for the assessment of the design of the vessel for the purpose of assignment of class. It is the responsibility of the Other Interested Party, Building Yard or Prospective Owner to ascertain that the design data are correct, complete and compatible with the use of the vessel.

1.3.6 Design data and calculations are to be adequately referenced. It is the duty of the Other Interested Party, Building Yard or Prospective Owner to ascertain that the references used are correct, complete and applicable to the design of the vessel.

1.3.7 In the case of conflicting information, submitted documentation will be considered in the following order of precedence: design data, plans, design calculations.

1.3.8 It is the responsibility of the Other Interested Party, Building Yard or Prospective Owner to ascertain that drawings used for the procurement, construction and other works are in accordance with the reviewed plans.

1.4 Supervision of construction and trials

1.4.1 The Society will assess the production facilities and procedures of the Building Yard, subcontractors and other manufacturers, to determine whether they meet the requirements of the Society's Rules and any additional requirements of the Other Interested Party or Prospective vessel Owner as agreed in the building specification. This assessment may be connected with a quality assurance certification.

1.4.2 Materials, components, appliances and installations subject to inspection are to comply with the relevant rule requirements and are to be presented for inspection by the Society's Surveyors, unless otherwise provided as a result of special arrangements agreed upon with the Society.

It is the duty of the Building Yard, subcontractors and other manufacturers to inform the Society's inspection office in due time about particular surveys to be carried out.

1.4.3 In order to enable the Surveyor to fulfill his duties, he is to be given free access to the workshops and to the vessel. For performance of the tests required, the Building Yard, subcontractors and other manufacturers are to give the Surveyor any assistance necessary by providing the staff and the equipment needed for such tests which always remain under their full responsibility.

1.4.4 During the phase of construction of the vessel or installation, the Society will satisfy itself by surveys and inspections that:

- parts for hull, machinery and electrical installations or special equipment subject to review have been constructed in compliance with the reviewed drawings/documents
- all tests and trials stipulated by the Rules for classification and construction are performed satisfactorily
- workmanship is in compliance with current engineering standards and/or the Society's rule requirements
- welded parts are produced by qualified welders having undergone the tests required by the applicable Rules
- for hull sections or components requiring the Society's approval, certificates have been presented; the Building Yard, subcontractors or other manufacturers will have to ensure that any parts and materials requiring approval will only be delivered and installed, if the appropriate certificates have been issued
- type-tested or type-approved appliances and equipment are used, in accordance with the rule requirements, where individual certificates are not required.

1.5 Tests

1.5.1 As far as practicable, the machinery including electrical installations as well as special equipment and installations classed will be subjected to operational trials at the manufacturer's premises to the scope specified in the Rules.

Where the machinery, electrical installations or special equipment and installations are of novel design, the Society may require performance of trials under specified conditions.

1.6 Trials on board

1.6.1 Upon completion of the vessel, all hull, machinery including electrical installations as well as special equipment and installations classed will be subjected to operational trials in the presence of the Surveyor prior to and during the navigation trials. This will include, e.g.:

- tightness, operational and load tests of tanks, anchoring equipment, hatches and hatch covers, shell doors, ramps, etc.
- operational and/or load tests of the machinery, installations and equipment of importance for the operational safety of the vessel.

During a final survey, checks will be made in the presence of the Surveyor to ensure that any deficiencies found, for instance during the navigation trials, have been eliminated.

1.6.2 Reports, certificates, documentation

Satisfactory testing of materials, components, machinery, etc. at subcontractor's works will be certified by the Surveyor and/or the local Society's representation.

1.6.3 Upon satisfactory completion of the construction and the trials on board, the Surveyor will prepare construction and survey reports, on the basis of which the Society will issue the class certificate.

1.6.4 The classification data of each vessel will be included in the Society's data file. An extract of these vessel data will be indicated in the Register.

2 Classification after construction of existing vessels

2.1 Admission to class

2.1.1 Vessels not originally built under supervision of the Society may be classed subsequently following the procedures described in the following.

2.1.2 The vessel’s Owner should contact the Society for the necessary arrangements. The written order for admission to class of existing vessels or special equipment including the required documents shall be formally addressed to the Society's head office using the form provided by the Society.

2.1.3 In the case of transfer of class, the Society is to be informed about the previous class status and period, as well as about any conditions of class/recommendations imposed by the previous classification Society.

2.1.4 The documents listed in [2.1.5], updated to present status shall be submitted for examination where applicable. Information shall be provided about any additional Regulations to be observed.

2.1.5 Particulars for hull and machinery

- Particulars of the type and main dimensions of the vessel, building year, building yard, major conversions, if any, freeboard, stability documentation and details of the anchor equipment
- particulars of the type, output and main data, building year and manufacturer of the main engine(s) and of the auxiliary machinery essential for operational safety, the electrical installations, the automatic/remote-control system, the safety arrangements, the steering gear and the windlasses
- general arrangement, capacity plan, hydrostatic and cross curves, loading manual, where required, midship section, longitudinal and transverse sections, transverse bulkheads, decks, shell expansion, engine and boiler foundations, stem and stern frame, rudder and rudder stock, hatch covers
- machinery arrangement and layout, thrust, intermediate and screw shafts, propellers, main engines, propulsion gears and clutch systems, starting-air receivers, auxiliary boilers and related systems, cooling water and lubricating oil systems, bilge and ballast systems, fuel oil and starting-air systems, air and sounding pipe systems, electrical arrangements and wiring diagrams
- steering gear arrangement and piping system and steering gear manufacturer, make and model information
- pumping arrangements at the forward and after ends, drainage of cofferdams and pump rooms and general arrangements of cargo piping in tanks and on decks, for tankers
- torsional vibration calculations of the main shafting system including its branches for propelling installation less than two years old
- instrument and alarm list, fire alarm system, list of automatic safety functions, e.g. slowdowns, etc.
- plans required for vessels to which an additional class notation is assigned
- alternative technical data may be accepted by the Society in lieu of specific items of the listed documentation not available at the time of the transfer of class.

2.2 Examination of design and surveys

2.2.1 The requirements according to [1.2] are applicable in principle. The report on the survey according to [2.3] will be evaluated together with the examination of the particulars and/or drawings to be reviewed.

2.2.2 Where sufficiently detailed documentation required for review is not available, the necessary information may have to be gathered by an additional survey, possibly including measurements, and/or by additional investigations, computations, etc.

2.2.3 If the vessels as well as the special equipment and installations classed have the valid class of another classification Society, and if sufficient proof has been furnished regarding the present class status, the Society may dispense with parts of the examination of drawings and computations and may reduce the scope of the survey. However, at least a survey to the scope of an intermediate survey according to Part A, Chapter 3 is to be carried out.

2.3 Reports, certificates, documentation

2.3.1 Upon satisfactory completion of the examinations and surveys mentioned above, a class certificate will be issued and a class period defined.

2.3.2 Regarding Surveyor's reports and certificates, the provisions of [1.4] apply also to the classification of existing vessels.

2.3.3 Once a vessel and the relevant equipment have been classed with the Society, the Rules in force for surveys as well as procedures applicable to vessels constructed under supervision of the Society will apply.

3 Documentation to be carried on board

3.1 General

3.1.1 To allow quick action in case of surveys, special operation and especially in case of damage, the following documentation must be kept on board and shall be made available to the Surveyor on request:

- class certificate - all survey statements and reports
- stability handbook and loading manual, if required
- description of corrosion protection system, if required
- "as built'' drawings and other documentation containing particulars or instructions of significance as far as the Society is concerned, e.g. use of special steel etc.
- list of important testing/monitoring procedures to be followed in connection with validity of class.

SECTION 5 HULL SURVEY FOR NEW CONSTRUCTION - STEEL AND ALUMINIUM ALLOYS

1 General

1.1

1.1.1 In this Section, the Building Yard is understood as acting directly or on behalf of the Party requesting classification.

1.1.2 When a hull construction is surveyed by the Society the Building Yard is to provide all appropriate evidence required by the Society that the hull is built in compliance with the rules and regulations, taking account of the relevant reviewed drawings.

2 Documentation to be available for the Surveyor during construction

2.1 General

2.1.1 During the construction, the Building Yard is to provide the Surveyors access to documentation required by the Society; this includes documentation retained by the Building Yard or other third parties.

2.1.2 The list of documents reviewed by the Society for the specific new construction are to be made available by the Building Yard in due time for the Society during the construction as follows:

a) plans and supporting documents required in Ch 2, Sec 4, [1.3]

b) examination and testing plans

c) NDE plans

d) welding consumable details

e) welding procedures specifications & welding procedures qualification records

f) welding plan or details

g) welder's qualification records

h) NDE operators qualification records.

2.1.3 As required, evidence of compliance with Ch 2, Sec 1, [2.3] is also to be made available by the Building Yard to the Surveyor whilst the construction process proceeds to prove that the material and equipment supplied to the vessel has been built or manufactured under survey relevant to the classification rules and delegated statutory requirements.

3 Vessel construction file

3.1 General

3.1.1 The Building Yard is to deliver documents for the vessel construction file. In the event that items have been provided by another Party such as the Owner and where separate arrangement have been made for document delivery which excludes the Building Yard, that Party has the responsibility.

3.1.2 The vessel construction file is to be placed on board the vessel by the Building Yard to facilitate operation, maintenance, survey and repair.

3.1.3 The vessel construction file is to include but not limited to:

- as-built structural drawings including scantling details, material details, and, as applicable, wastage allowances, location of butts and seams, cross section details and locations of all partial and full penetration welds, areas identified for close attention and rudders
- manuals required for classification and statutory requirements, e.g. loading and stability
- vessel structure access manual, as applicable
- copies of certificates of forgings and castings welded into the hull (refer to NR216 Materials and Welding)
- details of equipment forming part of the watertight and weathertight integrity of the vessel
- tank testing plan including details of the test requirements (refer to Pt B, Ch 8, Sec 4)
- corrosion protection specifications (refer to Pt B, Ch 8, Sec 1)
- details for the in-water survey, if applicable, information for divers, clearances measurements instructions etc., tank and compartment boundaries
- docking plan and details of all penetrations normally examined at drydocking.

4 Newbuilding survey planning

4.1 General

4.1.1 Prior to commencing any newbuilding project, the Building Yard is to discuss with the Society at a kick-off meeting the items of specific activities which are relevant to the shipbuilding functions listed in the kick-off meeting templates to be supplied by the Surveyor. The purpose of the meeting is to agree how the listed items are to be addressed. The meeting is to take into account the Building Yard construction facilities and vessel type and deal with sub-contractors if it is known that the Building Yard proposes to use them. This list is not exhaustive and can be modified to reflect the construction facilities or specific vessel type.

A record of the meeting is normally to be prepared and updated by the Building Yard, based upon the content of the kick-off meeting templates. The Building Yard is to agree to undertake ad hoc investigations during construction where areas of concern arise and to keep the Society advised of the progress of any investigation. Whenever an investigation is undertaken, the Building Yard is, in principle, to agree to suspend relevant construction activities if warranted by the severity of the problem.

4.1.2 The record of the meeting is normally to be updated by the Building Yard further to additional meeting and/or agreement with the Society as the construction process progresses in the light of changing circumstances, e.g. if the Building Yard chooses to use or change sub-contractors, or to incorporate any modification necessitated by changes in production or inspection methods, rules and regulations, structural modifications, or in the event where increased inspection requirements are deemed necessary as a result of a substantial non-conformance or otherwise.

4.1.3 Shipbuilding quality standards for hull structure during new construction are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with a recognized fabrication standard which has been accepted by the Society prior to the commencement of fabrication/construction. The work is to be carried out in accordance with these Rules and under survey of the Society.

5 Examination and test plan for newbuilding activities

5.1 General

5.1.1 The Building Yard is to provide to the Surveyor plans of the items which are intended to be examined and tested. These plans need not be submitted for approval and examination at the time of the kick-off meeting. They are to include:

- proposal for the examination of completed steelwork generally referred to as the block plan and are to include details of joining blocks together at the pre-erection and erection stages or at other relevant stages
- proposal for fit up examinations where necessary
- proposal for testing of the structure (leak and hydrostatic) as well as for all watertight and weathertight closing appliances
- proposal for non-destructive examination
- any other proposal specific to the vessel type or to the delegated statutory requirements.

5.1.2 The plans and any modification to them are to be submitted to the Surveyors in sufficient time to allow approval before the relevant construction phase commences. The Society is to require sample rates of NDE, proposal for steelwork survey, tank testing requirements, etc. if the actual construction process warrants it.

APPENDIX 1 REQUIREMENTS FOR THICKNESS MEASUREMENTS

1 General

1.1 General

1.1.1 Thickness measurements are a major part of surveys to be carried out for the maintenance of class, and the analysis of these measurements is a prominent factor in the determination and extent of the repairs and renewals of the vessel's structure.

This Appendix is intended to provide Owners, companies performing thickness measurements and the Society's Surveyors with a uniform means with a view to fulfilling Rule requirements for thickness measurements. In particular, it will enable all the above-mentioned parties to carry out:

- the planning and preparation
- the determination of extent and location, and
- the analysis,

of the thickness measurements in cooperation.

1.1.2 Objectives of thickness measurements

The corrosion and wear tolerances stipulate limits of wastage which are to be taken into account for reinforcements, repairs or renewals of hull structure. They are classified and determined by the Society, depending on the local conditions of the structural elements into:

- criteria on global and buckling strength
- criteria on local strength and pitting.

Each measured structural item is to be checked against these criteria, as far as applicable. When the criteria are not met, reinforcements, repairs and renewals are to be carried out as appropriate.

The thickness of structural elements is checked by measurements, in order to assess whether or not the values stipulated in the Rules are kept, taking into account the admissible corrosion tolerances. Unless severe corrosion has occurred owing to particular service conditions, thickness measurements will not be required until class renewal II.

Thickness measurements are to be carried out in accordance with recognized methods and by authorized personnel or companies.

NR533 Approval of Service Suppliers gives details about the authorisation.

Rust and contamination are to be removed from the components to be examined. The Surveyor is entitled to require check measurements or more detailed measurements to be performed in his presence. The thickness measurements are to be witnessed by the Surveyor on board to the extent necessary to control the process.

1.2 General requirements for thickness measurements

1.2.1 Main hull structural elements

As applicable, in class renewal II and all subsequent ones, the plate thickness of the main and essential longitudinal and transverse structural hull elements are to be checked by thickness measurements. The number of measurements depends on the vessel's maintenance condition and is left to the Surveyor's discretion. The minimum requirements for thickness measurements on the occasion of class renewal surveys are stated in [2.2], depending on the vessel's class renewal survey number. The number and locations of measurements are defined in [2.3].

1.2.2 Reduction of thickness measurements scope

The thickness measurements may be waived or their extent may be reduced in comparison with those stated in [2.2] after satisfactory examination, when structural elements in the considered area are found in good condition.

1.2.3 Extension of thickness measurement scope

The Surveyor may extend the scope of the thickness measurement as deemed necessary. This applies especially to areas with substantial corrosion. When thickness measurements indicate substantial corrosion, as defined in Ch 2, Sec 2, [2.2.7], the number of thickness measurements is to be increased to determine the extent of substantial corrosion.

1.2.4 Transverse sections

Transverse sections shall be chosen where largest corrosion rates are suspected to occur or are revealed by deck plating measurements.

1.2.5 Ballast tanks

If applicable, in the case of major corrosion damages, the structural elements of ballast tanks are to be checked by thickness measurements.

1.2.6 Substantial corrosion and suspect areas

Where special reasons exist, the Surveyor may demand thickness measurements to be carried out already on the occasion of class renewal I, also outside the area of 0,5 L amidships. The same applies in the case of conversion or repair of a vessel.

1.3 Hull surveys at class renewal surveys

1.3.1 Overall survey

Each class renewal survey is to include an overall survey of cargo tanks, cargo holds and all spaces. The extent of thickness measurements are given in [2.2]. For number and locations of measurements, see [2.3].

1.3.2 Close-up survey

A close-up survey may be required depending on the vessel age and/or condition.

2 Extent, number and location of measurements at class renewal survey

2.1 Scope of thickness measurements

2.1.1 The thickness measurements required by the Appendix consist of:

- systematic thickness measurements, i.e. measurements of different parts of the structure, in order to assess the overall and local strength of the vessel
- measurements of suspect areas as defined in Ch 2, Sec 2, [2.2.11]
- additional measurements on areas determined as affected by substantial corrosion as defined in Ch 2, Sec 2, [2.2.7]

2.2 Extent of thickness measurements

2.2.1 General

a) General requirements

Thickness measurements are to be carried out according to the procedure detailed in [1.2].

The extent of thickness measurements is detailed in [2.2.2], according to the vessel's type and age. The Surveyor may extend the thickness measurements as deemed necessary. When thickness measurements indicate substantial corrosion, the extent of thickness measurements is to be increased to determine areas of substantial corrosion in accordance with the requirements of Tab 1. These extended thickness measurements are to be carried out before the survey is credited as completed.

Thickness measurements locations are to be selected to provide the best representative sampling of areas likely to be most exposed to corrosion, considering cargo and ballast history and arrangement and condition of protective coatings.

Thickness measurements of internals may be specially considered by the Surveyor if the hard protective coating is in good condition.

When pitting is found on a plating and its intensity is 20% or more, thickness measurements are to be extended in order to determine the actual plate thickness out of the pits and the depth of the pits. Where the wastage is in the substantial corrosion range or the average depth of pitting is 1/3 or more of the actual plate thickness, the pitted plate is to be considered as a substantially corroded area.

b) Application of the requirements for thickness measurements.

Tab 2 provides interpretations for the application of the requirements for thickness measurements related to the locations and number of points to be measured.

2.2.2 Minimum requirements for thickness measurements

a) Tank vessels

The extent of thickness measurements at class renewal survey is given in Tab 3, depending on the vessel age at time of class renewal survey. For number and locations of thickness measurements, see [2.3.2], item a).

b) Cargo vessels

"Cargo vessel" applies to vessels intended to carry dry cargoes and covers the following type and service notations:

- Bulk cargo vessel
- Container vessel
- General cargo vessel, and
- RoRo cargo vessel.

The extent of thickness measurements at class renewal survey is given in Tab 4, depending on the vessel age at time of class renewal survey. For number and locations of thickness measurements, see [2.3].

c) Other vessels

The extent of thickness measurements at class renewal survey is given in Tab 5, depending on the vessel age at time of class renewal survey. For number and locations of thickness measurements, see [2.3], taking into account the vessel's specific particulars.

2.3 Number and locations of measurements

2.3.1 General

a) Scope

Considering the extent of thickness measurements as required in [2.2], the locations of the points to be measured are given in this Section for the most important items of the structure. Thus the number of points can be estimated.

Measurements are to be taken on both port and starboard sides of the selected transverse section or transverse bulkhead.

b) Definition

Cargo vessels include vessels assigned one of the following type and service notations:

- Bulk cargo vessel
- Container vessel
- General cargo vessel
- RoRo cargo vessel.

Table 1 : Guidance for additional thickness measurements in way of substantial corrosion areas

Structural member	Extent of measurements	Pattern of measurements
Plating	Suspect area and adjacent plates	5 point pattern over 1 square metre
Stiffeners	Suspect area	3 measurements each in line across web and flange

Table 2 : Interpretations of the requirements for the locations and number of points to be measured

<table>
<tr><td colspan="3">SYSTEMATIC MEASUREMENTS</td></tr>
<tr><td>ITEM</td><td>INTERPRETATION</td><td>FIGURE</td></tr>
<tr><td>Selected plates on deck, tank top, bottom, inner bottom and side.</td><td>“Selected” means at least a single point on one out of three plates, to be chosen on representative areas of average corrosion.</td><td>No figure</td></tr>
<tr><td>All deck, tank top, bottom, inner bottom and side plates.</td><td>At least two points on each plate to be taken either at each 1/4 extremity of plate or at representative areas of average corrosion.</td><td>No figure</td></tr>
<tr><td>Transverse section</td><td>Refer to the definition given in Ch 2, Sec 2, [2.2.5]
One point to be taken on each plate. Both web and flange to be measured on longitudinals, if applicable.</td><td>Fig 1 to Fig 4, for tank vessels
Fig 5 to Fig 8, for cargo vessels</td></tr>
<tr><td>Bulkheads</td><td>“Selected bulkheads” means at least 50% of the bulkheads.</td><td>Fig 9, for watertight bulkheads on double hull cargo vessels
Fig 10, for plane bulkheads
Fig 11, for corrugated bulkheads</td></tr>
<tr><td>Selected internal structure such as floors, longitudinals, transverse frames, web frames, deck beams and girders.</td><td>The internal structural items to be measured in each space internally surveyed are to be at least 20% within the cargo area and 10% outside the cargo area.</td><td>No figure</td></tr>
</table>

Table 3 : Minimum Requirements for thickness measurements - Tank vessels

<table>
<tr><td>Class renewal survey I</td><td>Class renewal survey II</td><td>Class renewal survey III</td><td>Class renewal survey IV and subsequent</td></tr>
<tr><td colspan="4">Suspect areas throughout the vessel</td></tr>
<tr><td rowspan="8"></td><td>Within the cargo area:
- one transverse section
- selected side / inner side plates
- selected bottom / inner bottom plates</td><td>Within the cargo area:
- two transverse sections
- all side / inner side plates
- selected bottom / inner bottom plates
- selected transverse and longitudinal cargo tank bulkhead (1)</td><td>Within the cargo area:
- three transverse sections
- all side / inner side plates
- all bottom / inner bottom plates
- all transverse and longitudinal cargo tank bulkheads (1)</td></tr>
<tr><td>Selected deck / trunk plates within the cargo area.</td><td>All deck /trunk plates within the cargo area</td><td>All deck / trunk plates full length.</td></tr>
<tr><td></td><td>Selected deck plates, bottom plates and side plates outside the cargo area</td><td>All deck plates, bottom plates and side plates outside the cargo area</td></tr>
<tr><td colspan="2">Collision bulkhead, forward machinery space bulkhead, aft peak bulkhead (1)</td><td>Selected transverse and longitudinal bulkheads outside cargo area (1)</td></tr>
<tr><td colspan="3">- river water manifold in engine room
- plating of river chests
- shell plating in way of overboard discharges as considered necessary by the attending Surveyor</td></tr>
<tr><td rowspan="3"></td><td>Internals in fore peak tank.</td><td>Internals in fore peak and after peak tanks.</td></tr>
<tr><td colspan="2">Selected internal structure such as floors and longitudinals, transverse frames, web frames, deck beams, girders</td></tr>
<tr><td></td><td>Representative exposed superstructure deck plates.</td></tr>
<tr><td colspan="4">(1) Including plates and stiffeners.</td></tr>
</table>

Table 4 : Minimum Requirements for thickness measurements - Cargo vessels

<table>
<tr><th>Class renewal survey I</th><th>Class renewal survey II</th><th>Class renewal survey III</th><th>Class renewal survey IV and subsequent</th></tr>
<tr><td colspan="4">Suspect areas throughout the vessel</td></tr>
<tr><td rowspan="8"></td><td>Within the cargo area:
- one transverse section
- selected side / inner side plates
- selected bottom / inner bottom plates</td><td>Within the cargo area:
- two transverse sections
- all side / inner side plates
- selected bottom / inner bottom plates
- selected cargo hold transverse bulkheads (1)</td><td>Within the cargo area:
- three transverse sections
- all side / inner side plates
- all bottom / inner bottom plates
- all cargo hold transverse bulkheads (1)</td></tr>
<tr><td>Selected top structure plates within the cargo area (1), (2).</td><td>All top structure plates within the cargo area (1), (2).</td><td>All top structure plates full length (1), (2).</td></tr>
<tr><td></td><td>Selected deck plates, bottom plates and side plates outside the cargo area</td><td>All deck plates, bottom plates and side plates outside the cargo area</td></tr>
<tr><td colspan="2">Collision bulkhead, forward machinery space bulkhead, aft peak bulkhead (1)</td><td>Selected transverse and longitudinal bulkheads outside cargo area (1)</td></tr>
<tr><td colspan="3">- river water manifold in engine room
- plating of river chests
- shell plating in way of overboard discharges as considered necessary by the attending Surveyor</td></tr>
<tr><td rowspan="3"></td><td>Internals in fore peak tank.</td><td>Internals in fore peak and after peak tanks.</td></tr>
<tr><td colspan="2">Selected internal structure such as floors and longitudinals, transverse frames, web frames, deck beams, girders</td></tr>
<tr><td></td><td>Representative exposed superstructure deck plates.</td></tr>
<tr><td colspan="4">(1) Including plates and stiffeners.
(2) Top structure includes deck, stringer plate, hatch coaming and shear strake.</td></tr>
</table>

Table 5 : Minimum Requirements for thickness measurements - Other vessels

<table>
<tr><th>Class renewal survey I</th><th>Class renewal survey II</th><th>Class renewal survey III</th><th>Class renewal survey IV and subsequent</th></tr>
<tr><td colspan="4">Suspect areas throughout the vessel</td></tr>
<tr><td rowspan="8"></td><td>Within the central part:
- one transverse section
- selected side / inner side plates
- selected bottom / inner bottom plates</td><td>Within the central part:
- two transverse sections
- all side / inner side plates
- selected bottom / inner bottom plates
- selected transverse bulkheads (1)</td><td>Within the central part:
- three transverse sections
- all side / inner side plates
- all bottom / inner bottom plates
- all transverse bulkheads (1)</td></tr>
<tr><td>Selected exposed main deck plates within the central part.</td><td>All exposed main deck plates within the central part.</td><td>All exposed main deck plates full length.</td></tr>
<tr><td></td><td>Selected deck plates, bottom plates and side plates outside the central part.</td><td>All deck plates, bottom plates and side plates outside the central part.</td></tr>
<tr><td colspan="2">Collision bulkhead, forward machinery space bulkhead, aft peak bulkhead (1)</td><td>Selected transverse and longitudinal bulkheads outside central part. (1)</td></tr>
<tr><td colspan="3">- river water manifold in engine room
- plating of river chests
- shell plating in way of overboard discharges as considered necessary by the attending Surveyor</td></tr>
<tr><td rowspan="3"></td><td>Internals in fore peak tank.</td><td>Internals in fore peak and after peak tanks.</td></tr>
<tr><td colspan="2">Selected internal structure such as floors and longitudinals, transverse frames, web frames, deck beams, girders</td></tr>
<tr><td></td><td>Representative exposed superstructure deck plates.</td></tr>
<tr><td colspan="4">(1) Including plates and stiffeners.</td></tr>
</table>

2.3.2 Locations of measurements points

a) General

Figures are given to facilitate the explanations and/or interpretations concerning locations of thickness measurements according to Tab 6.

The Figures listed in Tab 6 show typical arrangements of tankers and cargo vessels. Due to the various designs of the other vessel types, figures are not given to cover all the different cases. However, the figures provided here may be used as guidance for vessels other than those illustrated.

The locations of measurement points on tank vessels fitted with independent cargo tank will be determined as follows:

- independent cargo tank: according to the requirements applicable to integrated cargo tanks
- surrounding vessel structure: according to the requirements applicable to a cargo vessel having similar structural arrangement.

b) Examples of locations of measurements points

Examples of locations of measurements points are shown in Fig 1 to Fig 11.

Figure 1 : Locations of measurements on a transverse section of single hull tank vessels: ordinary frame

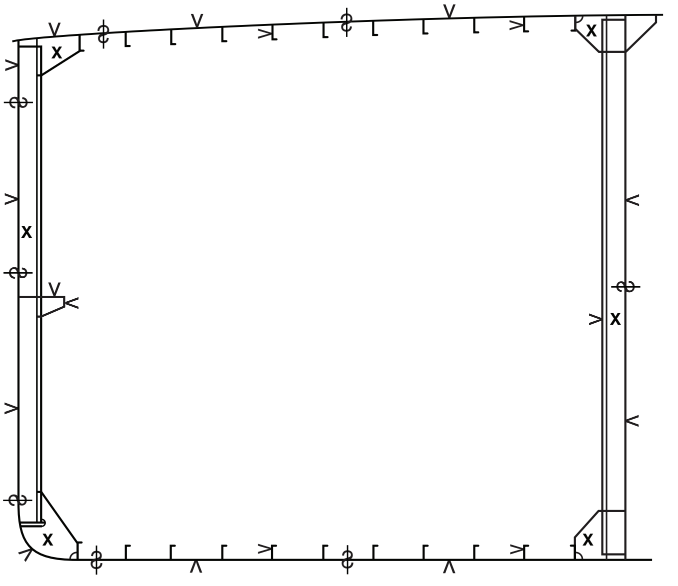


Table 6 : Locations of measurements

Vessel type	Structural item	Figure	Structural configuration
Tank vessels • Flush deck vessel • Integrated cargo tank	Transverse section - ordinary frame	Fig 1	Single hull Combination framing system
	Transverse section - web frame	Fig 2	
	Transverse section - ordinary frame	Fig 3	Double hull Combination framing system
	Transverse section - web frame	Fig 4	
	Transverse tank bulkhead	Fig 10	Plane bulkhead
	Transverse tank bulkhead	Fig 11	Corrugated bulkhead
Cargo vessels • Open deck vessel	Transverse section - web frame	Fig 5	Double hull Longitudinal framing system
	Transverse section - ordinary frame	Fig 6	
	Transverse section - ordinary frame	Fig 7	Double hull Transverse framing system
	Transverse section - web frame	Fig 8	
	Transverse watertight bulkhead	Fig 9	Plane bulkhead
	Transverse hold bulkhead	Fig 10	Plane bulkhead
	Transverse hold bulkhead	Fig 11	Corrugated bulkhead

Figure 2 : Locations of measurements on a transverse section of single hull tank vessels: web frame

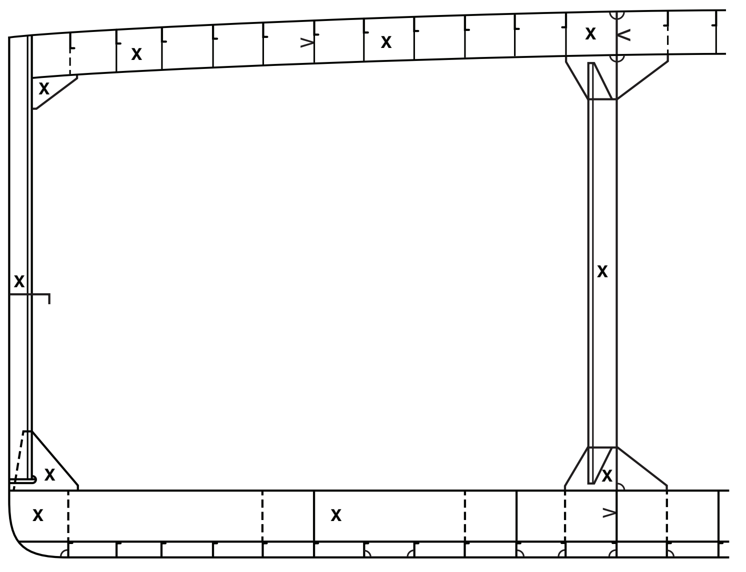


Figure 3 : Locations of measurements on a transverse section of double hull tank vessels: ordinary frame

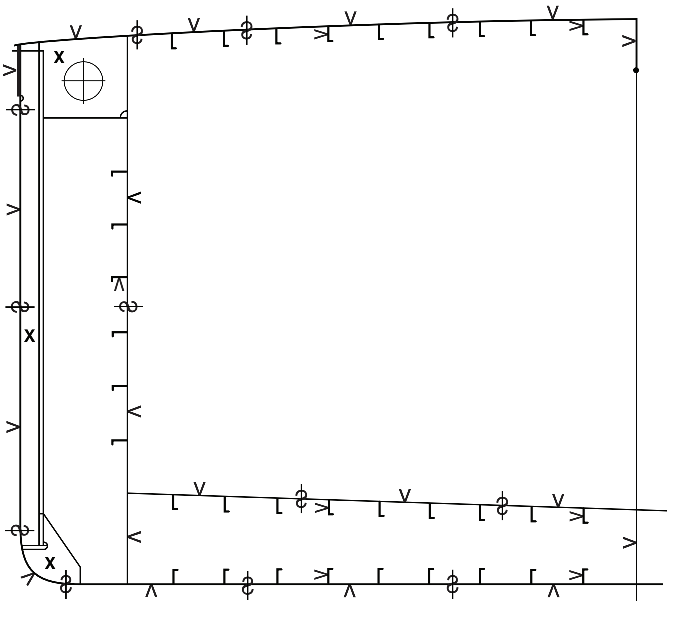


Figure 4 : Locations of measurements on a transverse section of double hull tank vessels: web frame

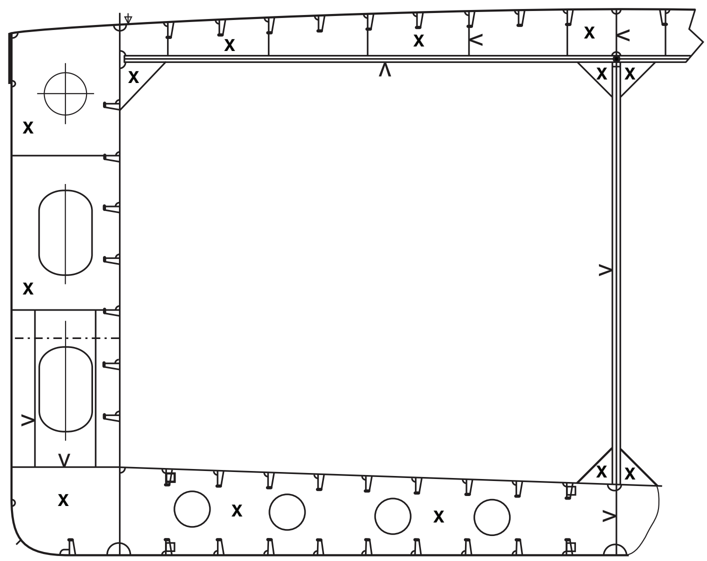


Figure 5 : Locations of measurements on a transverse section of double hull cargo vessels - web frame

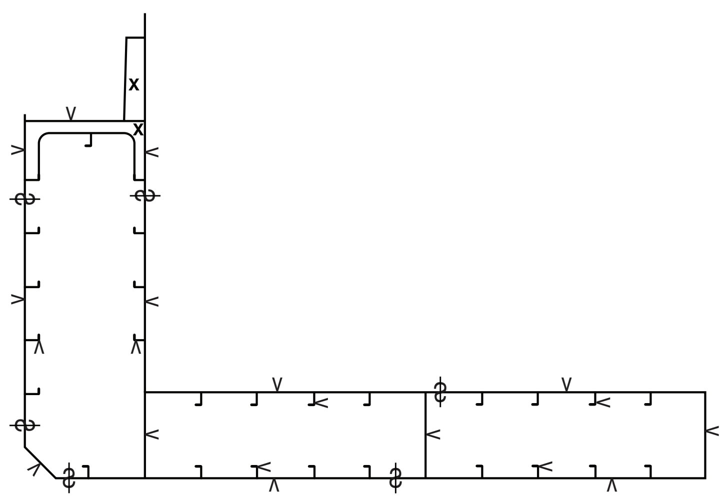


Figure 6 : Locations of measurements on a transverse section of double hull cargo vessels - ordinary frame

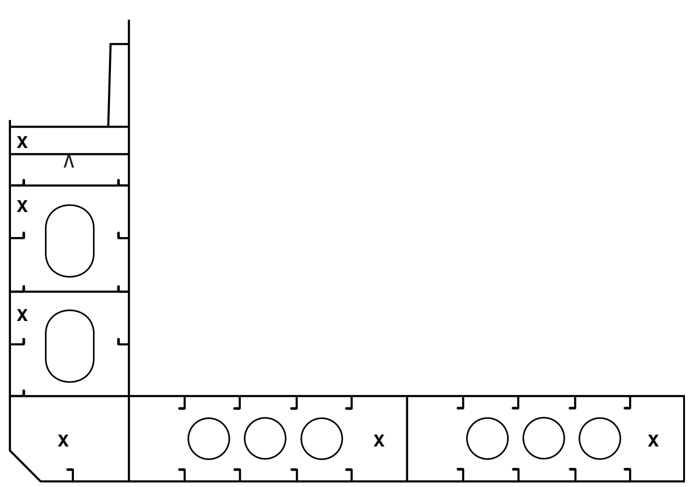


Figure 7 : Locations of measurements on a transverse section of double hull cargo vessels - ordinary frame

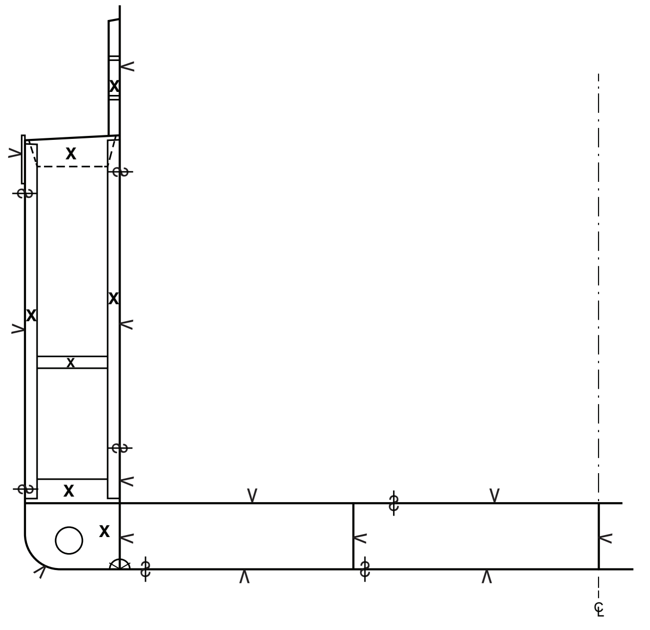


Figure 8 : Locations of measurements on a transverse section of double hull cargo vessels - web frame

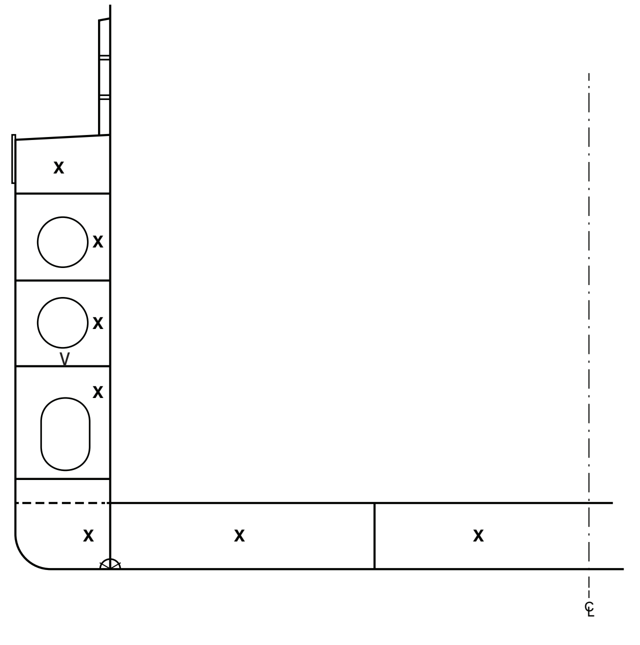


Figure 9 : Locations of measurements on watertight bulkheads - cargo vessels

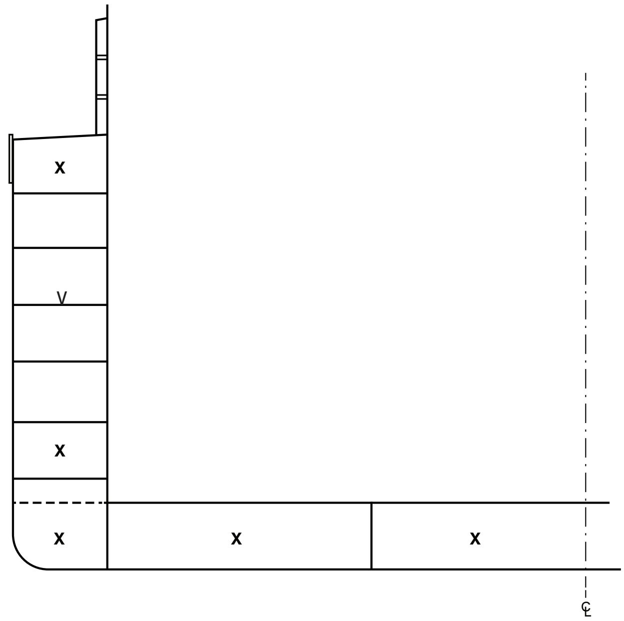


Figure 10 : Locations of measurements on tank bulkheads

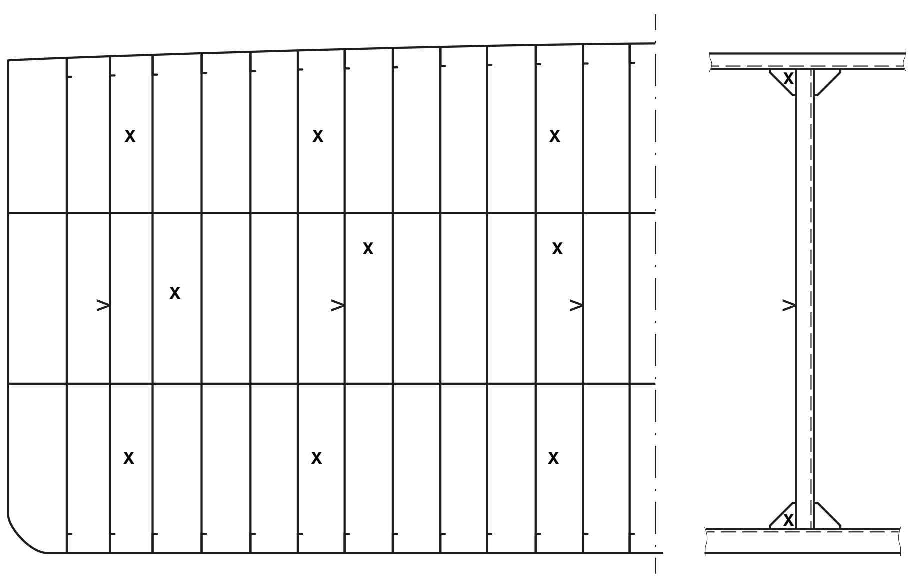
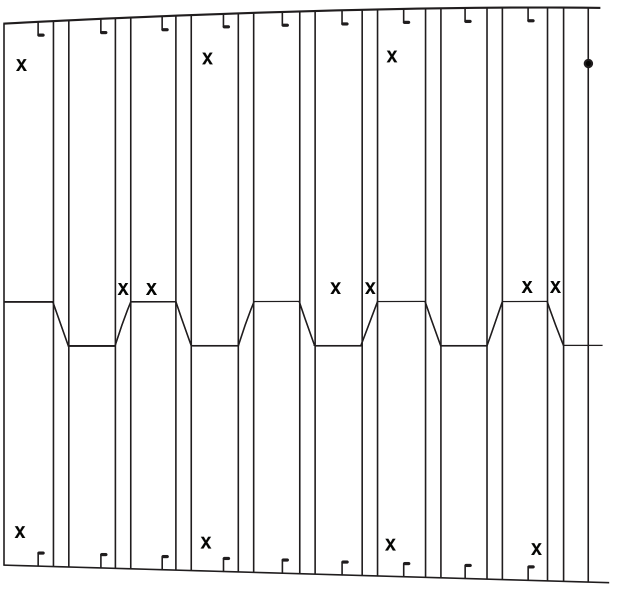


Figure 11 : Locations of measurements on transverse corrugated bulkheads



3 Measurements reporting

3.1 Application

3.1.1 This Article contains reporting forms to be used for recording thickness measurements as required in [2].

3.2 Reporting forms

3.2.1 General particulars

The first sheet of the report is to include general particulars information listed in Tab 7.

3.2.2 Deck plating, bottom shell plating or side shell plating

Appropriate reporting form is given in Tab 8.

This report is to be used for recording the thickness measurement of:

a) all strength deck plating within central part area

b) all keel, bottom shell plating and bilge plating within central part area

c) side shell plating, within central part area.

The strake position is to be clearly indicated as follows (see also [5]):

a) For strength deck, indicate the number of the strake of plating inboard from the stringer plate

b) For bottom plating, indicate the number of the strake of plating outboard from the keel plate

c) For side shell plating, give the number of the strake of plating below sheerstrake and letter as shown on shell expansion.

Measurements are to be taken at the forward and aft areas of plates.

The single measurements recorded are to represent the average of multiple measurements.

3.2.3 Shell and deck plating at transverse sections - strength deck and sheerstrake

Appropriate reporting form is given in Tab 9.

This report is to be used for recording the thickness measurement of strength deck plating and sheerstrake plating at transverse sections within the central part area comprising of the following structural items:

- Strength deck plating
- Stringer plate
- Sheerstrake
- Hatch coaming.

For flush deck and trunk deck vessels, the topside area comprises stringer plate and sheerstrake.

For open deck vessels, the topside area comprises hatch coaming plating, stringer plate and sheerstrake.

The exact frame station of measurement is to be stated.

The single measurements recorded are to represent the average of multiple measurements.

3.2.4 Shell and bottom plating at transverse sections

Appropriate reporting form is given in Tab 10.

This report is to be used for recording the thickness measurement of shell and bottom plating at transverse sections within the central part area comprising of the following structural items:

- Side shell plating
- Bilge plating
- Bottom shell plating
- Keel plate.

The bottom area comprises keel, bottom and bilge plating.

The exact frame station of measurement is to be stated.

The single measurements recorded are to represent the average of multiple measurements.

3.2.5 Longitudinal members at transverse sections

Appropriate reporting form is given in Tab 11.

This report is to be used for recording the thickness measurement of longitudinal members at transverse sections within the central part area.

The exact frame station of measurement is to be stated.

The single measurements recorded are to represent the average of multiple measurements.

3.2.6 Transverse structural members

Appropriate reporting form is given in Tab 12.

This report is to be used for recording the thickness measurement of transverse structural members.

The single measurements recorded are to represent the average of multiple measurements.

3.2.7 Transverse bulkheads

Appropriate reporting form is given in Tab 13.

This report is to be used for recording the thickness measurement of transverse bulkheads including bulkhead stiffeners.

The single measurements recorded are to represent the average of multiple measurements.

3.2.8 Miscellaneous structural members

Appropriate reporting form is given in Tab 14.

This report is to be used for recording the thickness measurement of miscellaneous structural members including items such as:

- Coaming of separate hatchways
- Hatch covers
- Superstructure
- Fore peak
- After peak.

The single measurements recorded are to represent the average of multiple measurements.

Table 7 : General particulars

GENERAL PARTICULARS
Vessel name: Service notation: Bureau Veritas register number: Port of registry: Deadweight: Date of build: Classification Society: Name of company performing thickness measurement: Thickness measurement company certified by: Certificate No: Certificate valid from .... to .... Place of measurement: First date of measurement: Last date of measurement: Type of survey: Scantling approach: Rule length (m): Details of measurement equipment: Qualification of operators: Report Number: ....consisting of .... sheets Name of operator:...Name of Surveyor: .... Signature of operator: .... Signature of Surveyor: .... Company official stamp: Society official stamp

Table 8 : Deck plating, bottom shell plating or side shell plating

REPORT ON THICKNESS MEASUREMENT OF DECK PLATING, BOTTOM SHELL PLATING OR SIDE SHELL PLATING **(1)**																		
Vessel's name: ....Register No.................................. Report No..............................																		
STRAKE POSITION	Strake / Deck N°......... **(2)**																	
PLATE POSITION	No or Lett.	Org. Thk. **(3)**	Forward Reading						Aft Reading						Mean dimin %		Max. allo. dim.
			Gauged		Diminution P		Diminution S		Gauged		Diminution P		Diminution S				
		mm	P	S	mm	%	mm	%	P	S	mm	%	mm	%	P	S	mm
12th fore																	
11th																	
10th																	
9th																	
8th																	
7th																	
6th																	
5th																	
4th																	
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10th																	
11th																	
12th aft																	
Operator signature: ....Surveyor's signature..																		

(1) Delete as appropriate
(2) For multiple deck vessels
(3) Rule thickness or as-built thickness

Table 9 : Strength deck and sheerstrake plating at transverse sections

REPORT ON THICKNESS MEASUREMENT OF STRENGTH DECK AND SHEERSTRAKE PLATING AT TRANSVERSE SECTIONS									
Vessel's name: ....Register No...;Report No......................									
	Transverse section at frame number								
STRAKE POSITION	No or lett.	Org Thk **(1)**	Max allow. dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Hatch coaming **(2)** / Trunk longit. bulk-head									
Stringer plate									
1st strake inboard									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
centre strake									
sheerstrake									
topside. total									
Operator's signature..Surveyor's signature..............................									
(1) Rule thickness or as-built thickness									
(2) For open deck vessels									

Table 10 : Side and bottom plating at transverse sections

REPORT ON THICKNESS MEASUREMENT OF SIDE AND BOTTOM PLATING AT TRANSVERSE SECTIONS									
Vessel's name: ....Register No.................................Report No......................									
	Transverse section at frame number								
STRAKE POSITION	No or lett.	Org. Thk. **(1)**	Max. allow. dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
1st strake below sheerstr.									
2nd									
3rd									
4th									
5th									
6th									
7th									
8th									
9th									
10th									
11th									
12th									
13th									
14th									
keel strake									
Bott. total									
Operator's signature..Surveyor's signature.........									
(1) Rule thickness or as-built thickness									

Table 11 : Longitudinal members at transverse sections

REPORT ON THICKNESS MEASUREMENT OF LONGITUDINAL MEMBERS AT TRANSVERSE SECTIONS									
Vessel's name: ....Register No..............................Report No......................									
Transverse section at frame number									
STRUCTURAL ITEM	it. No	Org. Thk. **(1)**	Max. allow. dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Operator's signature: .... Surveyor's signature:									
(1) Rule thickness or as-built thickness									

Table 12 : Transverse structural members

REPORT ON THICKNESS MEASUREMENT OF TRANSVERSE STRUCTURAL MEMBERS									
Vessel's name..Register No...................................Report No.									
DESCRIPTION									
LOCATION OF STRUCTURE									
STRUCTURAL MEMBERS	Item	Org. Thk. **(1)**	Max. allow. dim.	Gauged		Diminution P		Diminution S	
		mm	mm	P	S	mm	%	mm	%
Operator's signature...Surveyor's signature..									
(1) Rule thickness or as-built thickness									

Table 13 : Transverse bulkheads

REPORT ON THICKNESS MEASUREMENT OF TRANSVERSE BULKHEADS								
Vessel's name..Register No......................................Report No.								
LOCATION OF STRUCTURE	frame No. ...							
STRUCTURAL MEMBERS (plating / stiffeners)	Org. Thk. **(1)**	Max. allow. dim.	Gauged		Diminution P		Diminution S	
	mm	mm	P	S	mm	%	mm	%
Operator's signature..Surveyor's signature..								
(1) Rule thickness or as-built thickness								

Table 14 : Miscellaneous structural members

REPORT ON THICKNESS MEASUREMENT OF								
Vessel's name..Register No......................................Report No.								
LOCATION OF STRUCTURE:								
STRUCTURAL MEMBERS (plating / stiffeners)	Org. Thk. **(1)**	Max. allow. dim.	Gauged		Diminution P		Diminution S	
	mm	mm	P	S	mm	%	mm	%
Operator's signature..Surveyor's signature..								
(1) Rule thickness or as-built thickness								

4 Acceptance criteria

4.1 Application

4.1.1 The acceptance criteria for measured thicknesses are indicated in:

- [4.3] for vessels built according to gross scantling concept
- [4.4] for vessels built according to net scantling concept
- [4.5] for pitting.

When the acceptance criteria are not fulfilled, actions according to [4.2.1] to [4.2.3] are to be taken.

4.2 Definitions

4.2.1 Isolated area

The thickness diminution of an isolated area of an item is the localised diminution of the thickness of that item such as, for example, the grooving of a plate or a web or a local severe corrosion. It is expressed as a percentage of the relevant as built thickness.

It is not to be confused with pitting (see [4.5]).

If the criteria of acceptable diminution are not fulfilled for an isolated area, then this isolated area is to be repaired or replaced. In any case, the criteria of thickness diminution are to be considered for the corresponding item (see [4.2.2]).

4.2.2 Item

For each item, thicknesses are measured at several points and the average value of these thicknesses is to satisfy the acceptance criteria for the relevant item.

If the criteria of measured thicknesses are not fulfilled for an item, then this item is to be repaired or replaced.

Where the criteria are fulfilled but substantial corrosion as defined in Ch 2, Sec 2, [2.2.7] is observed, adequate provision is to be made in the report.

In any case, for the items which contribute to the hull girder longitudinal strength, the criteria in [4.2.3] are to be considered.

Table 15 : Zone definition - Flush deck vessels

Group of items	Zone structural items	Remarks
	DECK ZONE	
1	• Deck plating • Deck longitudinals • Deck girders	Including stringer plate
2	• Sheerstrake • Sheerstrake longitudinals	The height of a sheerstrake having the same thickness as the adjacent side shell is to be taken equal to 0,08D
3	• Inner side upper strake • Inner side upper strake longitudinals	The height of the inner side upper strake is to be taken equal to that of the sheerstrake
4	• Longitudinal bulkhead upper strake • Longitudinal bulkhead upper strake longitudinals	The height of the longitudinal bulkhead upper strake is to be taken equal to that of the sheerstrake
	NEUTRAL AXIS ZONE	
5	Side and inner side shell plating	
6	Side and inner side shell longitudinals	
7	Side and inner side shell stringers	
8	Longitudinal bulkhead plating	
9	Longitudinal bulkhead longitudinals	
10	Longitudinal bulkhead stringers	
	BOTTOM ZONE	
11	• Bottom plating • Bottom longitudinals • Bottom girders	Including keel plate
12	• Bilge plating • Bilge longitudinals	
13	• Inner bottom plating • Inner bottom longitudinals • Inner bottom girders	
14	• Inner side lower strake • Inner side lower strake longitudinals	The height of the inner side lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom
15	• Longitudinal bulkhead lower strake • Longitudinal bulkhead lower strake longitudinals	The height of the longitudinal bulkhead lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom

Table 16 : Zone definition - Trunk deck vessels

Group of items	Zone structural items	Remarks
	DECK ZONE	
1	• Trunk deck plating • Trunk deck longitudinals • Trunk deck girders	
2	• Trunk longitudinal bulkhead plating • Trunk longitudinal bulkhead longitudinals • Trunk longitudinal bulkhead girders	
3	• Stringer plate • Stringer plate longitudinals	In way of the vessel depth D
4	• Sheerstrake • Sheerstrake longitudinals	The height of a sheerstrake having the same thickness as the adjacent side shell is to be taken equal to 0,08D
5	• Inner side upper strake • Inner side upper strake longitudinals	The height of the inner side upper strake is to be taken equal to that of the sheerstrake
6	• Longitudinal bulkhead upper strake • Longitudinal bulkhead upper strake longitudinals	The height of the longitudinal bulkhead upper strake is to be taken equal to that of the sheerstrake
	NEUTRAL AXIS ZONE	
7	Side and inner side shell plating	
8	Side and inner side shell longitudinals	
9	Side and inner side shell stringers	
10	Longitudinal bulkhead plating	
11	Longitudinal bulkhead longitudinals	
12	Longitudinal bulkhead stringers	
	BOTTOM ZONE	
13	• Bottom plating • Bottom longitudinals • Bottom girders	Including keel plate
14	• Bilge plating • Bilge longitudinals	
15	• Inner bottom plating • Inner bottom longitudinals • Inner bottom girders	
16	• Inner side lower strake • Inner side lower strake longitudinals	The height of the inner side lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom
17	• Longitudinal bulkhead lower strake • Longitudinal bulkhead lower strake longitudinals	The height of the longitudinal bulkhead lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom

4.2.3 Zone

For consideration of the hull girder longitudinal strength, the transverse section of the vessel is divided into three zones defined in Tab 15 to Tab 17:

- deck zone
- neutral axis zone
- bottom zone.

Each zone is to be evaluated separately.

The sectional area diminution of a zone, expressed as a percentage of the relevant as built sectional area, is to fulfill the criteria of acceptable diminution for that zone.

If the criteria of acceptable diminution are not fulfilled for a zone, then some items belonging to that zone are to be replaced (in principle, those which are most worn) in order to obtain after their replacement an increased sectional area of the zone fulfilling the relevant criteria.

4.3 Acceptance criteria for vessels built according to gross scantling concept

4.3.1 Application

Acceptance criteria stipulate limits of wastage which are to be taken into account for reinforcements, repairs or renewals of steel structure. These limits are generally expressed for each structural item as a maximum percentage of acceptable wastage (W). When the maximum percentage of wastage is indicated, the minimum acceptable thickness (t_{min}) is that resulting from applying this percentage to the rule thickness (t_{rule}), according to the following formula:

$$t_{min} = \left(1 - \frac{W}{100}\right) t_{rule}$$

However, when the rule thickness is not available, the as-built thickness can be used.

Only for criteria related to an item (see [4.3.3], item d), 2), the Society may establish a list of renewal thicknesses tailored to the different structural items. In such a case these thicknesses are used in lieu of the minimum thicknesses calculated from the percentage of wastage.

Note 1: In any case, at the request of the Owner, the Society may perform a direct calculation based on the current measurements.

In cases where the vessel has some structural elements with reduced wear margins (e.g. due to vessel conversion, increase of draught), the minimum acceptable thickness for these elements is to be calculated with reference to the rule scantlings without taking account of any reduction originally agreed.

Decisions on steel renewals are taken by the attending Surveyor applying the criteria given in this Article and based on his judgment and the actual condition of the vessel. Should advice be needed to support his decision, the Surveyor may refer to the relevant technical office of the Society.

Table 17 : Zone definition - Open deck vessels

Group of items	Zone structural items	Remarks
	DECK ZONE	
1	• Hatch coaming plating • Hatch coaming longitudinals • Hatch coaming girders	Including under deck strake
2	• Stringer plate • Stringer plate longitudinals	
3	• Sheerstrake • Sheerstrake longitudinals	The height of a sheerstrake having the same thickness as the adjacent side shell is to be taken equal to 0,08D
4	• Inner side upper strake • Inner side upper strake longitudinals	The height of the inner side upper strake is to be taken equal to that of the sheerstrake
5	• Longitudinal bulkhead upper strake • Longitudinal bulkhead upper strake longitudinals	The height of the longitudinal bulkhead upper strake is to be taken equal to that of the sheerstrake
	NEUTRAL AXIS ZONE	
6	Side and inner side shell plating	
7	Side and inner side shell longitudinals	
8	Side and inner side shell stringers	
9	Longitudinal bulkhead plating	
10	Longitudinal bulkhead longitudinals	
11	Longitudinal bulkhead stringers	
	BOTTOM ZONE	
12	• Bottom plating • Bottom longitudinals • Bottom girders	Including keel plate
13	• Bilge plating • Bilge longitudinals	
14	• Inner bottom plating • Inner bottom longitudinals • Inner bottom girders	
15	• Inner side lower strake • Inner side lower strake longitudinals	The height of the inner side lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom
16	• Longitudinal bulkhead lower strake • Longitudinal bulkhead lower strake longitudinals	The height of the longitudinal bulkhead lower strake is to be taken equal to: - height of the bilge, for single bottom vessels - height of the double bottom

4.3.2 Criteria

The acceptance criteria for the minimum thicknesses are divided into:

- criteria on local strength, given in [4.3.3]
- criteria on global strength, given in [4.3.3]
- criteria on buckling strength, given in [4.3.4]
- criteria on pitting, given in [4.5].

Each measured structural item is to be checked against these four criteria, as far as applicable. When the criteria are not met, reinforcements, repairs and renewals are to be carried out as appropriate.

4.3.3 Local and global strength

a) Local and global strength criteria are given for the following vessel types:

   - Cargo vessels

     Cargo vessels include vessels carrying dry cargoes, i.e., bulk cargo vessels, container vessels, general cargo vessels and Ro-Ro cargo vessels
   - Tank vessels.

   These criteria may also be used for other vessel types taking into consideration the equivalence or similarity of structural elements and their contribution to local and/or global strength.

b) Structural items to be assessed are listed in Tab 18 for cargo vessels, Tab 19 for tankers and Tab 20 for other vessels, grouped according to their position and contribution to the local or global strength of the vessel.

c) Each structural item is to be assessed according to three different criteria which vary with regard to the domain under which it is considered, namely:

   1) an isolated area, which is meant as a part of a single structural item. This criterion takes into consideration very local aspects such as grooving of a plate or web, or local severe corrosion; however, it is not to be used for pitting for which separate criteria are considered (see [4.5])
   2) an item, which is meant as an individual element such as a plate, a stiffener, a primary supporting member web or flange, etc. This criterion takes into consideration the average condition of the item, which is assessed by determining its average thickness using the various measurements taken on the same item
   3) a zone, which is meant as all and only longitudinal elements contributing to the longitudinal strength of the vessel; in this regard, the three main zones are defined as deck zone, neutral axis zone and bottom zone.

d) The assessment of the thickness measurements is to be performed using the values given in the Tables for each structural element with regard to the three criteria defined above, in the following order:

   1) assessment of isolated areas (column 1 in Tab 18, Tab 19 and Tab 20)

      If the criterion is not met, the wasted part of the item is to be dealt with as necessary.
   2) assessment of items (column 2 in Tab 18, Tab 19 and Tab 20)

      If the criterion is not met, the item is to be dealt with as necessary in the measured areas as far as the average condition of the item concerned is satisfactory. In cases where some items are renewed, the average thicknesses of these items to be considered in the next step are the new thicknesses.
   3) assessment of zones (column 3 in Tab 18, Tab 19 and Tab 20).

      The criterion applicable to the zones is based on the general rule that the current hull girder section modulus is not to be less than 90% of the original section modulus within 0,5L amidships. At the request of the Owner, a direct calculation using the vessel's current thicknesses may be performed by the Society in order to accept greater diminutions than those given for this criterion.

e) These criteria take into consideration two main aspects:

   - the overall strength of the hull girder
   - the local strength and integrity of the hull structure, such as hatch covers, bulkheads, etc.

   As a rule, they are applicable to the structure within the cargo area of vessels having a length equal to or greater than 90 metres. However, they may also be used for smaller vessels and for structure outside the cargo area according to the following principles:

   - for vessels having a length less than 90 metres, the percentages of acceptable wastage given in the tables can be increased by 5 (%) (e.g. 15% instead of 10%, etc.), except for those of deck and bottom zones.
   - for structure outside the cargo area, the same 5 (%) increase can be applied

   on the understanding, however, that both conditions cannot be applied at the same time.

4.3.4 Buckling strength criterion

In general, the applicable criterion on buckling strength will be decided by the Society, if needed, on a case by case basis.

4.4 Acceptance for vessels built according to net scantling concept

4.4.1 Application

Acceptance criteria stipulate limits of wastage which are to be taken into account for reinforcements, repairs or renewals of steel structure.

Decisions on steel renewals are taken by the attending Surveyor applying the criteria given in this Section and based on his judgment and the actual condition of the vessel. Should advice be needed to support his decision, the Surveyor may refer to the relevant technical office of the Society.

Acceptance criteria on pitting, are given in [4.5].

Table 18 : Local and global acceptance criteria for cargo vessels (given in % of wastage)

Group of items	Description of items	1 Isolated area	2 Item		3 Zone
ITEMS CONTRIBUTING TO THE LONGITUDINAL STRENGTH (TRANSVERSE SECTION)					
	DECK ZONE **(1)**	–	–		10
1	Hatch coaming plating, stringer plate, sheer strake, inner side upper strake and longitudinal bulkhead upper strake	30	25	15 **(3)**	–
2	Hatch coaming, stringer plate, sheer strake, inner side upper strake and longitudinal bulkhead upper strake longitudinals	25	20		–
	NEUTRAL AXIS ZONE **(1)**	–	–		15
3	Side and inner side shell plating	30	25	15 **(3)**	–
4	Side and inner side longitudinals	25	20		–
5	Side and inner side shell stringers	25	20		–
	BOTTOM ZONE **(1)**	–	–		10
6	Bilge and bottom strakes, longitudinal bulkhead lower strake and inner side lower strake	30	25	15 **(3)**	–
7	Bilge and bottom longitudinals, longitudinal bulkhead lower strake and inner side lower strake longitudinals	25	20		–
8	Inner bottom plating	30	25	15 **(3)**	–
9	Inner bottom longitudinals	25	20		–
10	Bottom girders	25	20		–
OTHER ITEMS					
11	Hatch coaming plating **(2)**	25	20		–
12	Hatch coaming stiffeners stays	 30 30	 20 25		 – –
13	Hatch cover plating	25	20		–
15	Hatch cover stiffeners	30	20		–
16	Transverse bulkheads plating stringer web stringer flange stiffener brackets	 30 30 25 25 30	 20 20 20 20 20		 – – – – –
17	Side and inner side frames brackets	25 30	20 20		– –
18	Deck beams	25	20		–
19	Bottom transverse web frames / floors web flange brackets / stiffeners	 30 20 30	 20 15 20		 – – –
20	Cross tie web flange brackets	 25 20 20	 20 15 15		 – –
21	Forward and aft peak bulkheads **(4)** plating stiffener	 30 25	 20 20		 – –

(1) Each zone is to be evaluated separately.
(2) If continuous, to be included in item 1.
(3) When transverse framing.
(4) Including forward and aft peak bulkheads.

Table 19 : Local and global acceptance criteria for tankers (given in % of wastage)

Group of items	Description of items	1 Isolated area	2 Item		3 Zone
ITEMS CONTRIBUTING TO THE LONGITUDINAL STRENGTH (TRANSVERSE SECTION)					
	DECK ZONE **(1)**	–	–		10
1	Deck plating, deck stringer, sheer strake and longitudinal bulkhead upper strake, trunk longitudinal bulkhead and inner side upper strake	30	25	15 **(2)**	–
2	Deck and sheer strake longitudinals, trunk longitudinal bulkhead longitudinals and inner side upper strake longitudinals	25	20		–
3	Deck longitudinal girders	25	20		–
4	Longitudinals connected to long. bulkhead upper strake	25	20		-
	NEUTRAL AXIS ZONE **(1)**	–	–		15
5	Side and inner side shell plating	30	25	15 **(2)**	–
6	Side and inner side shell longitudinals	25	20		–
7	Side and inner side shell stringers	25	20		–
8	Longitudinal bulkhead plating	30	25	15 **(2)**	–
9	Longitudinal bulkhead longitudinals	25	20		–
10	Longitudinal bulkhead stringers	25	20		–
	BOTTOM ZONE **(1)**	–	–		10
11	Bilge and bottom strakes, longitudinal bulkhead lower strake and inner side lower strake	30	25	15 **(2)**	–
12	Bilge and bottom longitudinals, longitudinal bulkhead lower strake and inner side lower strake longitudinals	25	20		–
13	Inner bottom plating	30	25	15 **(2)**	–
14	Inner bottom longitudinals	25	20		–
15	Bottom girders	25	20		–
OTHER ITEMS					
16	Deck beams	25	20		–
17	Deck transverse web frames web flange brackets / stiffeners	 25 20 25	 20 15 20		 – – –
18	Expansion tank plating stiffeners	 25 25	 20 20		 – –
19	Side frames Side frame brackets	25 30	20 20		– –
20	Side shell web frames web flange brackets / stiffeners	 25 20 25	 20 15 20		 – – –

(1) Each zone is to be evaluated separately.
(2) When transverse framing.
(3) Including swash bulkheads, forward and aft peak bulkheads.

Group of items	Description of items	1 Isolated area	2 Item	3 Zone
21	Longitudinal bulkheads vertical stiffeners brackets	 25 30	 20 20	 – –
22	Longitudinal bulkhead web frames web flange brackets / stiffeners	 25 20 25	 20 15 20	 – – –
23	Bottom transverse web frames / floors web flange brackets / stiffeners	 25 20 25	 20 15 20	 – – –
24	Cross tie web flange brackets / stiffeners	 25 20 20	 20 15 15	 – – –
25	Transverse bulkheads **(3)** plating stringer web stringer flange stiffener	 25 25 20 25	 20 20 15 20	 – – – –

(1) Each zone is to be evaluated separately.
(2) When transverse framing.
(3) Including swash bulkheads, forward and aft peak bulkheads.

4.4.2 Values of corrosion additions

The values of corrosion additions are to be determined according to Pt B, Ch 2, Sec 5, [3].

4.4.3 Acceptance criteria for isolated areas

The thickness diminution of isolated areas of items is not to be greater than 1,25 t_C, where t_C is the value of corrosion addition as defined in Pt B, Ch 2, Sec 5, [3]. Otherwise, actions according to [4.2.1] are to be taken.

4.4.4 Acceptance criteria for items

The thickness diminution of isolated items is not to be greater than the value of corrosion addition as defined in Pt B, Ch 2, Sec 5, [3]. Otherwise, actions according to [4.2.2] are to be taken.

4.4.5 Acceptance criteria for zones

The sectional area diminution of a zone (measured according to [4.2.3]) is not to be greater than 10% of the original sectional area. Otherwise, actions according to [4.2.3] are to be taken.

The criterion applicable to the zones is based on the general rule that the current hull girder section modulus is not to be less than 90% of the original section modulus within 0,5L amidships. At the request of the Owner, a direct calculation using the vessel's current thicknesses may be performed by the Society in order to accept greater diminutions than those given for this criterion.

4.5 Pitting

4.5.1 Pitting corrosion

Pitting corrosion is one of the most common forms that can be noted in ballast tanks. It is a localised corrosion that occurs on bottom plating, other horizontal surfaces and at structural details that trap water, particularly the aft bays of tank bottoms. For coated surfaces the attack produces deep and relatively small diameter pits that can lead to hull penetration.

Pitting of uncoated tanks, as it progresses, forms shallow but very wide scabby patches (e.g. 300m mm diameter); the appearance resembles a condition of general corrosion.

Pitting is caused by the action of a localised corrosion cell on a steel surface due to the breaking of the coating (if present), to the presence of contaminants or impurities on the steel (e.g. mill scale) or to impurities present in the steel.

4.5.2 Acceptance criteria

The maximum acceptable depth for isolated pits is 35% of the as-built thickness.

For areas with different pitting intensity, the intensity diagrams shown in Fig 12 are to be used to identify the percentage of affected areas.

Table 20 : Local and global acceptance criteria for other vessels (given in % of wastage)

<table>
<tr><th>Group of items</th><th>Description of items</th><th>1
Isolated area</th><th colspan="2">2
Item</th><th>3
Zone</th></tr>
<tr><td colspan="6">ITEMS CONTRIBUTING TO THE LONGITUDINAL STRENGTH (TRANSVERSE SECTION)</td></tr>
<tr><td></td><td>DECK ZONE (1)</td><td>–</td><td colspan="2">–</td><td>10</td></tr>
<tr><td>1</td><td>Deck plating, deck stringer and sheer strake</td><td>30</td><td>25</td><td>15 (2)</td><td>–</td></tr>
<tr><td>2</td><td>Deck and sheer strake longitudinals</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>3</td><td>Deck longitudinal girders</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td></td><td>NEUTRAL AXIS ZONE (1)</td><td>–</td><td colspan="2">–</td><td>15</td></tr>
<tr><td>4</td><td>Side shell plating</td><td>30</td><td>25</td><td>15 (2)</td><td>–</td></tr>
<tr><td>5</td><td>Side shell longitudinals</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>6</td><td>Side shell stringers</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>7</td><td>Longitudinal bulkhead plating</td><td>30</td><td>25</td><td>15 (2)</td><td>–</td></tr>
<tr><td>8</td><td>Longitudinal bulkhead longitudinals</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>9</td><td>Longitudinal bulkhead stringers</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td></td><td>BOTTOM ZONE (1)</td><td>–</td><td colspan="2">–</td><td>10</td></tr>
<tr><td>10</td><td>Bilge and bottom strakes and longitudinal bulkhead lower strake</td><td>30</td><td>25</td><td>15 (2)</td><td>–</td></tr>
<tr><td>11</td><td>Bilge and bottom longitudinals and longitudinal bulkhead lower strake</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>12</td><td>Inner bottom plating</td><td>30</td><td>25</td><td>15 (2)</td><td>–</td></tr>
<tr><td>13</td><td>Inner bottom longitudinals</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>14</td><td>Bottom girders</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td colspan="6">OTHER ITEMS</td></tr>
<tr><td>15</td><td>Deck beams</td><td>25</td><td colspan="2">20</td><td>–</td></tr>
<tr><td>16</td><td>Deck transverse web frames
web
flange
brackets / stiffeners</td><td>
25
20
25</td><td colspan="2">
20
15
20</td><td>
–
–
–</td></tr>
<tr><td>17</td><td>Side frames
brackets</td><td>25
30</td><td colspan="2">20
20</td><td>–
–</td></tr>
<tr><td>18</td><td>Side shell web frames
web
flange
brackets / stiffeners</td><td>
25
20
25</td><td colspan="2">
20
15
20</td><td>
–
–
–</td></tr>
<tr><td>19</td><td>Longitudinal bulkheads
vertical stiffeners
brackets</td><td>
25
30</td><td colspan="2">
20
20</td><td>
–
–</td></tr>
<tr><td>20</td><td>Longitudinal bulkhead web frames
web
flange
brackets / stiffeners</td><td>
30
20
30</td><td colspan="2">
20
15
20</td><td>
–
–
–</td></tr>
<tr><td>21</td><td>Bottom transverse web frames / floors
web
flange
brackets / stiffeners</td><td>
30
20
30</td><td colspan="2">
20
15
20</td><td>
–
–
–</td></tr>
<tr><td>22</td><td>Transverse bulkheads (3)
plating
stringer web
stringer flange
stiffener</td><td>
30
30
25
25</td><td colspan="2">
20
20
20
20</td><td>
–
–
–
–</td></tr>
<tr><td colspan="6">(1) Each zone is to be evaluated separately.
(2) When transverse framing.
(3) Including forward and aft peak bulkheads.</td></tr>
</table>

For areas having a pitting intensity of 50% or more, the maximum acceptable average depth of pits is 20% of the as-built thickness. For intermediate values between isolated pits and 50% of affected area, the interpolation between 35% and 20% is made according to Tab 21.

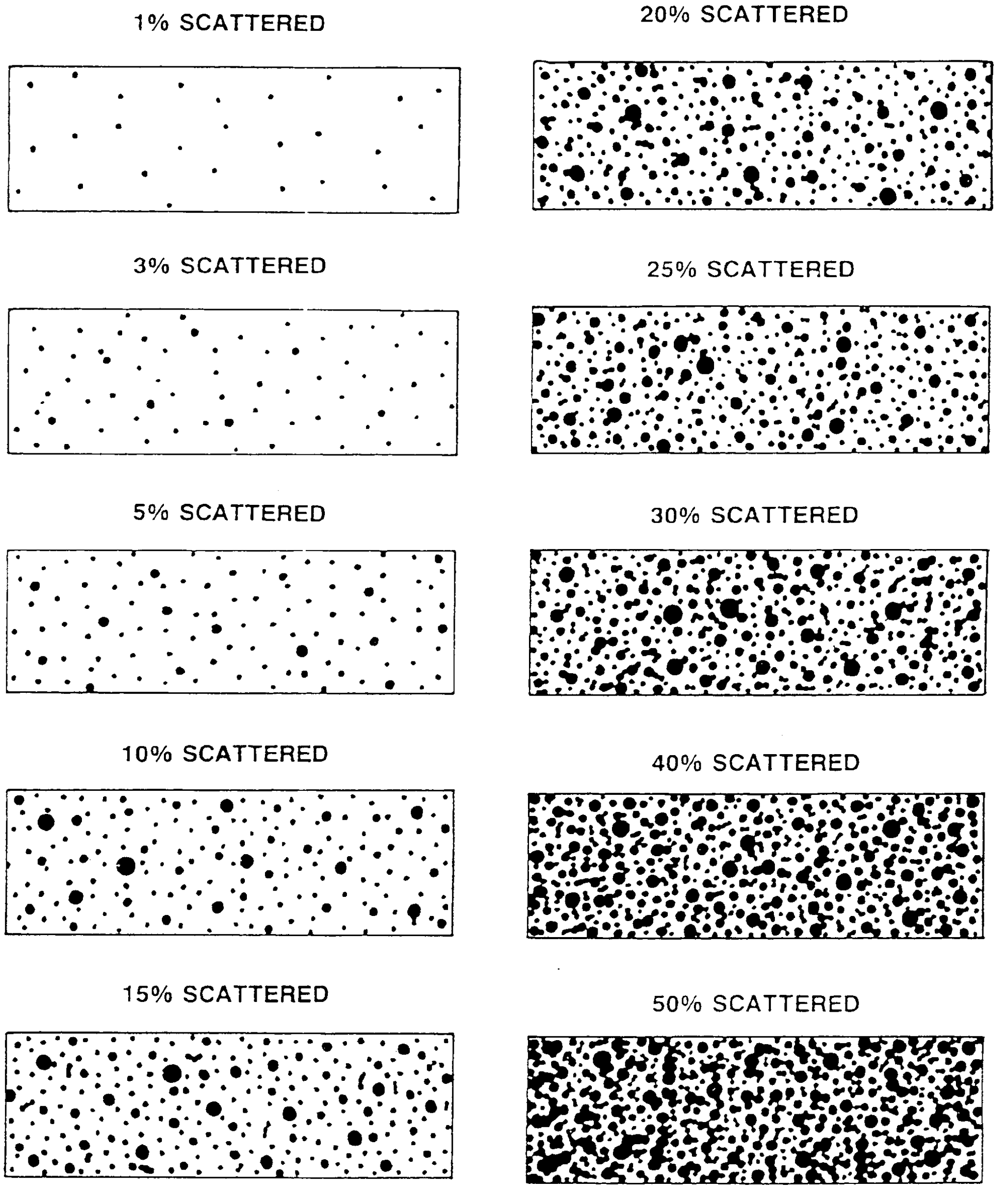
In addition, the thickness outside the pits in the area considered is to be assessed according to [4.3] and [4.4].

Note 1: Application of filler material (plastic or epoxy compounds) is recommended as a means to stop or reduce the corrosion process, but it is not considered an acceptable repair for pitting exceeding the maximum allowable wastage limits. Welding repairs may be accepted when performed in accordance with procedures agreed with the society.

Table 21 : Pitting intensity and corresponding maximum average depth of pitting

Pitting intensity (%)	Maximum average pitting depth (% of the as-built thickness)
Isolated	35,0
5	33,5
10	32,0
15	30,5
20	29,0
25	27,5
30	26,0
40	23,0
50	20,0

Figure 12 : Pitting intensity diagrams (from 1% to 50% intensity)



5 Examples of designation and location of plating strakes

5.1 Shell expansion

5.1.1 Non-propelled cargo vessel

See Fig 13.

5.1.2 Pontoon

See Fig 14.

5.1.3 Tug and pusher

See Fig 15.

5.1.4 Other vessels

For vessels other than those specified under [5.1.1] to [5.1.3], see Fig 16.

5.2 Main deck

5.2.1 Flush/trunk deck

See Fig 17.

5.2.2 Open deck

See Fig 18.

6 Guide to evaluation of coating

6.1 General

6.1.1 The information and recommendations aiming to support evaluation of the condition of the protective coatings when performing surveys are developed in NI607 Guidelines for Corrosion Protection Applicable to Inland Navigation Vessels.

Figure 13 : Non-propelled cargo vessel

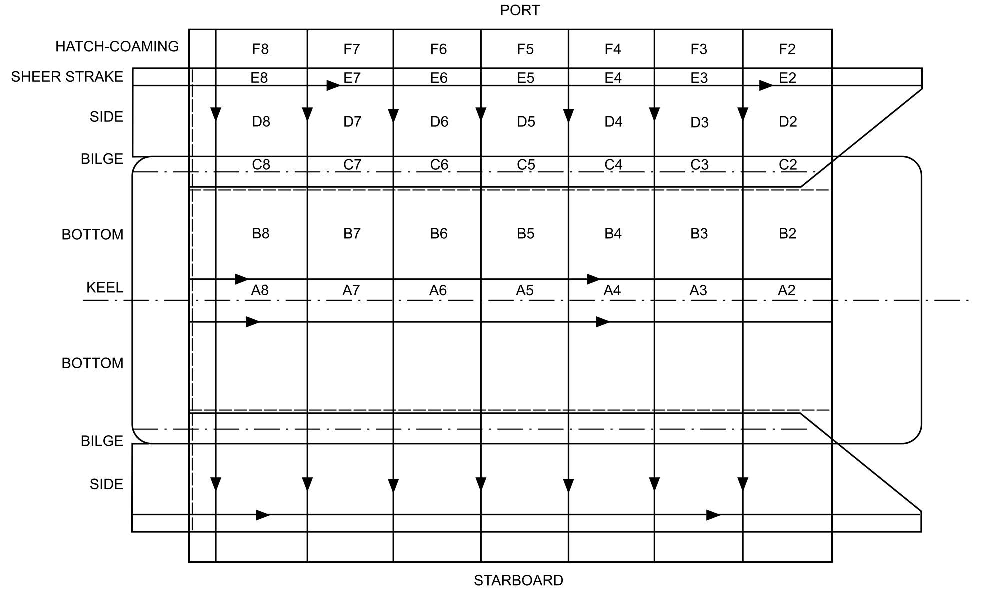


Figure 14 : Pontoon

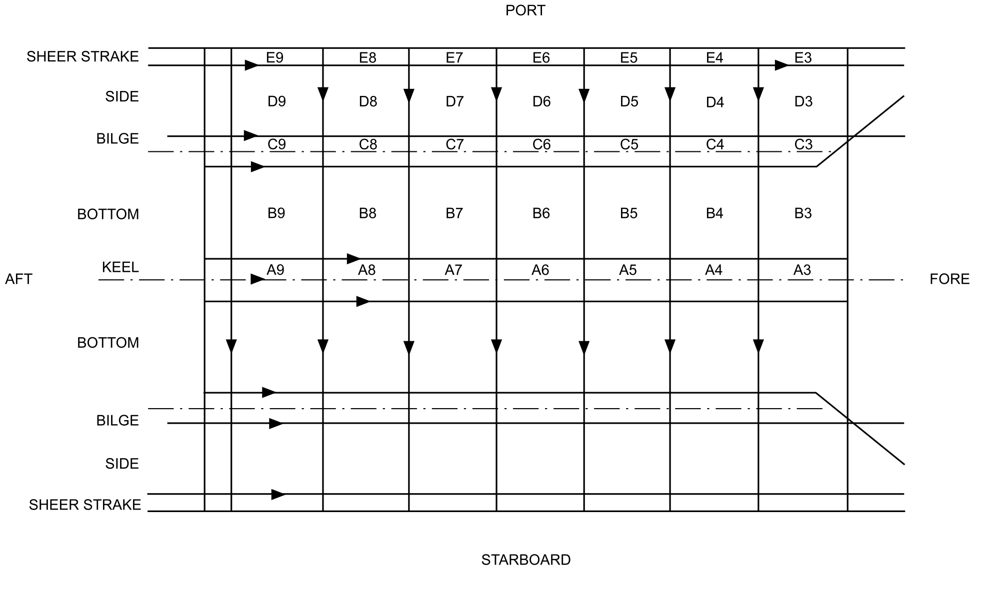


Figure 15 : Tug and pusher

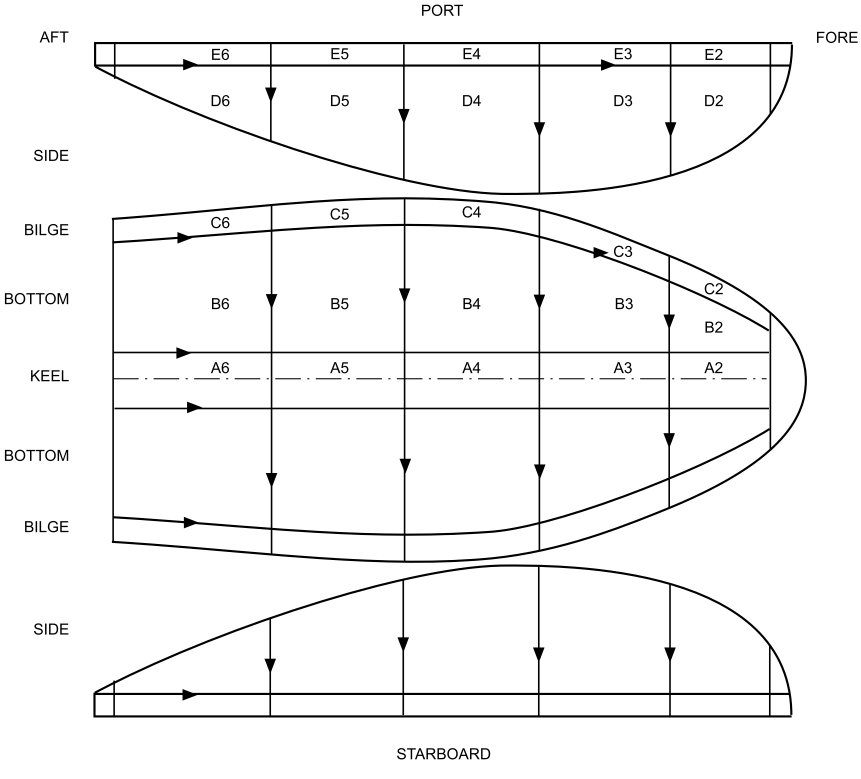


Figure 16 : Other vessels - shell plating

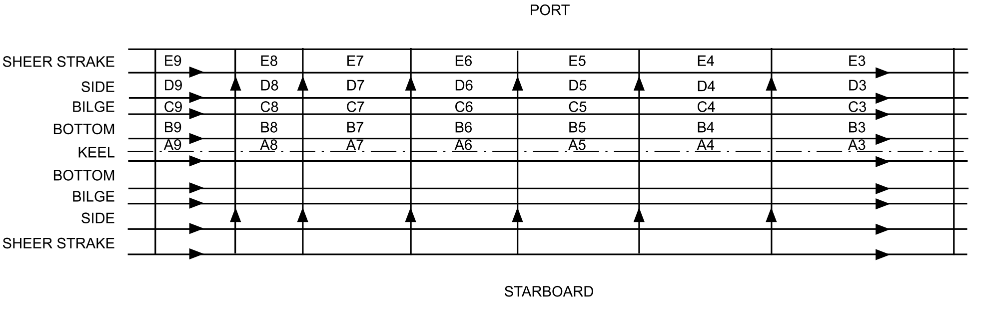


Figure 17 : Deck plating - flush deck vessels

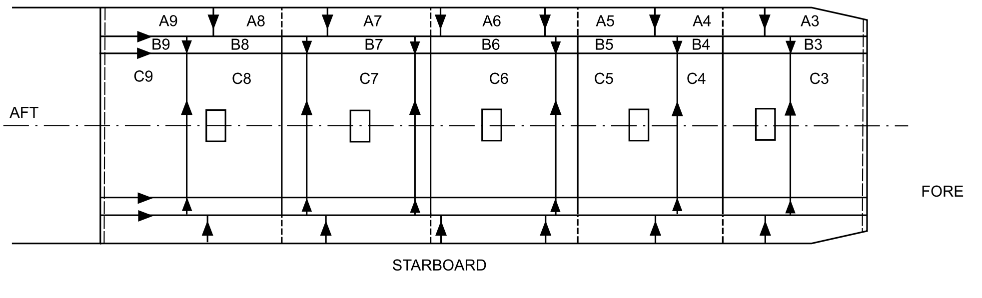
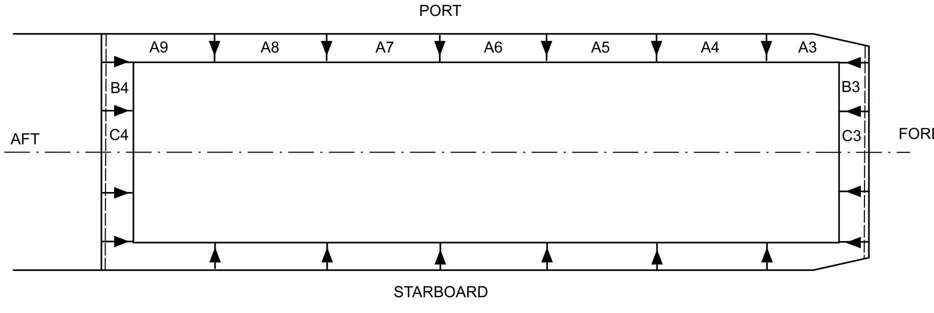


Table 22 : Coating Condition Rating Criteria

Description	Definition
GOOD	Condition with spot rusting is less than 3% of the area under consideration without visible failure of the coating. Rusting at edges or welds, must be less than 20% of edges or weld lines in the area under consideration.
FAIR	Condition with breakdown of coating or rust penetration is less than 20% of the area under consideration. Hard rust scale rust penetration must be less than 10% of the area under consideration. Rusting at edges or welds must be less than 50% of edges or weld lines in the area under consideration.
POOR	Condition with breakdown of coating or rust penetration is more than 20% or hard rust scale is more than 10% of the area under consideration or local breakdown concentrated at edges or welds is more than 50% of edges or weld lines in the area under consideration.
Note 1: Spot rusting is rusting in spots without visible failure of coating **Note 2:** Blistering of coatings is identified as coating failure.	

Figure 18 : Deck plating - open deck vessels



Part A
Classification and Surveys

Chapter 3
SURVEYS FOR MAINTENANCE OF CLASS

SECTION	1	ANNUAL SURVEY
SECTION	2	INTERMEDIATE SURVEY
SECTION	3	CLASS RENEWAL SURVEY
SECTION	4	SURVEY OF PROPELLER SHAFTS, PROPELLERS AND OTHER PROPULSION SYSTEMS
SECTION	5	BOTTOM SURVEY
SECTION	6	PRESSURE EQUIPMENT
SECTION	7	ADDITIONAL SURVEYS RELATED TO SERVICE NOTATIONS
SECTION	8	ADDITIONAL SURVEYS RELATED TO ADDITIONAL SERVICE FEATURES
SECTION	9	SCOPE OF SURVEYS RELATED TO ADDITIONAL CLASS NOTATIONS
APPENDIX	1	CLASS REQUIREMENTS AND SURVEYS OF LAID-UP VESSELS

SECTION 1 ANNUAL SURVEY

1 General

1.1 Application

1.1.1 An annual survey is required only for:

- vessels assigned with additional class notation **Annual survey** according to Ch 1, Sec 3, [11.1], and
- vessels complying with Ch 2, Sec 2, [5.2.2].

1.1.2 Depending on the findings of previous surveys, the Society may also require an annual survey, covering the check of the main hull elements and of components which are of significance for the vessel's safety, to be carried out.

1.2 Scope

1.2.1 For the vessels covered by [1.1.1], the annual survey is to be carried out according to Pt D, Ch 2, Sec 9, [2].

1.2.2 Where [1.1.2] applies, the scope and extent of the survey will be defined by the Society, on a case by case basis.

SECTION 2 INTERMEDIATE SURVEY

1 General

1.1

1.1.1 The requirements of this Section apply to intermediate surveys of all vessels. The specific requirements for intermediate surveys related to service notations, additional service features and additional class notations assigned to vessels are addressed in Ch 3, Sec 7, Ch 3, Sec 7 and Ch 3, Sec 9, respectively.

1.1.2 A survey planning meeting is to be held prior to the commencement of the survey.

1.1.3 For vessels assigned additional class notation **Annual survey** and vessels complying with Ch 2, Sec 2, [5.2.2], the intermediate survey is to be carried out according to Pt D, Ch 2, Sec 9.

1.1.4 The intermediate survey is to include examination and checks on a sufficiently extensive part of the structure to show that the structures of the vessel are in satisfactory condition so that the vessel is expected to operate until the end of the current period of class, provided that the vessel is properly maintained and other surveys for maintenance of class are duly carried out during this period.

2 Surveys performance

2.1 General

2.1.1 Intermediate survey shall include all the inspections and checks required for eventual annual surveys. Additionally, the requirements stated under [3] to [5] shall be observed.

Note 1: More extensive Regulations of the country, where the vessel is registered, are to be observed.

2.1.2 Additional requirements may have to be observed for particular vessel types, due to the request of the Owner or in connection with manufacturer's recommendations for special equipment.

3 Hull and hull equipment

3.1 General

3.1.1 The main structural elements of the hull are to be subjected to a general visual inspection, as far as accessible. If applicable, ballast tank, storage and engine rooms are to be surveyed at random, depending on the vessel type and the age and general condition of the vessel. Where damages or excessive wastage affecting the class are suspected, the Surveyor is entitled to carry out further investigations as well as thickness measurements, if required.

3.1.2 The rudder and manoeuvring arrangement and the anchor equipment are to be checked for visible damages. For the related machinery and for operability, see [4.1.1].

3.1.3 The foundations and their substructure of special equipment, particularly on the upper deck, shall be inspected for damages.

3.1.4 Compartments and rooms normally not accessible, or accessible only after special preparations, may be required to be opened for inspection, depending on the vessel's age and available information about service conditions.

3.2 Ballast tanks

3.2.1 Depending on the vessel's age, the Surveyor may require opening of ballast tanks for visual inspection, particularly if deterioration of the coating or excessive wastage has already been observed at previous surveys.

If the coating in such ballast tanks is found to be in poor condition (see Ch 2, Sec 2, [2.2.9]), maintenance of class is to be subject to the tanks in question being examined at annual intervals, and thickness measurements carried out as considered necessary.

If coating is to be partly or totally renewed, only approved coating is applicable in the case of a repair. The whole working procedure including the surface preparation has to be documented.

3.3 Hatches and covers, bow, side and stern doors

3.3.1 Hatches and covers, bulkhead and hull doors, ramps and any openings in the outer shell shall be surveyed regarding structural integrity as well as tightness and operability of all closures.

3.3.2 Additionally to the overall survey the following structural members of bow, side and stern doors are to be thoroughly inspected:

- all hinges and the pertinent hydraulic cylinders in way of their securing points
- all securing elements of the locking devices and stoppers.

3.3.3 Where considered necessary by the Surveyor, additionally crack tests shall be carried out at structural members of bow, side and stern doors.

Essentially, the crack tests will cover:

- main joining welds and their interfacial areas both on the vessel's hull and on the doors
- highly stressed areas in way of the centres of rotation of the hinges
- highly stressed areas of the locking devices and their stoppers
- repair welding.

For crack detection the dye penetration method or the magnetic particle inspection method shall be employed, and a test protocol is to be prepared.

3.4 Dry dock survey

3.4.1 Intermediate surveys have to be carried out in dry-dock in the following cases:

- the vessel's shell is riveted, at the Surveyor's discretion
- the vessel's age exceeds 20 years, at the Surveyor's discretion
- the vessel's age exceeds 20 years and the service notation granted is tanker for transport of dangerous goods
- the vessel is granted with the range of navigation **IN(1,2 < x ≤ 2)**, at the Society's discretion, depending on the frequency of operation in restricted maritime stretches of water or lakes (salt or brackish waters).

For performance of dry dock surveys, see Ch 3, Sec 5, [2].

3.4.2 Hull plates before protective application, appendages, discharge valves, river chests, etc. have to be examined. In case of doubt, thickness measurements can be requested by the Surveyor.

4 Machinery and electrical installations

4.1 General

4.1.1 The machinery including electrical installations will be subjected to the following surveys and operational checks:

- general inspection of machinery and boiler rooms, with special regard to the propulsion system, the auxiliary engines, possible fire and explosion sources, and checking of emergency exits as to their free passage
- external inspection of boilers and pressure vessels, with their appliances and safety devices. For details regarding boilers, see Ch 3, Sec 6
- inspection and checking of the remote control, quick-closing/stopping devices of pumps, valves, ventilators, etc.
- random checking of the remote control and automation equipment
- inspection and functional checking of the main and auxiliary steering gear, including their appliances and control systems
- if applicable, checking of all communication systems between bridge and machinery/boiler and steering gear rooms
- inspection of the bilge system, including remote control actuators and bilge filling level monitors
- checking of the main and emergency power supply systems, including the switch gear and other important electrical installations
- survey of explosion-proof installations
- random inspection and checking of essential equipment to the Surveyor's discretion.

4.2 Fire extinguishing systems

4.2.1 General requirement

The following items/systems are subject to inspection and/or testing, where applicable:

- fire mains system, including hoses and nozzles
- gas fire extinguishing system
- dry powder fire extinguishing system
- foam fire extinguishing system
- sprinkler system, including water mist sprinkler system
- water and/or foam drencher system
- any other fixed fire extinguishing system provided
- portable fire extinguishers, mobile fire extinguishers, including portable foam application units
- fire detection and alarm systems
- emergency stops for ventilation fans, boiler forced draft fans, fuel transfer pumps, fuel oil purifiers
- quick-closing fuel valves
- fire closures, fire dampers, etc.
- fireman's outfits, if required.

4.2.2 Fire hoses and nozzles

Fire hoses and nozzles provided are to be included in the testing of the fire mains system to the Surveyor's discretion.

4.2.3 Fixed fire extinguishing systems

Fixed fire extinguishing systems, such as gas, foam, dry powder or water mist systems, including gas cylinders are subject to maintenance every 2 years.

On the occasion of these inspections all hose assemblies must be subjected to a visual check. All hose assemblies made of synthetic rubber must be replaced according to manufacturer's instructions.

The installation, maintenance, monitoring and documentation of fixed fire extinguishing systems according to Statutory Regulations, for the engine room, pump room and all spaces containing essential equipment, such as switchboards, compressors, etc., and for the refrigeration equipment, if any, shall only be performed by recognized specialized companies.

4.2.4 Portable and mobile fire extinguishers

Portable and mobile fire extinguishers are subject to inspection by approved or recognized specialized company every 2 years. Maintenance and eventual pressure testing shall be carried out as appropriate in accordance with the manufacturer's instructions or applicable Rules. Each extinguisher is to be provided with a label showing the date of inspection and name and signature of the approved or recognized specialized company.

A protocol of the inspections and maintenance work carried out is to be kept on board.

4.2.5 Foam concentrate

Foam concentrate for fixed foam fire extinguishing systems is to be examined not later than 3 years after filling into the system, and yearly thereafter. The examination is to be performed by the manufacturers or by an independent recognized laboratory. Reports are to be presented to the Surveyor. Manufacturer's certificates stating the properties of the foam concentrate shall be available on board for reference.

The foam concentrate for the portable foam applicators is to be renewed on the occasion of each class renewal.

More extensive regulations regarding other inspection intervals/performance of the tests should be observed.

4.3 Machinery

4.3.1 Measurements

The following measurements are generally to be performed unless it can be proved by valid protocols that they have been carried out recently:

- crank web deflection, main engine(s)
- crank web deflection, auxiliary diesel engine(s) (where relevant)
- axial thrust bearing clearance of shafting system(s).

4.3.2 Operational tests

In addition to the requirements under [4.1.1], the following system components are to be subjected to operational tests:

- emergency generating set, including emergency switchboard (where applicable)
- emergency bilge valve(s)
- bilge, ventilation and monitoring systems for the carriage of dangerous substances
- drainage facilities of starting-air and control-air receivers
- general operational test of the machinery and electrical installation to demonstrate unrestricted operability, as indicated by the Surveyor.

4.3.3 Monitoring equipment

The monitoring equipment and the automated functions of the machinery installation are to be subjected to operational trials under service conditions. The bridge remote control equipment of the propulsion system will be examined as required by the Surveyor.

4.4 Electrical installations and equipment

4.4.1 The Surveyor will check the good condition, particularly the earthing of the electrical equipment, and the satisfactory operating condition of the entire electrical installation. If he judges it necessary, the insulation measurements of the electrical installation will be carried out.

4.5 Automated installations

4.5.1 The good working of the fire detectors and bilge floating alarms is to be checked. The satisfactory operation of some selected equipment (alarms, safety equipment, automatic equipment, etc.) has to be checked.

5 Pressure equipment

5.1 General

5.1.1 For steam boiler installations, thermal oil plants and pressure vessels, see Ch 3, Sec 6.

SECTION 3 CLASS RENEWAL SURVEY

1 General

1.1

1.1.1 The requirements of this Section apply to class renewal surveys of all vessels. The specific requirements for class renewal surveys related to service notations, additional service features and additional class notations assigned to vessels are addressed in Ch 3, Sec 7, Ch 3, Sec 8 and Ch 3, Sec 9, respectively.

1.1.2 A survey planning meeting is to be held prior to the commencement of the survey.

1.1.3 The class renewal survey is to include sufficiently extensive examination and checks to show that the structures, main and auxiliary machinery, systems, equipment and various arrangements of the vessel are in satisfactory condition or restored to such condition as to allow the vessel to operate for the new period of class of **p** years to be assigned, provided that the vessel is properly maintained and operated and other surveys for maintenance of class are duly carried out during this period.

The examinations of the hull are to be supplemented by thickness measurements and testing as required in [2.4] and [2.5], to ensure that the structural integrity remains effective. The aim of the examination is to discover substantial corrosion, significant deformation, fractures, damages or other structural deformation that may be present.

1.1.4 The Owner is to provide the necessary facilities to enable this class renewal survey. The conditions for survey as detailed in Ch 2, Sec 2, [2.6] and Ch 2, Sec 2, [2.7] are to be met.

2 Hull and hull equipment

2.1 Bottom survey in dry condition

2.1.1 A bottom survey in dry condition is to be carried out, as detailed in Ch 3, Sec 5, [2], and in addition the requirements given in [2.1.3] to [2.1.5] are to be complied with.

2.1.2 For vessels of unusual characteristics or engaged on special services, means of underwater inspection equivalent to the bottom survey in dry condition may be considered as an alternative by the Society, particularly when a suitable high resistance paint is applied to the underwater portion of the hull.

2.1.3 Anchors, windlass(es) and chain cables are to be ranged and examined, and the required complement and condition are to be checked. When the vessel is more than 5 years old, chain cables are to be gauged.

Any length of chain cable which is found to be damaged or excessively worn is to be renewed.

2.1.4 River valves and cocks are to be opened up for internal examination.

2.1.5 Thickness measurements of the outer shell plating, as and if required within the scope of the related class renewal survey, are to be carried out (refer to [2.5]), if not already done within 12 months before the end of class period.

2.2 Decks, hatch covers and equipment

2.2.1 Decks are to be examined, particular attention being given to the areas where stress concentration or increased corrosion are likely to develop, such as hatch corners and other discontinuities of structure.

Deck erections such as hatch coamings, deckhouses and superstructures are to be examined.

The sheathing of wood-sheathed steel decks may be removed, at the Surveyor's discretion, in the case of doubt as to the condition of plating underneath.

Due attention is to be given to the examination in way of end and side openings and related shell and inner doors.

2.2.2 The hatch covers and coamings are to be surveyed as follows:

- a thorough survey of the items listed in Ch 3, Sec 2, [3.3] including close-up survey of hatch cover plating and hatch coaming plating, is to be carried out
- checking of the satisfactory operation of all mechanically operated hatch covers is to be made, including stowage and securing in open condition, proper fit, locking and efficiency of sealing in closed position, operational testing of hydraulic and power components, wires, chains and link drives
- checking the effectiveness of sealing arrangements of all hatch covers by hose testing or equivalent is to be carried out.

2.2.3 The survey of hull equipment is to cover the following points:

- windlass and chain stoppers, with disassembly as deemed necessary to verify the condition of the equipment and control and safety devices, hawse pipes
- steering arrangements, including steering gear, control and indication devices, operational tests and disassembly as deemed necessary; in the case of chain and rod gears, chains, rods, sheaves, pins and rollers are to be examined for wear
- connection of masts and standing rigging to the hull structure as well as condition of structure underneath.

2.2.4 All bilge and ballast piping systems are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory.

2.3 Holds and other dry compartments

2.3.1 Holds, cofferdams, pipe tunnels and duct keels, void spaces and other dry compartments which are integral to the hull structure are to be internally examined, ascertaining the condition of the structure, bilges and drain wells, sounding, venting, pumping and drainage arrangements.

2.3.2 Machinery and boiler spaces, pump rooms and other spaces containing machinery are to be internally examined, ascertaining the condition of the structure. Particular attention is to be given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops, and bulkheads in way of tank tops and bilge wells. Particular attention is to be given to the river suctions, river water cooling pipes and overboard discharge valves and their connections to the shell plating. Where wastage is evident or suspected, thickness measurements are to be carried out, and renewals or repairs effected when wastage exceeds allowable limits.

2.3.3 Chain lockers are to be internally examined, while the anchor chains are ranged as required for the bottom survey in dry condition (see [2.1.3]). The pumping arrangement of the chain lockers is to be tested.

2.4 Tanks

2.4.1 The type and number of tanks to be internally examined at each class renewal survey are detailed in Tab 1.

This internal examination is to ascertain the condition of the structure, bilges and drain wells, sounding, venting, pumping and drainage arrangements, including piping systems and their fittings. Due attention is to be given to plating or double plates below the lower end of sounding and suction pipes.

Where the inner surface of the tanks is covered with cement or other compositions, the removal of coverings may be waived provided they are examined, found sound and adhering satisfactorily to the steel structures.

Note 1: Due attention is also to be given to fuel oil piping passing through ballast tanks, which is to be pressure tested when the vessel is more than 10 years old.

2.4.2 For ballast tanks, excluding double bottom tanks, where a hard protective coating is found in poor condition and it is not renewed, where soft or semi-hard coating has been applied or where a hard protective coating was not applied from time of construction, the tanks in question are to be examined at annual intervals. Thickness measurements are to be carried out as deemed necessary by the Surveyor.

When such breakdown of hard protective coating is found in double bottom ballast tanks and it is not renewed, where a soft or semi-hard coating has been applied, or where a hard protective coating was not applied from the time of construction, the tanks in question may be examined at annual intervals. When considered necessary by the Surveyor, or where extensive corrosion exists, thickness measurements are to be carried out.

2.4.3 For integral tanks which are intended to contain liquid cargoes such as edible oil, the Surveyor may waive the requirement specified in [2.4.5] subject to a satisfactory internal examination.

2.4.4 Boundaries of double bottom, deep, ballast, peak and other tanks, both integral and independent tanks, including holds adapted for the carriage of salt water ballast, are to be tested with a head of liquid to the top of air pipes or to near the top of hatches for ballast/cargo holds.

Table 1 : Requirements for internal examination of integral (structural) tanks at class renewal survey

Tank	Class renewal survey No. I	Class renewal survey No. II	Class renewal survey No. III	Class renewal survey Nos. IV and subsequent
Peaks (all use)	all	all	all	all
Water ballast tanks (all types)	all	all	all	all
Fresh water	none	one	all	all
Fuel oil bunkertanks:				
• Engine room	none	none	one	one
• Cargo length area	none	one	two **(1)**	half, minimum two **(1)**
Lubricating oil tanks	none	none	none	one
Cargo tanks	all	all	all	all

(1) One deep tank is to be included, if fitted.

Note 1: Independent non-structural tanks located in machinery spaces are to be externally examined; the relevant fittings, with particular regard to the remote control shut-off valves under hydrostatic head, are to be externally examined to check the efficiency of manoeuvres and the absence of cracks or leakage.

Note 2: The extent of the survey of tanks dedicated to liquids other than those indicated in this table will be considered by the Society on a case by case basis according to the nature of the liquids.

Note 3: If a selection of tanks is accepted to be examined, then different tanks are to be examined at each class renewal survey, on a rotational basis. Tanks not internally examined may be examined externally from accessible boundaries.

2.4.5 Boundaries of fuel oil, lube oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil, lube oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries, and a confirmation from the Master stating that the pressure testing has been carried out according to the requirements with satisfactory results. The Surveyor may extend the testing as deemed necessary.

2.4.6 The test pressure to be applied is defined in Pt B, Ch 3, Sec 4, [5] and Pt B, Ch 8, Sec 4.

2.5 Thickness measurements

2.5.1 General

Thickness measurements required for hull structural elements are to be carried out in compliance with Ch 2, App 1.

2.5.2 Hull equipment

In class renewal II and all subsequent class renewals the cross sectional areas of the anchor chain cables are to be determined. The mean diameters of the anchor chain cables are to be determined by representative measurements, approximately 3 links per length of 27,5 m, made at the ends of the links where the wear is the greatest. The weights of the anchors are to be checked in class renewal III and all subsequent class renewals. For permissible tolerances, see Ch 2, Sec 2, [2.4.2].

2.5.3 Piping system

Where thickness measurements of piping system are carried out, they are to be checked against permissible tolerances according to Ch 2, Sec 2, [2.4.3].

2.6 Additional inspection and check - Class renewal I

2.6.1 Hull structure

Thickness measurements are to be carried out in way of suspect areas, defined in Ch 2, Sec 2, [2.2.11].

2.6.2 Rudder, equipment, deck openings, etc.

The class renewal survey also covers other parts essential for the operation and safety of the vessel, such as rudder and steering gear, watertight doors, sluice valves, air and sounding pipes, gas-freeing and safety arrangements of cargo tanks, life-boat davits, companionways, hatches, scuppers and water drain pipes with their valves, fire protecting arrangements, masts, anchors, anchor chains and hawsers.

The rudder, rudder couplings and bearings, as well as the stock are to be surveyed in mounted condition, the rudder clearance to be measured and documented. The steering gear is to be subjected to an operational trial.

If considered necessary in view of the inspection results, the rudder and/or parts of the steering gear may have to be dismantled.

Bow, side and stern doors, if any, are to be checked.

2.6.3 Engine room structure

Particular attention is to be given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops, engine room bulkheads in way of tank top and the bilge wells. Where wastage is evident or suspected, thickness measurements are to be carried out.

2.7 Additional inspection and check - Class renewal II

2.7.1 The requirements for the second class renewal include those for class renewal I. Additionally the following investigations are to be carried out.

2.7.2 The structural parts behind ceilings, floor coverings and insulation are to be examined, as required by the Surveyor and depending on the general condition of the vessel, see also [2.8.2].

2.7.3 The chain cables are to be ranged so that they can be examined for wear and other damages throughout their length. The mean diameter of the anchor chain cables is to be determined on at least 3 links per length.

2.8 Additional inspection and check - Class renewal III and subsequent ones

2.8.1 The requirements for the third and the subsequent class renewals include those for the class renewal II. Additionally, the following investigations are to be carried out.

2.8.2 Ceilings, linings and insulation of all spaces and cargo holds including steel ceiling adjacent to the shell plating and the inner bottom shall be removed, as indicated by the Surveyor, to enable the steel structure to be examined in detail.

For class renewals III and subsequent ones, the inner bottom ceilings may be partially removed at the Surveyor's discretion, to enable their assessment.

For class renewals IV and subsequent ones, the inner bottom ceilings are to be completely removed and the tank top is to be carefully cleaned, such as to enable proper assessment of the tank top's condition.

The wall lining underneath windows in the outer shell is to be lifted as required by the Surveyor so that the structure behind may be examined.

2.8.3 The rudder body is to be examined. The connections to the rudder stock and pertinent securing devices are to be inspected. Clearance has to be checked.

The rudder stock is to be surveyed as far as accessible. If deemed necessary in view of findings during this external inspection, the stock is to be dismantled. In way of the bearings, stock and pintle are to be examined for corrosion.

2.8.4 The weight of the anchors is to be checked.

3 Machinery and electrical installations

3.1 General

3.1.1 Except for individual machinery components as indicated in the following, the scope of all class renewal surveys related to the machinery including electrical installations is identical.

The class renewal survey includes the surveys and checks in Ch 3, Sec 2, [4].

3.2 Surveys requiring dry docking

3.2.1 While the vessel is in dry dock, the river inlet and discharge valves are to be examined as to their condition and to be opened up and overhauled once within the class period.

Bow thrusters and positioning equipment are to be subjected to a general survey and to trials upon floating of the vessel.

For propeller(s), propeller and stern tube shaft(s), see Ch 3, Sec 4.

3.3 Propulsion system

3.3.1 Inspection of the propulsion system is mainly to cover:

- intermediate shafts and bearings, including thrust bearings
- gearing
- mechanical and flexible couplings
- turning gear
- the main propulsion engines, see [3.4.1].

3.3.2 Spring elements under shear load made of rubber (with or without plies of fabric), of rubber ring clutches and other rubber couplings, are to be renewed, if required on account of negative inspection results.

3.4 Main propulsion diesel engines

3.4.1 The following components are to be inspected and checked in the dismantled condition, where deemed necessary by the Surveyor:

- cylinders, cylinder covers, pistons, piston rods and bolts, cross heads, crankshaft and all bearings
- camshaft, with drive and bearings
- tie rods, frame, foundation and fastening elements
- injection system, attached pumps and compressors, superchargers, suction and exhaust lines, charging air coolers, filters, monitoring, control, protective and safety devices, starting, reversing and manoeuvring equipment.

Class renewal survey of the main engine can be made during the main overhaul subject to the presence of the Surveyor.

Note 1: In case of medium speed diesel engines, dismantling and replacement of main and crank bearings may be postponed until the service life limits have been reached.

3.5 Auxiliary engines

3.5.1 For all auxiliary engines, the survey scope is identical to that applying to the main engines. A reduction in the scope of survey may be agreed to upon examination of the maintenance protocols.

3.6 Auxiliary machinery, equipment and piping, survey performance

3.6.1 The following components are to be inspected and tested in dismantled condition, where deemed necessary by the Surveyor:

- all pumps of the essential systems
- air compressors, including safety devices
- separators, filters and valves
- coolers, pre-heaters
- main and auxiliary steering gear
- anchor and other windlasses, including drives
- piping, pipe connections, compensators and hoses
- emergency drain valves and bilge piping systems
- tank filling level indicators
- installations preventing the ingress of water into open spaces
- freshwater distillation plant, where provided
- oil purifier and sewage systems
- additional systems and components, where deemed necessary by the Surveyor, as well as special equipment and installations if included in the scope of classification.

3.7 Electrical installations

3.7.1 On main and emergency switchboards, after cleaning when necessary, feeder circuit breakers being open, busbar circuit closed, measuring and monitoring instruments disconnected, the resistance of insulation measured across each insulated busbar and hull, and across insulated busbars is not to be less than 1 megohm.

3.7.2 For generators, the equipment and circuits normally connected between the generator and first circuit breaker being connected, preferably at working temperature whenever possible, the resistance of insulation, in ohms, is to be more than 1000 times the rated voltage, in volts. The insulation resistance of generators separate exciter gear is not to be less than 250000 ohms.

3.7.3 With all circuit breakers and protective devices closed, except for the generators, the insulation resistance of the entire electrical system is to be checked.

In general, the resistance is not to be less than 100000 ohms. However, the variation of the resistance with time is to be checked by comparing the current figure with previous readings. If insulation resistance drops suddenly or is insufficient, the defective circuits are to be traced by disconnecting the circuits as necessary.

3.7.4 These measurements are subject to a report to be submitted to the Surveyor. In case the results are not satisfactory, supplementary investigation and necessary repairs have to be carried out to the Surveyor's satisfaction.

3.7.5 The proper operation of the remote stopping systems of:
- transfer and fuel oil pumps
- forced draught fans and engine room ventilation fans,

are to be verified.

3.7.6 The proper operation of navigation lights and associated alarms and signal devices has to be verified.

3.8 Automated installations

3.8.1 The class renewal survey of classed automated installations consists of
- a general examination of the control systems and random check of the proper operation of the main measuring, monitoring, alarm and automatic shut-off systems
- the checking of the fire detectors and bilge flooding alarms
- the checking of a number of other alarm channels selected at random, according to complementary program of the examinations, tests and checks prepared in agreement with the Owner and based upon operating conditions of the vessel and the experience of previous surveys.

These checks are to carried out in normal operation, when practicable, or by simulation.

3.9 Pipes in tanks

3.9.1 Where pipes are led through tanks, they are to be examined and, if required by the Surveyor, subjected to hydraulic tests, if for the respective tanks an internal examination is required. Depending on the results obtained, thickness measurements may be required.

3.10 Fire extinguishing and fire alarm systems

3.10.1 General requirements

Proof is to be furnished to the Surveyor that the entire fire extinguishing equipment is ready for operation and in a satisfactory condition.

On the occasion of every class renewal survey, the installation must be subjected to a visual inspection and test, if deemed necessary by the Surveyor.

Equipment (cylinders, bottles, fire extinguishers, etc.) has to be inspected according to the manufacturer's instructions or applicable codes by an approved or recognized company. Reports of these inspections have to be provided to the Surveyor.

Emergency exits/escapes are to be inspected.

3.11 Trials

3.11.1 Upon completion of the surveys for class renewal, the Surveyor must be satisfied that the machinery installation including electrical installations and steering gear, as well as special equipment and installations are operable without restrictions. In case of doubt, trials and/or operational tests may be necessary.

4 Pressure equipment

4.1 General

4.1.1 For steam boiler installations, thermal oil plants and pressure vessels, see Ch 3, Sec 6.

SECTION 4 SURVEY OF PROPELLER SHAFTS, PROPELLERS AND OTHER PROPULSION SYSTEMS

1 Normal survey of propeller shafts

1.1 Survey with drawing of the shaft

1.1.1 The normal survey of propeller shafts consists of the following, as applicable:

a) removal of propeller and key, where fitted, and their examination

b) complete withdrawal of shaft to permit the examination of sterntube bearings (outboard or inboard depending on the type of shaft)

c) examination by an appropriate crack detection method of the after end of the cylindrical part of the shaft and forward one third of shaft cone, or the fillet of the flange in the case of a flanged coupling

d) examination of shaft bearing surfaces, liners, joints, threaded end and nut

e) examination of oil sealing glands with the necessary dismantling

f) measurements of clearances and/or weardown (prior to and after the survey) and their recording.

1.2 Survey without drawing of the shaft

1.2.1 Where the prerequisites as defined in Ch 2, Sec 2, [5.5.2] apply, for oil lubricating arrangement the scope of normal survey without drawing of the shaft consists in the following:

- examination of all accessible parts of the shaft including the propeller connection to the shaft
- non-destructive examination by an approved crack-detection method of the aft end of the cylindrical part of the shaft and of about one third of the length of the taper from the large end and of the area of the keyway for keyed propellers, or of the forward part of the aft shaft taper for keyless propellers, or of the after fillet flange area of the shaft for solid flange coupling propellers. The area to be examined is to be sufficiently exposed, if necessary by shifting of the propeller shaft or backing-off of the propeller
- examination of the bearing clearances, respectively wear down of the aft bearing
- overhaul of the shaft sealing glands according to manufacturer's instructions (sealing rings, liners, etc.)
- examination of the records of all regularly carried out lubricating oil analyses
- examination of the records of the oil consumption.

Where doubts exist regarding the findings, the shaft is to be drawn to permit an entire examination.

The crack detection test of the aft flange fillet area of the shaft for solid flange coupling propellers may in the case of proven designs be omitted with the agreement of the Society. See also Ch 2, Sec 2, [5.5.2].

2 Modified survey of propeller shafts

2.1 General

2.1.1 A modified survey may be carried out for those propeller shafts which fulfill the conditions described in Ch 2, Sec 2, [5.5.3].

2.2 Performance

2.2.1 The modified survey for all types of shafts consists of the following:

- check of oil sealing glands in place
- measurements of weardown and their recording
- examination of the results of sterntube lubricating oil analyses, to confirm they have been regularly performed and the recorded parameters are within acceptable limits
- check of the records of lubricating oil consumption, to confirm it is within permissible limits.

In addition, for the different types of shafts, the following is required:

a) for shafts with keyed propeller coupling:
    - removal of propeller and key, and their examination in way of the connection area
    - examination by an appropriate crack detection method of the after end of the cylindrical part of shaft and forward one third of shaft cone

b) for shafts with keyless type propeller coupling:
    - check of the tightness of the propeller hub (propeller hood, fore gland)

c) for shafts with a solid flange coupling at the aft end and variable pitch propeller:
    - check of tightness in way of blade glands and distribution box
    - check of analysis of hydraulic oil
    - working test, as far as practicable, of the blade manoeuvring.

2.2.2 Where the Surveyor considers that the data presented is not entirely to his satisfaction, further dismantling may be required, including withdrawal of the propeller shaft.

3 Propellers

3.1 General

3.1.1 Propellers are to be examined visually on the occasion of each propeller shaft survey.

3.1.2 Damages, such as cracks, deformation, cavitation effects, etc. are to be reported and repaired at the Surveyor's discretion.

Controllable pitch propellers are to be checked for oil leakages. The function of the controllable pitch propellers has to be tested. The maintenance according to manufacturer's instructions has to be checked.

4 Rotating and azimuth thrusters

4.1 General

4.1.1 A scope of survey equivalent to that described in [4.1.2] may be agreed upon with the Surveyor, depending on the manufacturer's instructions/recommendations.

4.1.2 The periodical survey of rotating and azimuth thrusters consists of:

a) removing the propeller(s) in order to examine the following items, as applicable:
   - exposed parts
   - cone and keyway to be checked by an appropriate crack detection method
   - sealing glands
   - threaded end and nut

b) examining the results of a lubricating oil analysis (water content and presence of material particles) to detect possible deterioration of internal gears and bearings

c) examining the orientation device.

If the foregoing checks are not satisfactory, dismantling of the internal parts may be required.

5 Vertical axis propellers

5.1 General

5.1.1 A scope of survey equivalent to that described in [5.1.2] may be agreed upon with the Surveyor, depending on the manufacturer's instructions / recommendations.

5.1.2 The periodical survey of vertical axis propeller systems consists of:
- checking the tightness of the oil glands and the backlash of the gears from outside by action on the blades
- checking the condition of gears and couplings from inside the vessel
- examining the results of a lubricating oil analysis (water content and presence of material particles) to detect possible deterioration of internal gears and bearings.

If the foregoing checks are not satisfactory, dismantling of the internal parts may be required.

6 Pump jet systems

6.1 General

6.1.1 A scope of survey equivalent to that described in [6.1.2] may be agreed upon with the Surveyor, depending on the manufacturer's instructions / recommendations.

6.1.2 The periodical survey of pump jet systems consists of examining the following parts:
- impeller, shaft and clearances of bearings
- tightness of gland
- water duct
- steering nozzle
- reversing arrangements and control gear.

If the foregoing checks are not satisfactory, further dismantling may be required.

7 Pod propulsion systems

7.1 General

7.1.1 The scope of complete and - where applicable- modified survey of the pod propulsion system shafting arrangement is the one detailed in [1] and [2] for propeller shafts.

7.1.2 Where the system is fitted with:
- a vibration monitoring of roll bearings
- a temperature monitoring of bearings, and
- a monitoring of automatic bilge pumping system,

the shaft need not be withdrawn at the complete survey and items b) and d) of [1.1] need not be covered provided that all condition monitoring data (vibrations and temperatures in way of bearings, consumption and analysis of lubricating oil, running rate of bilge system) are found to be within permissible limits and the remaining requirements for the complete survey are complied with.

Where the Surveyor considers that the data presented is not to his satisfaction, further dismantling are to be required.

SECTION 5 BOTTOM SURVEY

1 General

1.1

1.1.1 Examinations of the outside of vessel's bottom and related items of vessels is normally to be carried out with the vessel in dry-dock or on a slipway. However, consideration may be given to alternate examination while the vessel is afloat as an in-water survey, subject to provisions of Ch 2, Sec 2, [5.4] and [3].

2 Dry dock survey

2.1 General

2.1.1 Vessels are generally to be subjected to a bottom survey once during the class period. As a matter of principle, class renewal includes a bottom survey in dry-dock.

2.1.2 Intermediate surveys have to be carried out in dry-dock in the following cases:

- the vessel's shell is riveted, at the Surveyor's discretion
- the vessel's age exceeds 20 years, at the Surveyor's discretion
- the vessel's age exceeds 20 years, the service notation granted is **Tanker** and the vessel is intended for the carriage of dangerous goods
- the vessel is granted with the range of navigation **IN(1,2 < x ≤ 2)**, at the Society's discretion, depending on the frequency of operation in restricted maritime stretches of water or lakes (wave and salt or brackish waters).

Moreover, for each bottom survey performed in addition to the bottom surveys stipulated by the classification requirements, a Society's Surveyor shall be called to attend.

2.2 Performance of dry dock survey

2.2.1 General

For the survey, the vessel is to be placed on sufficiently high and secure blocks, so that all necessary examinations can be carried out in a satisfactory manner. It may be necessary to clean the bottom and outer shell and/or remove rust from some areas to the Surveyor's satisfaction.

2.2.2 Hull bottom survey

The survey covers an examination of the bottom and side plates of the shell plating, including any attachments, the rudder, the scuppers and water drain pipes, including their closures.

2.2.3 Steering gear

The rudder, rudder couplings and bearings, as well as stocks and pintles, are to be surveyed in place, the rudder clearance is to be measured and documented. The steering gear is to be subjected to an operational trial.

If considered necessary in view of the inspection results, the rudder or parts of the steering gear will have to be dismantled.

Bow thrusters are normally to be inspected in place.

2.2.4 Machinery and propulsion systems

For propeller(s), propeller shaft(s), see Ch 3, Sec 4.

River inlet and discharge valves - including those of special equipment, if any - are to be checked as to their condition during each dry docking survey and to be opened up and overhauled once within a period of class.

3 In-water survey

3.1 General

3.1.1 With the prior agreement from the Society, in-water survey may be performed on a case by case basis under the conditions set out in [3.2] to [3.4].

3.2 Approval

3.2.1 The diving firm assisting in in-water surveys must be approved by the Society for this purpose according to the Society's procedures.

3.3 Performance of survey

3.3.1 Unless accessible from outside with the aid of the vessel's trim and/or heel, underwater parts are to be surveyed and/or relevant maintenance work is to be carried out with assistance by a diver whose performance is controlled by a Surveyor, using an underwater camera with monitor, communication and recording systems.

3.3.2 Surveys of the underwater body are to be carried out in sufficiently clear and calm waters.

The vessel should be in light vessel condition.

The shell sides below the waterline and the bottom must be free from fouling.

3.3.3 The underwater pictures on the surface monitor screen must offer reliable technical information such as to enable the Surveyor to judge the parts and/ or the areas surveyed.

3.3.4 Documentation suited for video reproduction including voice is to be made available to Society.

3.4 Additional examinations

3.4.1 Where, for instance, grounding is assumed to have taken place, the Surveyor may demand individual parts of the underwater body to be additionally inspected from inside.

If during the in-water survey damages are found which can be assessed reliably only in dry-dock or require immediate repair, the vessel is to be dry docked. If the coating of the underwater body is in a condition which may cause corrosion damages affecting vessel's class to occur before the next dry docking, the vessel is to be dry docked.

SECTION 6 PRESSURE EQUIPMENT

1 Steam boiler installations

1.1 General

1.1.1 Auxiliary steam generators/boilers external and internal inspections are to be carried out at intermediate survey and at class renewal survey.

1.1.2 More extensive Regulations of the country, where the vessel is registered, are to be observed by the Owner.

1.2 External inspection performance

1.2.1 The operability and general condition of the boiler, including its valves and fittings, pumps, piping, insulation, foundation, control and regulating systems and its protective and safety equipment, are to be examined.

1.2.2 In detail, the following items are to be examined:

- the steam boiler plant for leakages
- the condition of the insulation
- the functioning of the indication, control and safety equipment
- the remote controls for the shut-off and discharge valves
- the leakage monitors for the heaters
- the emergency switch-off devices (oil firing, pumps)
- the safety switch-off devices for the oil burner
- lighting, emergency lighting and labelling.

1.3 Internal inspection performance

1.3.1 Where deemed necessary by the Surveyor, the boiler is to be cleaned on the water and flue gas sides and, if required, its outside surfaces are to be uncovered as well, so that all walls subject to pressure may be examined.

1.3.2 Where the design of the boiler does not permit an adequate internal inspection, hydraulic tests may be required. It is left to the Surveyor's discretion to have the internal inspection supplemented by hydraulic tests, if considered necessary on account of the general condition/appearance of the boiler.

1.3.3 Where there are doubts concerning the thickness of the boiler walls, measurements shall be made using a recognized gauging method. Depending on the results, the allowable working pressure for future operation is to be determined.

The hydraulic pressure test is to be carried out to a test pressure of 1,3 times the allowable working pressure. Only after repairs of major damages the test pressure shall be 1,5 times the allowable working pressure. If the maximum allowable working pressure is less than 2 bar, the test pressure shall be at least 1 bar above the maximum allowable working pressure. In no case the test pressure should exceed the test pressure applied during the first inspection of the boiler after completion.

1.3.4 Steam pipes and heating coils shall be examined according to agreed procedures.

1.4 Non periodical inspection

1.4.1 Beyond the above periodical inspections, the Surveyor may require hydraulic tests or extraordinary inspections to be performed on other occasions, e.g. following repairs and maintenance work.

2 Thermal oil plants

2.1 General

2.1.1 Thermal oil plants are subject to periodical surveys. Thermal oil plants are to be subjected to external inspection and functional tests while in operation. At the class intermediate and renewal surveys proof of continued usability of the thermal oil made by a competent testing institution, shall be furnished.

2.1.2 More extensive Regulations of the country, where the vessel is registered, are to be observed by the Owner.

2.1.3 Tightness and pressure test

Tightness and pressure test of the whole plant to the admissible working pressure is to be performed at intervals of **p** years, counting from commencement of initial operation and possibly in connection with a class renewal survey.

Following repairs and renewals of plant components exposed to pressure, a pressure test is to be carried out to 1,5 times the admissible working pressure.

2.2 Internal inspection performance

2.2.1 During the internal inspection every **p** years the heating surfaces and, where appropriate, the combustion chamber, are to be examined for contamination, corrosion, deformations and leakages.

2.3 External inspection performance

2.3.1 For external inspection performance, the following items are to be examined in detail:

- the thermal oil plant for leakages
- the condition of the insulation
- the functioning of the indication, control and safety equipment
- the remote controls for the shut-off and discharge valves
- the leakage monitors for the heaters
- the emergency switch-off devices (oil firing, pumps)
- the safety switch-off devices for the oil burner
- lighting, emergency lighting and labelling.

Reference is to be made to the test reports on the annual checks to be performed by an appropriate testing institution for continued usability of the thermal oil. This is to be confirmed in the report.

3 Pressure vessels

3.1 General

3.1.1 Pressure vessels are to be inspected internally and externally every **p** years (see Ch 1, Sec 2, [4] for definition of **p**), possibly in connection with class renewal survey.

Pressure vessels for which pressure [bar] times cubic capacity [l] is less than or equal to 200 are to be surveyed on the occasion of checking of the pertinent piping system.

3.1.2 Where pressure vessels cannot be satisfactorily examined internally and where their condition cannot be clearly stated during the internal inspection, approved non-destructive test methods and/or hydraulic pressure tests are to be carried out. The hydraulic pressure test is to be performed at a test pressure of 1,5 times the maximum allowable working pressure. If the maximum allowable working pressure is less than 2 bar, then the test pressure should be at least 1 bar more than the maximum allowable working pressure. Pressure vessels manufactured in accordance with non-class standards are to be tested according to those standards.

The test pressure must in no case exceed the initial test pressure.

3.1.3 Pressure vessels survey performance

Pressure vessels are to be examined internally and externally every **p** years, possibly in connection with a class renewal survey.

CO_2 cylinders and other gas cylinders for fire-extinguishing purposes including vessels for powder extinguishers are to be submitted to periodical survey according manufacturer instructions or applicable Standards. Reports relative to these surveys carried out by recognized company have to be submitted to the Surveyor.

Receivers in hydraulic or pneumatic control systems are to be examined during maintenance and repairs at the system; air receivers with a product of pressure by cubic capacity:

$p \cdot l \geq 1000$ (p in bar, l in litre),

are to be subjected to an internal inspection at least once during each class renewal.

The intervals between surveys as referred to may be reduced, depending on the findings.

SECTION 7 ADDITIONAL SURVEYS RELATED TO SERVICE NOTATIONS

1 General

1.1

1.1.1 The purpose of this Section is to give details on the scope of surveys of certain vessels which, due to the service notation assigned and related equipment, need specific requirements to be verified for the maintenance of their class.

1.1.2 These specific requirements either are additional to or supersede those stipulated in Ch 3, Sec 2 to Ch 3, Sec 6 which give general requirements for surveys applicable to all types of vessels (see indication in each Article of this Section). These surveys are to be carried out at intervals as described in Ch 2, Sec 2, [5], concurrently with the surveys of the same type, i.e. intermediate or class renewal surveys, detailed in Ch 3, Sec 2 to Ch 3, Sec 6.

2 Service notations subject to additional surveys

2.1 General

2.1.1 The specific requirements detailed in this Section are linked to the service notation(s) assigned to the vessel at the request of the Owner. Where a vessel has more than one service notation, the specific requirements linked to each one are applicable, insofar as they are not contradictory (in such a case, the most stringent requirement will be applied).

2.1.2 Tab 1 indicates which service notations are subject to specific requirements, and in which Article they are specified.

3 General cargo vessel and Bulk cargo vessel

3.1 General

3.1.1 The requirements of this Article are applicable to vessels assigned with the service notation **General cargo vessel** or **Bulk cargo vessel**.

3.1.2 These requirements are additional to those given in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

Table 1 : Service notations for which specific requirements are applicable

Service notations	Article applicable in this Section	Surveys affected by these specific requirements
General cargo vessel **Bulk cargo vessel**	Article [3]	class renewal
Container vessel	Article [4]	intermediate and class renewal
RoRo cargo vessel	Article [5]	intermediate and class renewal
Passenger vessel	Article [6]	intermediate and class renewal
Tug **Pusher**	Article [7]	intermediate and class renewal
Dredger **Hopper dredger** **Split hopper dredger** **Hopper barge** **Split hopper barge**	Article [8]	intermediate and class renewal

3.2 Scope of class renewal survey

3.2.1 The class renewal survey is to include examination, tests and checks of sufficient extent to ensure that the hull and related piping, as required in [3.2.3] is in satisfactory condition for the new period of class to be assigned, subject to proper maintenance and operation and to periodical surveys being carried out at the due dates.

3.2.2 All cargo holds, ballast tanks, including double bottom tanks, double side tanks as applicable, pipe tunnels, cofferdams and void spaces bounding cargo holds, decks and outer hull are to be examined, and this examination is to be supplemented by thickness measurement and testing required in Ch 3, Sec 3, [2], to ensure that the structural integrity remains effective. The aim of the examination is to discover substantial corrosion, significant deformation, fractures, damages or other structural deterioration that may be present.

3.2.3 All piping systems within the above spaces are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory.

3.2.4 Where hard protective coating in cargo holds is found in good condition, the extent of close-up surveys and thickness measurements may be specially considered.

4 Container vessel

4.1 General

4.1.1 The requirements of this Article are applicable to vessels assigned with the service notation **Container vessel**.

4.1.2 These requirements are additional to those given in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

4.2 Intermediate survey

4.2.1 The survey is to include:

- confirmation of the availability of instructions and instruments for stowage of containers, as required or fitted
- examination of container supports welded to the vessel's structure or on to the hatch covers
- examination of cell guides, if fitted.

4.3 Class renewal survey

4.3.1 The renewal survey is to include:

- examination of container supports welded to the vessel's structure or on to the hatch covers, checking for possible cracks and deformations
- examination of cell guides and associated elements, checking for possible cracks, deformations or corrosion.

4.3.2 Thickness measurements additional to those related to the transverse sections may be required.

5 RoRo cargo vessel

5.1 General

5.1.1 The requirements of this Article are applicable after construction to all self-propelled vessels assigned with the service notation **RoRo cargo vessel**.

5.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

5.2 Intermediate survey - Shell and inner doors

5.2.1 The requirements of this Sub-article apply to all shell and inner doors fitted on these vessels.

5.2.2 For the scope of survey of shell and inner doors, the following definitions are applicable:

- Securing device:

  A device used to keep the door closed by preventing it from rotating about its hinges
- Supporting device:

  A device used to transmit external or internal loads from the door to a securing device and from the securing device to the vessel's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the vessel's structure
- Locking device:

  A device that locks a securing device in the closed position.

5.2.3 It is to be checked that the operating procedures for closing the shell and inner doors are kept on board and posted at appropriate places.

When required, the Operating and Maintenance Manual is also to be checked for the verification of its approval and of any modification, reported repairs and proper endorsement by operating personnel.

5.2.4 The structural arrangements as well as welding are to be examined, including:

- plating, primary structure and secondary stiffeners
- hinging arms, hinges and bearings, thrust bearings
- hull and door side supports of securing, supporting and locking devices
- shell plating surrounding the openings and the securing, supporting and locking devices.

Hinge, bearing and thrust bearing clearances are to be measured when no dismantling is necessary for the measurement, or when the function tests detailed below are not satisfactory.

5.2.5 A close visual inspection of securing, supporting and locking devices, including their weld connections, is to be carried out and clearances are to be measured as required.

Non-destructive tests and/or thickness measurements may be required by the Surveyor after visual examination or in cases where cracks or deformations have been found.

5.2.6 A close visual inspection of sealing arrangements (packing material, rubber gaskets, packing retaining bars or channels) is to be carried out. For the tightness hose test, refer to [5.2.8].

5.2.7 The drainage arrangements including bilge wells, drain pipes and non-return valves are to be visually examined. A test of the bilge system between the inner and outer doors and that of the vehicle deck is to be carried out.

5.2.8 Function tests are to be carried out as follows, according to the required and/or existing equipment on board:

a) Doors are to be examined during a complete opening and closing operation; during this operation, the proper working of hinging arms and hinges, proper engagement of the thrust bearings and proper working of devices for locking the door in open position are to be checked

b) Securing, supporting and locking devices are to be examined during a complete opening and closing operation; the following items are to be checked:
   - opening/closing system and securing/locking devices are interlocked in such a way that they can only operate in proper sequence
   - mechanical lock of the securing devices

- the securing devices remain locked in the event of loss of hydraulic fluid, if they are of hydraulic type

c) Indicators of open/closed position of doors and of securing/locking devices at remote control stations are to be checked; other safety devices such as isolation of securing/locking hydraulic system from other hydraulic systems, access to operating panels, notice plates and warning indicator lights are to be checked

d) A tightness hose test or equivalent of sealing arrangements is to be carried out

e) A working test of the indicator system is to be carried out, including checking of:
   - visual indicators and audible alarms on the navigation bridge and operating panel
   - lamp test function, fail safe performance, power supply for indicator system
   - proper condition of sensors and their protection from water, ice formation and mechanical damage.

f) A working test of the water leakage detection system for inner doors and for the area between the bow door and the inner door (as applicable) is to be carried out and the proper function of audible alarms on the navigation bridge and the engine control room panel (as applicable) is to be ascertained

g) If fitted, the television surveillance system is to be verified with proper indication on the navigation bridge and engine control room monitors

h) Electrical equipment for opening, closing and securing the doors is to be examined.

5.3 Intermediate survey - Internal platforms and ramps

5.3.1 The intermediate survey of internal movable platforms and ramps (excluding those considered as inner doors and covered in [5.2]) and related equipment consists of:

- a general examination of the installation, particular attention being paid to the condition of steel cables
- confirmation of the proper operation of platforms/ramps and of mechanical stops and locks
- checking, as far as practicable, of the alarms and safety devices.

5.4 Class renewal survey - Shell and inner doors

5.4.1 A close visual inspection of structural arrangements is to be carried out, supplemented by non-destructive tests and/or thickness measurements, as deemed necessary by the Surveyor.

5.4.2 The close visual inspection of securing, supporting and locking devices, as required for the annual survey, is to be supplemented by non-destructive tests and/or thickness measurements.

5.4.3 Clearances of hinges, bearings and thrust bearings are to be measured. Dismantling may be required as deemed necessary by the Surveyor.

5.4.4 Non-return valves of drainage arrangements are to be checked after dismantling.

5.5 Class renewal survey - Internal platforms and ramps

5.5.1 The condition of pulleys, axles, cables and structure of the platforms and ramps is to be checked.

Electric motors and/or hydraulically operated equipment are to be surveyed according to the scope detailed in Ch 3, Sec 3, [3.6] for the class renewal survey of machinery installations.

6 Passenger vessel

6.1 General

6.1.1 The requirements of this Article are applicable after construction to all self-propelled vessels assigned with the service notation **Passenger vessel**.

6.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

6.2 Intermediate survey

6.2.1 Watertight bulkheads

The survey of watertight bulkheads and arrangements consists of:

- examination, as far as practicable, of collision and watertight bulkheads, and confirmation that their watertight integrity has not been impaired
- checking the diagram provided on the navigation bridge showing the location of the watertight doors and related indicators for their open/closed position
- testing operation of local and remote control (from the navigation bridge) of the watertight doors, and in particular, operation from each side of the bulkhead of audible alarms or visual signals and control handles, as required or fitted
- confirmation of operation of watertight doors in the event of failure of main and emergency sources of power
- confirmation that notices are affixed at appropriate locations.

6.2.2 Openings in shell plating

The survey consists of:

- examination of the arrangements for closing sidescuttles and their deadlights, as well as scuppers, sanitary discharges and similar openings and other inlets and discharges in the shell plating below the margin line
- confirmation that valves for closing the main and auxiliary river inlets and discharges in the machinery spaces are readily accessible, and that indicators showing the status of the valves are provided, as required or fitted
- confirmation that gangway access and cargo ports fitted below the margin line may be effectively closed and that the inboard ends of any ash or rubbish chutes are fitted with an effective cover.

6.2.3 Miscellaneous

It is to be verified that the emergency escape routes from passenger and crew spaces, including related stairways and ladders, are kept clear.

6.3 Class renewal survey

6.3.1 Stability

If modifications susceptible to affect the vessel displacement and/or weight distribution have been performed, a lightweight survey is to be carried out to verify any changes in lightship displacement and in the longitudinal position of the centre of gravity. Where, in comparison with the approved stability information, a deviation exceeding 2% in the lightship displacement or a deviation of the longitudinal centre of gravity exceeding 1% of the length between perpendiculars is found or anticipated, the vessel is to be submitted to a new inclining test.

7 Tug and Pusher

7.1 General

7.1.1 The requirements of this Article are applicable after construction to all vessels assigned with the service notation **Tug** or **Pusher**.

7.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

7.2 Intermediate survey

7.2.1 For **Tug**, the survey is to include a general external examination of the towing hook or towing winch, as fitted, and unhooking device, as far as practicable.

7.2.2 For **Pusher**, an examination of the pushing transom and coupling system is to be carried out.

7.3 Class renewal survey

7.3.1 For **Tug**, the survey is to include:

- checking the condition of the connection of the towing hook or towing winch to the structure, including related reinforcements of the structure
- checking the external condition of the towing hook or towing winch; when applicable, a no-load test of the unhooking device is to be carried out.

7.3.2 For **Pusher**, a visual examination of the pushing transom and coupling system is to be carried out, completed by thickness measurements and non-destructive tests as deemed necessary by the Surveyor.

8 Vessels for dredging activities

8.1 General

8.1.1 The requirements of this Article are applicable after construction to all vessels assigned with one of the following service notations:

- **Dredger**
- **Hopper dredger**
- **Split hopper dredger**
- **Hopper barge**
- **Split hopper barge**.

8.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 6 according to the relevant surveys.

8.2 Intermediate survey

8.2.1 The survey is to include the following items, as far as required or fitted, according to the service notation of the vessel:

- for **Dredger**, **Hopper dredger**, **Hopper barge**:
  - visual examination, as far as practicable, of attachments of suction piping and lifting systems to the structure and external examination of piping in dredging machinery spaces for absence of corrosion and leakage
  - checking the condition of the dredging machinery space and related equipment with regard to electrical shocks, protection from rotating machinery, fire and explosion hazards.
- for **Split hopper barge**, **Split hopper dredger**:
  - visual examination, as far as practicable, of superstructure hinges and blocks, deck hinges, hydraulic jacks and associated piping systems and alarms.

8.3 Class renewal survey

8.3.1 The survey is to include the following items, as far as required or fitted, according to the service notation of the vessel:

- for **Hopper dredger**, **Hopper barge**:
  - visual examination of hopper bottom doors or valves and accessories, such as hinges, actuating rods, hydraulic systems, with dismantling as deemed necessary by the Surveyor.
- for **Dredger**, **Hopper dredger**, **Split hopper dredger**:
  - visual examination, as far as practicable, of attachments of suction piping and lifting systems to the structure and external examination of piping in dredging machinery spaces for absence of corrosion and leakage
  - checking the condition of the dredging machinery space and related equipment with regard to electrical shocks, protection from rotating machinery, fire and explosion hazards.
- for **Split hopper barge**, **Split hopper dredge**:
  - visual examination, as far as practicable, of superstructure hinges and blocks, deck hinges, hydraulic jacks and associated piping systems and alarms, with dismantling and/or further checks as deemed necessary by the Surveyor.

SECTION 8 ADDITIONAL SURVEYS RELATED TO ADDITIONAL SERVICE FEATURES

1 General

1.1

1.1.1 The purpose of this Section is to give details on the scope of surveys of certain vessels which, due to the additional service feature assigned, need specific requirements to be verified for the maintenance of their class.

1.1.2 These specific requirements either are additional to or supersede those stipulated in Ch 3, Sec 2 to Ch 3, Sec 7 which give general requirements for surveys applicable to all types of vessels (see indication in each Article of this Section). These surveys are to be carried out at intervals as described in Ch 2, Sec 2, [5], concurrently with the surveys of the same type, i.e. intermediate or class renewal surveys, detailed in Ch 3, Sec 2 to Ch 3, Sec 7.

2 Additional Service features subject to additional surveys

2.1 General

2.1.1 Ch 3, Sec 7, Tab 1 indicates which additional service features are subject to specific requirements, and in which Article they are specified.

Table 1 : Additional Service features for which specific requirements are applicable

Additional Service features	Article applicable in this Section	Surveys affected by these specific requirements
Type N & **DG-N** **Type C** &**DG-C**	[3]	intermediate and class renewal
Type G & **DG-G**	[4]	intermediate and class renewal
A	[5]	class renewal and bottom survey
C	[6]	class renewal
W	[7]	class renewal and bottom survey
Battery system	[8]	intermediate and class renewal
Gasfuel **Dualfuel**	[9]	intermediate and class renewal

3 Type N & DG-N and Type C & DG-C

3.1 General

3.1.1 The requirements of this Article are applicable to tank vessels assigned with one of the additional service feature **Type N**, **DG-N**, **Type C** or **DG-C**.

3.1.2 These requirements are additional to those given in Ch 3, Sec 2 to Ch 3, Sec 7, according to the relevant surveys.

3.2 Intermediate survey

3.2.1 Safety systems

The following installations and equipment are to be checked:

- level/overfill alarms
- level indicators
- tank venting systems
- flame arresters
- piping, valves and fittings, pumps
- pump room equipment, including ventilation system
- fire-extinguishing equipment
- pressure/vacuum relief valves.

3.2.2 Cargo piping system

a) examination of the cargo tank openings, including gaskets and covers

b) examination of the cargo tank pressure / vacuum relief valves or equilibrating devices

c) examination of the flameproof devices and flame screens

d) examination of the cargo piping and their auxiliaries

e) testing of all cargo tank alarms.

3.2.3 Inert gas system

Inert gas installations of the cargo tanks are to be checked as to their operability.

3.2.4 Cofferdams

The cofferdams are to be inspected, if provided.

3.2.5 Cargo pump room

For cargo pump rooms, the survey consists of the verification of the good condition of:

- access ladders
- sumps
- all bulkheads for signs of leakage or fractures and, in particular, the sealing arrangements of the bulkhead penetrations
- piping systems, their pumps and auxiliaries
- pump room ventilation system including ducting, dampers and screens.

3.2.6 Electrical installations and equipment

The Surveyor will check that the insulation level of the electrical installation has been verified within the last three years and that the results are to his satisfaction, particularly in pump rooms and in the cargo area. Furthermore, the good condition of the safety electrical equipment in respect to explosive atmosphere has to be checked. Special attention is to be paid to the cable runs and connecting terminals.

3.3 Class renewal survey - Hull

3.3.1 On tankers which - as can be proved - have exclusively carried cargo not causing corrosion, the cargo tanks shall be inspected at each alternate class renewal only, provided that it may be assumed on the basis of random checks that the component parts are still in satisfactory condition, and provided that no objections will result from the tightness and pressure tests as per Ch 3, Sec 3, [2.4.4].

3.3.2 During each class renewal, the cofferdams of tankers are to be hydrostatically tested to the test pressure as defined in Pt B, Ch 3, Sec 4, [5] and Pt B, Ch 8, Sec 4.

3.3.3 At each alternate class renewal only, the cargo tanks of tankers including gas collector if any, are to be tested by water and/or air pressure, to the test pressure stated in the Rules. In the case of air tightness and pressure test, the test has to be made according to Ch 3, Sec 3, [2.4.4]. Where substances are carried which cause corrosion in connection with water, the kind of testing is to be specified.

3.3.4 At each class renewal, cargo tanks of tankers carrying acids and lye solution will be subjected to an internal examination and, at each alternate class renewal, to a hydrostatic pressure test. The test pressure, to be fixed in accordance with Pt B, Ch 3, Sec 4, [5], depends on the density of the cargo.

3.3.5 Close-up survey

The minimum requirements for close-up surveys are given in Ch 2, App 1.

3.4 Class renewal survey - Machinery

3.4.1 The requirements of this Subarticle apply to vessels assigned one of the additional service feature **Type N**, **DG-N**, **Type C** or **DG-C**, in addition to those prescribed in [3.2] for intermediate survey.

3.4.2 Piping system

Cargo piping, including valves and fittings, pumps as well as gas-freeing and safety equipment is to be surveyed.

At each class renewal, the loading and discharge pipes of tankers are to be tested to 1,25 times the allowable working pressure.

The Surveyor may require dismantling and /or thickness measurements of piping.

Note 1: When components are replaced in the cargo handling installation, it is the responsibility of the Owner to verify their compatibility with the chemical characteristics of the products transported.

3.4.3 Inert gas system

Inert gas installations of the cargo tanks are to be checked as to their operability.

3.4.4 Electrical installations

For vessels carrying flammable products, the condition of safety electrical equipment in relation to explosive atmospheres has to be verified and particular attention is to be paid to cable runs and connecting terminals, especially in the cargo area.

4 Type G & DG-G

4.1 General

4.1.1 The requirements of this Article are applicable to vessels assigned one of the additional service features **Type G** or **DG-G** intended for the carriage of liquefied gases.

4.1.2 The requirements apply to:

- the surveys of installations and equipment related to the carriage and handling of liquefied gas, and
- the surveys of hull structure and related piping systems in way of cargo tanks, pump rooms, compressor rooms, cofferdams, pipe tunnels, void spaces and fuel oil tanks within the cargo area, and
- the surveys of all ballast tanks.

They are additional to the requirements applicable to the remainder of the vessel, given in Ch 3, Sec 2 to Ch 3, Sec 6, according to the relevant surveys.

4.1.3 The requirements contain the minimum extent of examination, thickness measurements and tank testing. When substantial corrosion, as defined in Ch 2, Sec 2, [2.2.7], and/or structural defects are found, the survey is to be extended and is to include additional close-up surveys when necessary.

4.1.4 Thickness measurements of structures in areas where close-up surveys are required are to be carried out simultaneously with close-up surveys.

4.2 Intermediate survey

4.2.1 Safety systems

The following installations and equipment are to be checked:

- level/overfill alarms
- level indicators
- tank venting systems
- piping, valves and fittings, pumps
- compressor / pump room equipment, including ventilation system
- fire-extinguishing equipment
- pressure/vacuum relief valves.

4.2.2 Access to cargo tanks and/or inerted hold spaces is not normally required.

4.2.3 Recorded entries in the log book, if any, since the last survey are to be examined in order to check the past performance of the system and to establish if certain parts have shown any irregularities in operation or if the evaporation rate has been abnormally high.

4.2.4 Spaces and areas such as cargo control rooms, air locks, compressor rooms are to be examined together with cargo handling piping and machinery including cargo and process piping, cargo heat exchangers, evaporators, compressors, during operation, whenever possible.

4.2.5 Electric bonding of cargo tanks and cargo piping systems is to be verified.

4.2.6 Inert gas system

Inert gas installations of the cargo tanks are to be checked as to their operability.

4.2.7 Examination and checking of the following items:

a) Venting system of cargo tanks and hold spaces

b) All gastight bulkhead penetrations including gastight shaft sealing, if provided

c) Cargo handling control and safety systems, if practicable, such as:
   - emergency shut down valves at shore connections and tanks
   - control, alarm and safety systems monitoring the pressure in cargo tanks, cargo piping and hold spaces
   - cargo tanks level gauging including alarm and safety functions
   - cargo temperature monitoring systems
   - control, alarm and safety systems of cargo compressors and cargo pumps.

d) Gas detection equipment including indicators and alarms in operation

e) Ventilation systems of all spaces in the cargo area

f) Inert gas or dry air installations in operation, including the means for preventing backflow of cargo vapour to gas safe areas

g) Gastightness of wheelhouse doors and windows

h) Sealing arrangements of tank/tank domes, penetrating decks/tank covers, of portable and permanent drip trays or insulation for deck protection in the event of cargo leakage.

4.2.8 Electrical installations and equipment

The Surveyor will check that the insulation level of the electrical installation has been verified within the last three years and that the results are to his satisfaction, particularly in pump/compressor rooms and in the cargo area. Furthermore, the good condition of the safety electrical equipment in respect to explosive atmosphere has to be checked. Special attention is to be paid to the cable runs and connecting terminals.

4.3 Class renewal survey - Hull

4.3.1 On tankers which - as can be proved - have exclusively carried cargo not causing corrosion, the cargo tanks shall be inspected at each alternate class renewal only, provided that it may be assumed on the basis of random checks that the component parts are still in satisfactory condition, and provided that no objections will result from the tightness and pressure tests as per Ch 3, Sec 3, [2.4.4].

4.3.2 During each class renewal, the cofferdams of tankers are to be hydrostatically tested to the test pressure as defined in Pt B, Ch 3, Sec 4, [5] and Pt B, Ch 8, Sec 4.

4.3.3 At each alternate class renewal only, the cargo tanks of tankers including gas collector if any, are to be tested by water and/or air pressure, to the test pressure stated in the Rules. In case of air tightness and pressure test, the test has to be made according to Ch 3, Sec 3, [2.4.4]. Where substances are carried which cause corrosion in connection with water, the kind of testing is to be specified.

4.3.4 At each class renewal, cargo tanks of tankers carrying acids and lye solution will be subjected to an internal examination and, at each alternate class renewal, to a hydrostatic pressure test. The test pressure, to be fixed in accordance with Pt B, Ch 3, Sec 4, [5], depends on the density of the cargo.

4.3.5 The following examinations, measurements and testing are to be carried out:

a) Thickness measurements and non-destructive testing of cargo tanks
   - thickness measurements of cargo tanks may be required. During these examinations, the state of insulation is checked around the considered areas
   - during the internal survey of the tanks, a non destructive testing procedure supplements the examination of cargo tanks, according to a programme and control means approved beforehand by the Society

- when independent tanks (cylindrical under pressure) are concerned, in principle, 10% of the length of welded seams, in critical areas are tested: tank supports, reinforcement rings, attachment of hollow bulkheads, weldings of the fittings (domes, sumps) to the tank-plates, supports of pumps, ladders, pipe connections. It may be necessary to remove partially the tank insulation to perform these examinations
- for tanks where anti-corrosion coatings are found to be in satisfactory condition, the extent of thickness measurements may be specially considered, at the discretion of the Surveyor.

b) Testing of cargo tanks

- tanks for the carriage of pressurized liquefied gases are to be tested like pressure vessels. Deviating there from, cargo tanks need to be subjected to an internal inspection on the occasion of each other subsequent class renewal only, if in these tanks only gases or gas mixtures have been carried, which have no corrosive effect upon their walls, and if random checks suggest that the tanks are in satisfactory condition
- tightness of cargo tanks and domes is to be verified. However, for a vessel of less than fifteen years of age, a separate tightness test may not be required for each tank, provided the examination of the log book raises no doubts as to their tightness
- where the results of tanks examination and testing, or the examination of the log book raise doubts as to the structural integrity or tightness of a cargo tank, or when significant repairs have been carried out, hydraulic or hydropneumatic testing is to be carried out.

c) External examination of cargo tanks

- all independent tanks are to be examined externally wherever practicable. Where the insulation of a cargo tank or of the hull structure is accessible, the Surveyor examines the insulation externally including any vapour or protective barrier. If considered necessary by the Surveyor, insulation is to be removed in part or entirely so as to check the condition of the tank. Cargo tank supports, chocks and keys and the adjacent hull structure are to be examined
- pressure relief valves of cargo tanks are to be opened up for examination, adjusted, sealed and tested to the Surveyor's satisfaction
- pressure / vacuum relief valves or other pressure relief devices in the tank spaces, are to be examined to the Surveyor's satisfaction and, according to their design, opened up, adjusted and tested.

d) Examination of the cargo area

- the venting system of cargo tanks and hold spaces is to be checked. All gastight bulkheads are to be examined. Gastight bulkhead penetrations, including eventual gastight shaft sealings, are to be examined
- gas detection equipment, including indicators and alarms in operation, are to be verified to be in good working order
- the inert gas or dry air installation in operation, including the means for preventing backflow of cargo vapour to gas safe areas will be checked
- sealing arrangements of tanks/tank domes, penetrating decks / tank covers, of portable and permanent drip trays or insulation for deck protection in the event of cargo leakage are to be verified
- hose and spool pieces used for segregation of piping systems for cargo, inert gas and bilge are to be examined.

4.3.6 Close-up survey

The minimum requirements for close-up surveys are given in Ch 2, App 1.

4.4 Class renewal survey - Machinery

4.4.1 The requirements of this Subarticle apply to vessels assigned one of the additional service feature **Type G** or **DG-G**, in addition to those prescribed in [4.2] for intermediate survey.

4.4.2 Cargo handling installation

The cargo piping system including valves, their monitoring devices, etc. are to be opened up for examination and their insulation removed as the Surveyor deems necessary. The complete system is tested to 1,25 times the design pressure. If the maximum delivery pressure of pumps is less than the design pressure of the piping system, testing to the pumps maximum delivery pressure may be accepted. In such cases, selected expansion bellows are to be dismantled, examined internally and tested to their design pressure to the Surveyor's satisfaction.

All pressure relief valves are to be opened up for examination, adjusted, sealed and tested to the Surveyor's satisfaction.

The cargo pumps, compressors, heat exchangers and other machinery including their prime movers which are a part of the cargo handling installation are to be examined.

4.4.3 Cargo handling control and safety installations

The cargo handling control and safety installations, such as:

- emergency shut down valves at shore connections and tanks
- control, alarm and safety systems monitoring the pressure in cargo tanks, cargo piping and hold spaces
- cargo tanks level indicators including alarm and safety functions
- cargo temperature monitoring systems
- control, alarm and safety systems of cargo compressors and cargo pumps,

are to be verified on good working.

Note 1: When components are replaced in the cargo handling installation, it is the responsibility of the Owner to verify their compatibility with the chemical characteristics of the products transported.

4.4.4 Inert gas system

Inert gas installations of the cargo tanks are to be checked as to their operability.

5 Additional service feature A

5.1 General

5.1.1 The requirements of this Article are applicable to vessels assigned with the additional service feature **A**.

5.1.2 These requirements are additional to those given in Ch 3, Sec 2 to Ch 3, Sec 7, according to the relevant surveys.

5.2 Class renewal survey

5.2.1 For vessels assigned the additional service feature **A**, the highly stressed areas are to be externally examined and dye penetrant checks are to be carried out, as found necessary by the Surveyor.

Thickness measurements are to be carried out, in areas where chaffing or corrosion may have developed, as found necessary by the Surveyor.

5.3 Bottom survey

5.3.1 For vessels built in aluminium alloy, the appendages of the hull are to be examined as found necessary by the Surveyor, with particular attention to their fixation to the hull and to the surrounding area specially where deterioration of the hull protection is found.

6 Additional service feature C

6.1 General

6.1.1 The requirements of this Article are applicable to vessels assigned with the additional service feature **C**.

6.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 7, according to the relevant surveys.

6.2 Class renewal survey

6.2.1 For vessels assigned the additional service feature **C**, an external examination of the coating condition is to be carried out. This examination is to be directed at discovering significant alteration of the coating or contact damages.

7 Additional service feature W

7.1 General

7.1.1 The requirements of this Article are applicable to vessels assigned with the additional service feature **W**.

7.1.2 These requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 7, according to the relevant surveys.

7.2 Class renewal survey

7.2.1 For vessels built with laminate wood and provided with coating, an external examination of the protection of edges against water ingress is to be carried out.

7.2.2 For vessels built with plank seams and butts, the condition of plank seams, butts and caulking is to be externally examined and renewal is to be carried out as found necessary by the Surveyor.

Where applicable, the timber of the main structural items is to be tapped specially in place where ventilation is poor.

When traces of worm or rot are found, the damaged pieces are to be added to sound wood or renewed as found necessary by the Surveyor.

7.3 Bottom survey

7.3.1 The seams and butts of the garboard and bilges at midship, the keel scarphs and rabbets are to be examined. The same applies to caulking of the underwater parts specially butts and rabbets. The Surveyor may require caulking to be renewed or the hull to be recaulked as found necessary.

7.3.2 For hulls built with planks, a particular attention is to be given to the tightness of the junctions between planks.

The condition of the bolting and fastening and, in general, of metal parts, is to be examined.

If decay or rot is found or if the wood is worn, it is to be renewed as found necessary by the Surveyor.

Where the planking is sheeted with composite material, such as fibre reinforced plastic, the edges of planks are to be examined as found necessary by the Surveyor, in order to ascertain that no ingress of water has occurred along them.

8 Battery system

8.1 General

8.1.1 The requirements of this Article apply to ships which have been assigned the additional class notation **Battery sytem** as defined in Ch 1, Sec 3, [1.3.7].

8.2 Intermediate survey

8.2.1 The intermediate survey is to include:

- general examination of the battery pack(s)
- general examination of the battery monitoring system
- general examination of the battery support system
- general examination of the battery compartment, including visual check of the safety measures and functions related to battery spaces, i.e. battery installation, ventilation, fire safety measures and alarms
- check of the electrolyte level and pH level
- check of State of health (SOH) of battery system according to the Manufacturer's specification and verification that the battery capacity has been regularly recorded and complies with the parameters specified by the Manufacturer

- test of sensor and alarm associated to the battery at random
- undertaking of measurement of insulation of battery packs
- additional checks when some specific part of battery is or has been replaced (e.g. battery cells, BMS) according to the Manufacturer specification and to the satisfaction of the Surveyor.

8.3 Class renewal survey

8.3.1 The requirements given in [8.2.1] for intermediate survey are to be complied with.

In addition:

- a comprehensive test of indication and alarms is to be carried out
- the traceability of cells replacement is to be checked
- the traceability of software modification is to be checked
- a battery capacity (State of Health - SOH) test is to be witnessed when:
  - release of flammable or toxic gases during battery operation was identified (e.g. hydrogen for lead-acid batteries)
  - loss of battery might jeopardize manoeuvrability of the vessel.

9 Gas-fuelled vessels

9.1 General

9.1.1 The requirements of this Section apply to all self-propelled vessels, other than those covered by [4], which utilize gas or other low flash points fuels as a fuel for propulsion prime mover/auxiliary power generation arrangements and associated systems, or which have been assigned one of the following additional service features:

- **Gasfuel**
- **Dualfuel**

9.1.2 These requirements are in addition to those laid down in Ch 3, Sec 6 as applicable.

These survey requirements do not cover fire protection, fire-fighting installation, and personnel protection equipment.

9.1.3 More extensive Regulations of the country where the vessel is registered, are to be observed by the Owner.

9.2 Intermediate survey

9.2.1 In addition to the requirements in [9.3] and [9.4], the intermediate survey is also to include:

- random test of gas detectors, temperature sensors, pressure sensors, level indicators, and other equipment providing input to the fuel safety system, to confirm their satisfactory operating condition
- verification of the proper response of the fuel safety system upon fault conditions.

9.3 Intermediate survey - Hull items

9.3.1 General

The following requirements are to be verified during the survey of the fuel storage, fuel bunkering system and fuel supply system.

The logbooks and operating records are to be examined with regard to correct functioning of the gas detection systems, fuel supply/gas systems, etc. The hours per day of the reliquefaction plant, gas combustion unit, as applicable, the boil-off rate, and nitrogen consumption (for membrane containment systems) are to be considered together with gas detection records.

The manufacturer/builder instructions and manuals covering the operations, safety and maintenance requirements and occupational health hazards relevant to fuel storage, fuel bunkering, and fuel supply and associated systems for the used of the fuel, are to be confirmed as being aboard the vessel.

9.3.2 Gas related spaces, fuel preparation and handling rooms and piping

The survey is to include:

- examination of portable and fixed drip trays and insulation for the protection of the ship’s structure in the event of a leakage
- examination of electrical bonding arrangements in hazardous areas, including bonded straps where fitted.

9.3.3 Fuel storage, bunkering and supply systems

The following requirements are to be examined, so far as applicable. Insulation need not to be removed, but any deterioration or evidence of dampness is to be investigated.

For fuel storage, the survey is to include:

- external examination of the storage tanks including secondary barrier if fitted and accessible
- general examination of the fuel storage hold place
- internal examination of tank connection space
- external examination of tank and relief valves
- verification of satisfactory operation of tank monitoring system
- examination and testing of installed bilge alarms and means of drainage of the compartment
- testing of the remote and local closing of the installed main tank valve.

For fuel bunkering system, the survey is to include:

- examination of bunkering stations and the fuel bunkering system
- verification of the satisfactory operation of the fuel bunkering control, monitoring and shutdown systems.

For fuel supply system, during working condition as far as practicable, the survey is to include:

- verification of the satisfactory operation of the fuel supply system control, monitoring and shutdown systems
- testing of the remote and local closing of the master fuel valve for each engine compartment.

9.4 Intermediate survey - Gas fuel machinery

9.4.1 Control, monitoring and safety systems

The survey is to include:

- confirmation that gas detection and other leakage detection equipment in compartments containing fuel storage, fuel bunkering, and fuel supply equipment or components or associated systems, including indicators and alarms are in satisfactory operating condition
- verification that recalibration of the gas detection systems is done in accordance with the manufacturer's recommendations.
- verification of the satisfactory operation of the control, monitoring and automatic shutdown systems as far as practicable of the fuel supply and bunkering systems
- operational test, as far as practicable, of the shutdown of ESD-protected machinery spaces.

9.4.2 Fuel handling piping, machinery and equipment

The survey is to include:

- examination, as far as practicable, of piping, hoses, emergency shutdown valves, relief valves, machinery and equipment for fuel storage, fuel bunkering, and fuel supply such as venting, compressing, refrigerating, liquefying, heating, cooling or otherwise handling the fuel
- examination of the means for inerting
- confirmation, as far as practicable, of the stopping of pumps and compressors upon emergency shutdown of the system.

9.4.3 Ventilating systems

The survey is to include:

- examination of the ventilation system, including portable ventilating equipment where fitted, is to be made for spaces containing fuel storage, fuel bunkering, and fuel supply units or components or associated systems, including air locks, pump rooms, compressor rooms, fuel preparation rooms, fuel valve rooms, control rooms and spaces containing gas burning equipment
- operational test, as far as practicable, of alarms, such as differential pressure and loss of pressure, where fitted.

9.4.4 Hazardous areas

The survey is to include:

- examination of electrical equipment and bulkhead/deck penetrations including access openings in hazardous areas, for continued suitability for their intended service and installation area.

9.5 Class renewal survey - Hull items

9.5.1 General

The class renewal survey is to include, in addition to the requirements of the intermediate surveys, examinations, tests and checks of sufficient extent to ensure that the fuel installations are in satisfactory condition and fit for intended purpose for the new period of class to be assigned, subject to proper maintenance and operation and to periodical surveys being carried out at the due dates.

9.5.2 Fuel handling and piping

All piping for fuel storage, fuel bunkering, and fuel supply such as venting, compressing, refrigerating, liquefying, heating, storing, burning or otherwise handling the fuel and liquid nitrogen installations are to be examined.

Removal of insulation from the piping and opening for examination may be required.

Where deemed suspect, a hydrostatic test to 1,25 times the maximum allowable relief valve setting (MARVS) for the pipeline is to be carried out.

After reassembly, the complete piping is to be tested for leaks.

Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, the surveyor may accept alternative fluids or alternative means of testing.

9.5.3 Fuel valves

a) Fuel storage tank pressure relief valves

   The survey is to include:

   - opening for examination, adjustment and function test of the pressure relief valves for the fuel storage tanks
   - if the tanks are equipped with relief valves with non-metallic membranes in the main or pilot valves, replacement of such non-metallic membranes.

b) Fuel supply and bunkering piping pressure relief valves

   The survey is to include:

   - opening for examination, adjustment and function test of pressure relief valves for the fuel supply and bunkering piping
   - where a proper record of continuous overhaul and retesting of individually identifiable relief valves is maintained, consideration will be given to acceptance on the basis of opening, internal examination, and testing of a representative sampling of valves, including each size and type of liquefied gas or vapor relief valve in use, provided there is logbook evidence that the remaining valves have been overhauled and tested since crediting the previous class renewal survey.

9.5.4 Pressure/vacuum relief valves

The survey is to include:

- opening, examination, test and readjustment as necessary, depending on their design, of the pressure/vacuum relief valves, rupture disc and other pressure relief devices for interbarrier spaces and hold spaces.

9.5.5 Fuel storage tanks

Fuel storage tanks are to be examined in accordance with an approved survey plan.

Liquefied gas fuel storage tanks are to be examined based on a survey/inspection plan, in which requirements for the survey of liquefied gas fuel containment systems are to be in accordance with the requirements laid down in [4.3], except as noted below:

- the tank insulation and tank support arrangements shall be visually examined. Non-destructive testing may be required if conditions raise doubt to the structural integrity
- vacuum insulated independent fuel storage tanks of type C need not be examined internally. Where fitted, the vacuum monitoring system shall be examined and records should be reviewed.

9.6 Class renewal survey - Gas fuel machinery items

9.6.1 Fuel handling equipment

Fuel pumps, compressors, process pressure vessels, inert gas generators, heat exchangers and other components used in connection with fuel handling are to be examined according to the requirement of [4.4], as applicable.

9.6.2 Electrical equipment

The survey is to include:

- examination of electrical equipment to include the physical condition of electrical cables and supports, intrinsically safe, explosion proof, or increased features of electrical equipment
- function testing of pressurized equipment and associated alarms
- testing of systems for de-energizing electrical equipment which is not certified for use in hazardous areas
- electrical insulation resistance test of the circuit terminating in, or passing through, the hazardous zones and spaces is to be carried out.

9.6.3 Safety systems

Gas detectors, temperature sensors, pressure sensors, level indicators, and other equipment providing input to the fuel safety system are to be tested to confirm satisfactory operating condition.

Proper response of the fuel safety system upon fault conditions is to be verified.

Pressure, temperature and level indicating equipment are to be calibrated in accordance with the manufacturer's requirements.

SECTION 9 SCOPE OF SURVEYS RELATED TO ADDITIONAL CLASS NOTATIONS

1 General

1.1 Application

1.1.1 The purpose of this Section is to give details on the scope of surveys of specific equipment and systems fitted on board the vessel, which are covered by an additional class notation. Unless otherwise specified in Ch 1, Sec 3, the scope of these surveys provides the requirements to be complied with for the maintenance of the relevant additional class notation.

1.1.2 These specific requirements are additional to those laid down in Ch 3, Sec 2 to Ch 3, Sec 7. These surveys are to be carried out at intervals as described in Ch 2, Sec 2, [5], as far as possible concurrently with the surveys of the same type, i.e. annual, intermediate or class renewal survey.

1.1.3 The equipment and systems are also to be submitted to occasional survey whenever one of the cases indicated in Ch 2, Sec 2, [6.1.1] occurs.

1.1.4 For the assignment of the additional class notations, vessels are to be submitted to an admission to class survey as described in Ch 2, Sec 4, [1] and Ch 2, Sec 4, [2] for new and existing installations, respectively, as applicable.

1.2 Additional class notations subject to additional surveys

1.2.1 The specific requirements detailed in this Section are linked to the additional class notation(s) assigned to the vessel. Where a vessel has more than one additional class notation, the specific requirements linked to each additional class notation are applicable as long as they are not contradictory.

1.2.2 Tab 1 indicates which additional class notations are subject to specific requirements, and in which Article they are specified.

Table 1 : Additional class notations for which specific survey requirements are applicable

Additional class notations		Reference or Article applicable in this Section	Surveys affected by these specific requirements
Automated machinery systems	**AUT-UMS**	[2]	intermediate and class renewal
Comfort on board	**COMF-NOISE** **COMF-VIB**	NR467, Pt A, Ch 5, Sec 10, [10]	annual and class renewal
Pollution prevention	**Cleanvessel** **AWT** **GWT** **NDO-x days** **NOX-x%** **OWS-x ppm** **SOX-x%**	[3]	intermediate and class renewal
Carriage of wheeled vehicles in passenger vessels	**Ferry**	[4]	intermediate and class renewal
Fire safety	**Fire**	[5]	intermediate and class renewal
Dry bulk cargo handling	**Grabloading**	[6]	class renewal
Green passport for vessel recycling	**Green passport**	[7]	class renewal
Navigation in ice environment	**Ice** **Ice-30** **Ice-40** **Ice-40+**	[8]	class renewal
Stability	**Damage stability**	[9]	class renewal

2 Automated machinery systems

2.1 General

2.1.1 The requirements of this Article apply to vessels which have been assigned the additional class notation **AUT-UMS**, as described in Ch 1, Sec 3, [11.2].

2.2 Intermediate survey

2.2.1 The Owner or his representative is to declare to the attending Surveyor that no significant modifications have been made without prior approval by the Society.

2.2.2 The intermediate survey is to include:

- an examination of the engineers' log-book to verify the proper operation of automation systems in the period subsequent to the last survey and measures taken to avoid repetition of any malfunctions or failures which have occurred during the same period
- a general examination of the control systems covered by the notation, including a random check of the proper operation and calibration of main measuring, monitoring, alarm, and automatic shut-off devices
- a check of the fire detectors
- a check of the bilge flooding alarms
- a running test which may be also performed by a spot check method.

2.3 Class renewal survey

2.3.1 The requirements given in [2.2] for intermediate survey are to be complied with. An additional program of examinations, checks and tests is to be devised in agreement with the Owner and based on the operational data and experience of previous surveys. This program is to include verification of the calibration of instruments and testing of control and safety functions of the machinery. The Owner is to produce evidence that all these checks and tests have been carried out and this will be verified by the Surveyor at random. In addition, the proper operation of the control system of propulsion machinery is to be checked during river trials.

3 Pollution prevention

3.1 General

3.1.1 Application

The requirements of this Article apply to vessels which have been assigned one of the following additional class notations related to pollution prevention systems, as described in Ch 1, Sec 3, [11.15]:

- **Cleanvessel**
- **AWT**
- **GWT**
- **NDO-x days**
- **NOX-x%**
- **OWS-x ppm**
- **SOX-x%**

3.2 Prevention of water pollution

3.2.1 First survey

a) Confirmation of no discharge period

During the first survey, the Surveyor collects the results of tests and measurements undertaken by the vessel Owner according to Pt D, Ch 2, Sec 11, [4]. These results are used to confirm or modify the no discharge numeral appended to the notations NDO-x days.

b) Audit

An on board audit of the procedures, as required in Pt D, Ch 2, Sec 11, is done by the Surveyor in order to ascertain that the Master and crew are familiar with the vessel's on board procedures for preventing pollution and in order to check that the discharge records mentioned in Pt D, Ch 2, Sec 11 are properly completed.

3.2.2 Intermediate survey

a) General

The survey is to include, as far as practicable:

- confirmation of the installation being in accordance with the plans. If modifications have been made, checking that these modifications are in accordance with approved documentation (for all additional class notations related to pollution prevention systems)
- general examination of the most important components of the sewage treatment plant, the garbage treatment plant, the oil filtering equipment, the incinerators if fitted, the comminuters and grinders, the hazardous wastes recovery unit if fitted (for **Cleanvessel)**
- general examination of the holding tanks, including examination of a possible corrosion protection of the inside surfaces of the tanks which are to be in good condition (for **Cleanvessel)**
- verification of the satisfactory condition of the standard discharge connections for oil and wastewater (for **Cleanvessel**, **AWT** and **NDO-x days**)
- external examination and operating tests of the equipment and systems as required in Pt D, Ch 2, Sec 11 (for all additional class notations related to pollution prevention systems).
- confirmation that the hazardous wastes are properly stowed as specified in the garbage management plan (for **Cleanvessel** and **NDO-x days**).

For some pollution prevention system of [3.1.1], the survey is also to include, as far as practicable:

- ascertainment of the correct concentration of the disinfectant in the effluent (for **Cleanvessel**, **AWT** and **GWT**)
- ascertainment of possible concentration of other chemicals in the effluent (for **Cleanvessel**, **AWT** and **GWT**).

b) Review of records

The following records for the preceding 12 months are to be reviewed as necessary:

- oil record book (for **Cleanvessel** and **OWS-x ppm**)
- garbage record book (for **Cleanvessel** and **OWS-x ppm**)
- sewage and grey water discharge book (for **Cleanvessel**, **GWT** and **AWT**)
- emissions record (for **NOX-x%** and **SOX-x%**)
- results of the tests on effluents done by the vessel Owner according to Pt D, Ch 2, Sec 11, [4.2.3] for any pollution prevention system of [3.1.1] (for **AWT**).

3.2.3 Class renewal survey

The requirements given in [3.2.2] for intermediate surveys are to be complied with. In addition, for all additional class notations related to pollution prevention systems, the following is to be carried out:

- demonstration, under working conditions, of the correct functions of the most important components of the sewage treatment plant or AWT plant if fitted, the garbage treatment plant, the oil filtering equipment, the incinerators if fitted, the comminuters and grinders, the hazardous waste recovery unit if fitted
- ascertainment of the correct function of the alarms.

3.3 Prevention of air pollution

3.3.1 Intermediate survey

a) Ozone depleting substances (**Cleanvessel**)

A procedure for annual verification of the system and equipment condition by an authorised organisation is to be settled. The interval of this verification may be extended in case of predictive maintenance scheme approved by the Society.

A procedure for weekly verification and maintenance is to be settled enabling to:

- check the tightness of the circuits by satisfactory means (such as weighing or vessel pressure monitoring)
- identify the location of possible leakage
- carry out necessary corrective actions.

Record books tracing all the operations carried out on board the vessel are to be kept on-board and updated after each intervention. They are to include in particular the following records:

- presence of leak and corrective action
- volume of substance recovered and indication of the storage location
- volume of substance recharged
- volume of substance consumed
- volume of substance disposed.

The survey is to include the following items:

- verification that the above procedures for annual and weekly checking of systems with ozone depleting substances are available on-board
- confirmation that appropriate entries are being made in the record book for ozone depleting substances
- test of the proper operation of the leak detectors and related audible and visual alarms.

Review of ozone depleting substance record book.

b) NO_X emission (**NOX-x%**)

- during the intermediate survey, it is to be confirmed that the NOx emission control procedure is available on-board
- NOx emission records.

c) SO_X emission (**Cleanvessel**, **SOX-x%**)

Procedures are to be established to detail the maximum sulphur content in the fuel oil purchase orders, and to check the actual content of sulphur at the delivery of bunker.

In the case the actual sulphur content is checked by sampling testing and analysis, procedures are to be carried out in accordance with a recognised standard acceptable to the Society.

The fuel management procedures are to be established and followed as part of the certified ship management system of the ship.

Records on purchase orders and on type of checking carried out, including results, are to be kept on-board.

The survey is to include the following items:

- verification that the above procedures for defining, ordering and checking fuel oils for control of SOx emission are available on-board
- confirmation that fuel oil sulphur content records are available on-board
- emission record (when exhaust gas cleaning is provided (EGC)).

d) On board incinerator (**Cleanvessel**)

The intermediate survey is to include the following items, when fitted:

- external examination of the incinerators and confirmation that such equipment operates satisfactorily
- test of the alarms, exhaust monitoring devices and emergency stop located outside the compartment.

3.3.2 Class renewal survey

The requirements given in [3.3.1] for intermediate surveys are to be complied with. In addition, the following is to be carried out:

- confirmation of the operation and calibration of the emissions analysers if fitted (for **NOX-x%** and **SOX-x%**)
- external examination and operating tests of the equipment and systems, as required in Pt D, Ch 2, Sec 11 (for all additional class notations related to pollution prevention systems).

4 Ferry

4.1 General

4.1.1 The requirements of this Article apply to vessels which have been assigned the additional class notation **Ferry** as described in Ch 1, Sec 3, [11.8].

4.2 Intermediate and class renewal surveys

4.2.1 The scope of the intermediate survey and class renewal survey of **Ferry** is to include the scope of surveys required for the service notations **RoRo cargo vessel** and **Passenger vessel**, as detailed in Ch 3, Sec 7, [5] and Ch 3, Sec 7, [6], respectively.

4.2.2 In addition to [4.2.1], for both intermediate survey and class renewal survey, the condition of means of escape as well as of fire protection, detection and extinction is to be checked.

5 Fire

5.1 General

5.1.1 The requirements of this Article apply to vessels which have been assigned the additional class notation **Fire** as described in Ch 1, Sec 3, [11.9].

5.2 Intermediate and class renewal surveys

5.2.1 The intermediate and class renewal surveys are to include:

- a general examination of arrangements for structural fire protection
- a checking of the condition of means of escape as well as of fire protection, detection and extinction.

6 Grabloading

6.1 General

6.1.1 The requirements of this Article apply to vessels which have been assigned the additional class notation **Grabloading**, as described in Ch 1, Sec 3, [11.10.1].

6.2 Class renewal survey

6.2.1 The reinforced area of inner bottom plating, hold sides, bulkheads and adjacent associated structures, as applicable, are to be visually examined for possible deformations, fractures or other damage. If deemed necessary, thickness measurements may be required.

7 Green passport for vessel recycling

7.1 General

7.1.1 Application

The requirements of this Article apply to vessels which have been assigned the additional class notation **Green passport** related to vessel recycling, as described in Ch 1, Sec 3, [11.15.4].

7.2 Class renewal survey

7.2.1 The class renewal survey is to be carried out in compliance with the requirements of NR528 Green Passport.

8 Navigation in ice

8.1 General

8.1.1 The requirements of this Article apply to vessels which have been assigned one of the following additional class notations, as described in Ch 1, Sec 3, [11.13]:

- **Ice**
- **Ice-30**
- **Ice-40**
- **Ice-40+**

8.2 Class renewal survey

8.2.1 Thickness measurements

Additional systematic thickness measurements are required in the areas where strengthening for navigation in an ice environment has been applied in accordance with the requirements in Pt D, Ch 2, Sec 1, [2], as per Tab 2.

Table 2 : Scope of survey for navigation in ice

Class renewal survey		
No. I	No. II	Nos. III and subsequent
–	selected plates	all plates
		selected internal frames, stiffeners and stringers

8.2.2 River chests

During the bottom survey in dry condition which is to be carried out concurrently with the class renewal survey (see Ch 3, Sec 5), the specific arrangements related to river chests protected against ice blocking, such as heating coil and cooling water discharge piping, are to be checked.

9 Stability

9.1 General

9.1.1 The requirements of this Article apply to vessels which have been assigned the additional class notation **Damage stability**, as described in Ch 1, Sec 3, [11.14].

9.2 Class renewal survey

9.2.1 If modifications susceptible to affect the vessel displacement and/or weight distribution have been performed, a lightweight survey is to be carried out to verify any changes in lightship displacement and in the longitudinal position of the centre of gravity. Where, in comparison with the approved stability information, a deviation in lightship displacement or in the longitudinal position of the centre of gravity exceeding the values prescribed in Pt B, Ch 2, Sec 2, [3.1.3] is found or anticipated, the vessel is to be submitted to a new inclining test.

APPENDIX 1 CLASS REQUIREMENTS AND SURVEYS OF LAID-UP VESSELS

1 General

1.1

1.1.1 In order to maintain its class during a normal operation period, a vessel is to be submitted to the surveys described in Ch 2, Sec 2 at their due dates and to the satisfaction of the Society, and is to be free of overdue surveys and conditions of class during the considered period.

1.1.2 When a vessel stops trading and is put out of commission for a certain period, i.e. is laid-up, the normal survey requirements may no longer apply provided that the Owner notifies the Society of this fact. The Owner is also to submit a lay-up maintenance program to the Society for approval.

1.1.3 The lay-up maintenance program includes:

- the safety conditions to be kept throughout the lay-up period
- the measures taken to preserve the maintenance of the vessel throughout the lay-up period
- the survey requirements to be complied with for lay-up, maintenance of class in lay-up and re-commissioning.

2 Safety conditions

2.1 General

2.1.1 Power supply

Adequate power supply is to be supplied, or readily available, all around the clock, either from independent means on board the vessel or from shore.

The following safety conditions are to be kept throughout the lay-up period.

2.1.2 Manning

Watch personnel are to be provided. The number of the watch personnel will depend on the size of the vessel, the lay-up site and mooring arrangements, the shore assistance available in case of fire, leakage or flooding, the maintenance required to provide adequate preservation. A permanent shore communication installation (radio, telephone) is also to be available.

2.1.3 Fire protection and fire fighting

The following is to be complied with:

- automatic fire alarm systems, where provided, are to be in working order and in operation
- fire-fighting installations are to be tested regularly and readily available
- the fire main is to be readily available and periodically tested under pressure
- ventilation trunks, air inlets and watertight doors are to be kept closed.

2.1.4 Protection against explosion

Cargo spaces and piping systems are to be cleaned and ventilated to prevent gas from forming any pockets.

An inert gas system in operation is recommended for the cargo spaces of tankers intended to carry dangerous goods.

All flammable materials, sludge, etc. are to be removed from the vessel's bilge, tank tops, double bottom tanks, engine room, pump rooms and similar spaces.

Hot work is not be carried out during lay-up, unless special precautionary measures are taken.

2.1.5 Safety equipment

All the equipment usually recommended for the safety of the watch personnel is to be provided, kept in working order and tested regularly.

The usual life-saving equipment such as liferafts, life-buoys, breathing apparatus, oxygen masks and distress signals is to be provided and made accessible.

The requirements of the flag Administration and of the local port authorities of the lay-up site are usually to be applied.

2.1.6 Emergency power

Where provided, the emergency source of power, emergency generator and/or emergency air compressor are to be kept in working order and tested weekly.

3 Preservation measures for lay-up and maintenance

3.1 General

3.1.1 A lay-up log-book is to be kept on board, in which the maintenance work and tests carried out during the lay-up period are to be entered with the corresponding dates. The nature and frequency of the maintenance, inspections and tests are also to be defined in the lay-up log book.

3.1.2 The following measures for preservation and maintenance during the lay-up period are to be taken by Owners according to the type of vessel, hull equipment, machinery installations and the specific cases of lay-up conditions.

3.2 Exposed parts of the hull

3.2.1 Underwater parts of the hull are to be protected against corrosion. The condition of sacrificial anodes is to be evaluated at the annual lay-up condition surveys.

3.2.2 The coating of the hull above the waterline, exposed decks, access doors or covers on exposed decks, and hatch covers is to be maintained in satisfactory condition.

All accesses leading to internal spaces are to be kept closed.

All vent pipes and ventilation trunks are to be kept closed.

3.3 Internal spaces

3.3.1 Cargo tanks and cargo holds are to be emptied, cleaned and kept dry.

Ballast tanks are to be kept either full or empty. When ballast spaces are kept filled with water, special care is to be taken to keep such spaces topped up and protected against corrosion. When provided, sacrificial anodes are to be renewed when deemed necessary. The topping up is to be regularly verified.

3.3.2 Chain lockers are to be drained, cleaned and kept dry. Coating with bituminous paint is recommended.

3.3.3 Fuel oil and lubricating oil tanks are to be drained regularly.

Lubricating oil analysis is to be performed regularly and the oil renewed when the result is not satisfactory. Prior to being refilled, tanks are to be cleaned.

Empty lubricating oil tanks are to be cleaned and kept dry.

Fresh water or distilled water tanks are to be kept full or empty. Empty tanks are to be cleaned and kept dry. Where cement wash is used as a coating, this is to be examined and repaired prior to filling.

3.3.4 The bilge and tank top in engine rooms are to be cleaned and kept dry.

Hull water inlet and outlet valves not in use are to be kept closed.

3.4 Deck fittings

3.4.1 The windlass, capstans and winches are to be regularly greased and turned once a week.

All wire cables are to be kept greased.

Visible parts of chains are to be coal-tarred and examined regularly.

Chocks and hawse pipes are to be coated with bituminous paint or equivalent if deemed necessary.

Cargo piping on deck is to be drained, blown through if deemed necessary and kept dry by opening up drains.

Electrical machinery and navigational equipment are to be protected by watertight covers.

3.5 Machinery

3.5.1 Machinery spaces

The air temperature inside the machinery spaces is normally to be kept above 0°C.

Humidity is to be kept as low as possible and within acceptable limits.

3.5.2 Machinery - General

Exposed mechanical parts of machinery are to be greased.

All rotating machinery such as diesel engines, pumps, turbines, electric motors and generators are to be turned at regular intervals with a limited number of revolutions (the lubricating oil system should be put in operation or proper priming applied). Units are not to be stopped in the same position as the previous one.

Bearing boxes are to be emptied, cleaned and refilled with new oil.

3.5.3 Condensers and heat exchangers

Condensers and heat exchangers are to be drained and kept dry.

Desiccant is to be placed in steam spaces.

Water sides are to be washed with fresh water.

The condition of the zinc anodes is to be periodically checked.

When tubes are fitted with plastic or fibre packing, water sides are to be filled with alkaline distilled water.

When tubes are expanded or fitted with metal packing, water sides are to be provided with desiccants and kept dry.

3.5.4 Auxiliary machinery

Air receivers are to be drained, opened up and cleaned. Pressure relief valves are to be cleaned and slightly lubricated.

Air compressor crankcases are to be drained, cleaned and refilled with clean oil. Cylinders and valves are to be lubricated. Coolers are to be drained and dried. Air drains are to be opened and the system dried.

Air start lines are to be drained and dried.

Hot-wells/return tanks are to be drained and dried.

De-aerators are to be drained and dried.

Feed pumps and extraction pumps are to be drained and dried.

Air ejectors are to be drained and dried.

Main circulation pumps are to be drained and dried.

Evaporators are to be drained, cleaned and dried.

3.5.5 Piping

Pipes not in use are to be drained and kept dry.

3.5.6 Diesel engines

Daily tank fuel oil outlet pipes and all injection equipment are to be filled with filtered gas oil.

Fresh water circuits are to be filled with water mixed with rust inhibitors. Fresh water pH is to be checked monthly.

Oil of hydraulic regulators is to be replaced.

River water cooling pipes are to be drained.

Crankcases are to be provided with desiccant.

Starting valves are to be lubricated (internally and externally).

Motor oil is to be sprayed in cylinders and on all external parts liable to corrosion.

Cams and cylinders are to be motor oil sprayed monthly.

Turbo-compressor/charger ball bearings are to be oil sprayed and rotated for an integer number of revolutions plus one quarter of a revolution.

Engine air inlets and exhaust gas pipes are to be sealed.

Scavenge spaces are to be cleaned.

Engines are to be turned weekly.

3.5.7 Shaft lines

Shaft lines are to be coated with grease.

Shaft bearing cooling pipes are to be drained.

For river water lubricated propeller shafts, the packing gland of the engine room stuffing box is to be tightened.

For oil lubricated sterntubes, lubricating oil is to be analysed and renewed if not satisfactory. The oil level in the tank is to be verified regularly.

Propeller shaft lines are to be rotated an integer number of revolutions plus one quarter of a revolution.

3.6 Electrical installations

3.6.1 Main and secondary switchboards, sub-feeder panels, fuse panels and starters are to be made tight. Desiccant is to be provided.

Contacts of relays, breakers and switch-breakers are to be coated with neutral vaseline.

Bearings of generators are to be cleaned of old grease and protected with new oil or grease.

Carbon brushes are to be lifted off their commutations.

3.6.2 Electrical insulation of each item is to be kept at a minimum 200,000 Ohms and general insulation is to be not less than 50,000 Ohms. Local electric heating may be necessary to improve the level of insulation, particularly in the generators/alternators and large motors.

A insulation resistance test is to be performed regularly.

3.7 Steering gear

3.7.1 Exposed mechanical parts are to be greased or oil sprayed.

For electrical parts the same preservation measures given in [3.6] are to be taken.

It is recommended that the steering gear should be operated monthly.

3.8 Boilers

3.8.1 Smoke sides of boilers are to be swept, washed clean with basic hot water and hot air dried.

3.8.2 Water and steam sides should preferably be preserved using the dry method, keeping the moisture at the lowest possible level, the ideal level being between 30% and 35%. It is advisable to ensure that no residual water remains to cause rapid corrosion. Drum doors are to be kept closed.

In other cases, it is advisable to keep the boilers, superheaters and economisers filled with water having a pH around 10,5. Hydrazine hydrate treatment of the water is preferable to reduce risks of corrosion caused by dissolved oxygen. The water is to be regularly analysed.

3.8.3 Air heaters are to be cleaned and kept dry.

Uptake, shell and fan outlets are to be cleaned and kept closed with watertight hoods.

Burners are to be dismantled, and atomisers greased.

Desiccant is to be provided in furnaces where deemed necessary.

Expansion arrangements (sliding feet) are to be suitably greased.

The internal condition of boilers is to be checked every three months.

3.9 Automated installation

3.9.1 Recommendations for electronic components are the same as those given for electrical installations.

For pneumatic parts the manufacturers' recommendations are to be followed and the system is to be checked regularly.

Pressure, temperature or level sensors are generally not affected by damage when not used. However, when available, the manufacturers' recommendations are to be followed.

4 Lay-up site and mooring arrangements

4.1 General

4.1.1 The choice and suitability of the lay-up site, as well as the type of mooring conditions, the mooring arrangements and their efficiency during the lay-up period remain the responsibility of the Owner.

However, at the Owner's request, the mooring arrangement may be reviewed by the Society.

4.2 Recommendations for the lay-up site

4.2.1 The following recommendations are to be considered by Owners regarding the choice and suitability of the lay-up site.

The site should be:

- sheltered from strong currents and waves
- not exposed to whirling winds or turbulent tidal waves
- not exposed to moving ice
- clear of corrosive waste waters
- provided with adequate vessel/shore communications.

4.3 Recommendations for the mooring arrangements

4.3.1 The following recommendations are to be considered by Owners with respect to the mooring arrangements:

- ground holding should be adequate
- vessels laid-up to buoys or anchored should be moored in such a way as to be prevented from swinging with normal wind and tidal changes
- chain cables should not be subject to cross-contact or twisting and stern anchorage should generally be provided
- laid-up vessels should be in ballast condition in order to reduce the effects of wind. Due consideration should be given to the still water bending moment. For guidance, normal ballast draft should be roughly between 30% and 50% of the maximum draft.

4.3.2 Vessels should normally be moored singly. However, when several vessels are moored together, the following provisions are to be made:

- vessels are to be moored bow to stern
- vessels are to be of approximately the same size
- the number of vessels moored together is, in principle, not to exceed six
- breast-lines are to be of similar elasticity
- fenders are to be provided.

4.4 Review of the mooring arrangements

4.4.1 As indicated in [4.1.1], at the Owners' request, the mooring arrangements may be reviewed by the Society.

4.4.2 The proposal for the mooring arrangements is, in such case, to be submitted by the Owner and is to include the following information, as applicable:

a) Mooring site
   - geographical area (to be specified on a map)
   - characteristics of the sea/river bottom
   - water depth
   - preferential angular sectors (effects of wind / tide / current) indicated according to statistical studies
   - wave characteristics (amplitude, periods)

b) Geometry of mooring arrangements
   - vessel's position and direction
   - shore anchorage
   - diagram showing mooring equipment (fore and aft)
   - angle between chain cables and vessel's centreline.

c) Characteristics of mooring equipment
   - maximum holding strength of each anchor
   - type of mooring lines (chains, cables, sinkers, etc.)
   - length of each section
   - weight of each section
   - mechanical characteristics of each section (breaking load)
   - weight of sinkers.

4.4.3 On completion of the installation, the mooring arrangements are to be surveyed by the Society. When the vessel is anchored, the underwater installation is to be inspected by a diver whose report is to be presented to the Society.

4.4.4 It is the responsibility of the Owners to ascertain the efficiency of the mooring arrangements during the lay-up period. The mooring arrangements are to be re-examined at regular intervals (at least each year when the vessel is anchored) and when abnormal weather conditions occur at the lay-up site.

5 Surveys

5.1 Laying-up survey

5.1.1 At the beginning of the lay-up period a laying-up survey is to be carried out whose scope is to verify that the safety conditions, preservation measures, lay-up site and mooring arrangements are in accordance with the program agreed by the Society.

5.1.2 Upon satisfactory completion of this survey, an endorsement to confirm that the vessel has been placed in lay-up is entered on a memorandum, which is subsequently to be kept on board.

5.2 Lay-up condition survey

5.2.1 As described in Ch 2, Sec 2, [11], a lay-up condition survey is to be performed to ascertain that the lay-up maintenance program implemented is continuously complied with.

5.2.2 It is to be checked that the arrangements made for the lay-up are unchanged and that the maintenance work and tests are carried out in accordance with the maintenance manual and recorded in the lay-up log-book.

5.2.3 Upon satisfactory completion of the survey, the Certificate of Classification is endorsed.

5.3 Re-commissioning survey

5.3.1 Owners are to make the necessary arrangements to remove the temporary lay-up installations provided for preservation measures and the protective materials and coatings (oil, grease, inhibitors, desiccants), before the survey is commenced.

It is the Owners' responsibility to verify that the vessel parts that are not covered by class are reactivated in satisfactory operational condition.

5.3.2 The scope of the re-commissioning survey is to include:

- a general examination of the hull, deck fittings, safety systems, machinery installations (including boilers whose survey is not due) and steering gear
- all periodical surveys due at the date of re-commissioning or which became overdue during the lay-up period
- dealing with the recommendations due at the date of re-commissioning or which became due during the lay-up period.

5.3.3 For the hull the following is to be carried out:

- examination of shell plating above the waterline, deck plating, hatch covers and coamings
- examination of load line items
- overall survey of all cargo tanks/holds
- overall survey of representative ballast tanks when the lay-up period does not exceed two years
- overall survey of all ballast tanks when the lay-up period is two years and over
- function tests of bilge and ballast systems.

5.3.4 For the deck fittings the following is to be carried out:

- examination of the fire main under working pressure
- where possible, examination of deck piping under working pressure
- function tests of class items
- checking inert gas installation under working condition after inspection of water seal and function test of deck non-return valve and pressure/vacuum valves.

5.3.5 For machinery installations the following is to be checked:

- the analysis of lubricating oil of main engines, auxiliary engines, reduction gears, main thrust bearings and sterntube
- the general condition of crankcase, crankshaft, piston rods and connecting rods of diesel engines
- the crankshaft deflections of diesel engines. In addition when engines have been laid-up for more than two years, one piston is to be disconnected and one liner is to be removed for examination. Dismantling is to be extended if deemed necessary
- the condition of the water side of condensers and heat exchangers
- the condition of expansion arrangements
- the condition of reduction gears through the inspection doors
- the condition after overhauling of pressure relief devices
- the test of bilge level alarms, when fitted.

5.3.6 The main and emergency electrical installations are to be tested. The parallel shedding of main generators and main switchboard safety devices are to be checked. An insulation resistance test of the electrical installation is to be performed.

5.3.7 For the fire prevention, detection and fire-fighting systems, the following is to be examined and/or tested:

- remote control for quick closing of fuel oil valves, stopping of fuel oil pumps and ventilation systems, closing of fire doors and watertight doors
- fire detectors and alarms
- fire-fighting equipment.

5.3.8 The automated installation is to be checked for proper operation.

5.3.9 When classed, the installations for refrigerated cargo are to be examined under working conditions. Where the lay-up period exceeds two years, representative components of the installation are to be dismantled.

5.3.10 For cargo installations on liquefied gas carriers, the following is to be carried out:

- inspection of the primary barrier in tanks
- for membrane tanks, a global gas test of tanks whose results are to be compared with those obtained at ship's delivery
- testing of gas piping at working pressure using inert gas.

A Surveyor of the Society is to attend the first cooling down and loading of the vessel.

5.3.11 For other specific classed installations, the Owners are to submit a survey program to the Society.

5.3.12 On completion of the above surveys, navigation trials are to be performed in the presence of a Surveyor of the Society.

The navigation trials are to include:

- verification of the satisfactory performance of the deck installations, main propulsion system and essential auxiliaries, including a test of the safety devices
- an anchoring test
- complete tests of steering gear
- full head and full astern tests
- tests of automated machinery systems, where applicable.

5.3.13 Upon satisfactory completion of the surveys, an endorsement to confirm the carrying out of all relevant surveys and the re-commissioning of the ship is entered on a memorandum.

Shaping a World of Trust

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Rules for the Classification of Inland Navigation Vessels

PART B – Hull Design and Construction

Chapters 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8

NR 217.B1 DT R06 E June 2021

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BUREAU VERITAS MARINE & OFFSHORE

GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 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.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of the above listed being relieved from any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 Only the Society is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards ("Applicable Referential"), in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification (or Certification as defined in clause 2.2) is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules and/or to Applicable Referential for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules (available online on veristar.com), guidance notes and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the Rules and/or the Applicable Referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, and/or to the Applicable Referential, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate nor on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisement made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involves, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interest equal to twelve (12) months LIBOR plus two (2) per-cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to resolve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 The Services shall be automatically and immediately terminated in the event the Client can no longer establish any form of interest in the Unit (e.g. sale, scrapping).

9.3 The Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, or immediately in the event of termination under clause 9.2, subject to compliance with clause 4.1 and 6 above.

9.4 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, will be treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, other than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed in accordance with and governed by the laws of England and Wales.

15.2 Any dispute shall be finally settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

15.3 Notwithstanding clause 15.2, disputes relating to the payment of the Society's invoices may be submitted by the Society to the *Tribunal de Commerce de Nanterre*, France, or to any other competent local Court, at the Society's entire discretion.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics and, when applicable, Business Partner Code of Conduct both available at https://group.bureauveritas.com/group/corporate-social-responsibility/operational-excellence.

Rules for Inland Navigation Vessels

Part B
Hull Design and Construction

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Chapter 1 GENERAL

Chapter 2 HULL AND STABILITY PRINCIPLES

Chapter 3 DESIGN LOADS

Chapter 4 GLOBAL STRENGTH ANALYSIS - METALLIC HULLS

Chapter 5 HULL SCANTLINGS

Chapter 6 OTHER STRUCTURES

Chapter 7 HULL OUTFITTING

Chapter 8 CONSTRUCTION AND TESTING

June 2021

These Rules apply to inland navigation vessels for which contracts for construction are signed on or after June 1st, 2021.

The English version of these Rules takes precedence over editions in other languages.

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Part B

Hull Design and Construction

Chapter 1

GENERAL

SECTION 1 APPLICATION

SECTION 2 SYMBOLS AND DEFINITIONS

SECTION 3 DOCUMENTATION TO BE SUBMITTED

SECTION 1 APPLICATION

1 General

1.1 Structural requirements

1.1.1 Part B of the Rules contains the requirements for determination of the minimum hull scantlings, applicable to all types of inland navigation vessels as well as vessels operated in restricted maritime stretches of water, of displacement type, of normal form, speed and proportions, having a rule length:

- $L \leq 135$ m for vessels made of steel or aluminium alloy
- $L < 40$ m for vessels made of composite material or plywood.

These requirements are to be integrated with those specified in Part D, for any individual vessel type, depending on the class notations assigned to the vessels.

1.1.2 The requirements of Part B and Part D need to be complemented by applicable requirements of the Society's Rule Notes:

- NR561 Hull in Aluminium alloys, for vessels assigned additional service feature **A**
- NR546 Hull in Composite Materials and Plywood, for vessels assigned additional service feature **C** or **W**.

1.1.3 Vessels with rule length exceeding the limits specified in [1.1.1] and vessels with novel features or unusual hull design are to be individually considered by the Society, on the basis of the principles and criteria adopted in the Rules.

1.1.4 The strength of vessels constructed and maintained according to the Rules is sufficient for the scantling draught considered when applying the Rules.

1.1.5 For vessels with high design speed and/or where high trim angles are expected or for dynamically supported vessels, other applicable Society's Rules are to be complied with.

1.2 Limits of application to lifting appliances

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

1.2.2 The fixed parts of lifting appliances and their connections to the vessel's structure are covered by the Rules, even when the certification of lifting appliances is not required.

2 Rule application

2.1 Vessel parts

2.1.1 General

For the purpose of application of the Rules, the vessel is considered as divided into the following four parts:

- fore part
- central part
- machinery space, where applicable
- aft part.

2.1.2 Fore part

The fore part includes the structures of the stems and those:

- located in the part before the cargo zone in the case of vessels with a separated cargo zone (separated by bulkheads)
- located in the part extending over 0,1L behind the stem in all other cases unless otherwise mentioned.

2.1.3 Central part

The central part includes the structures within the greater of:

- the region extending over 0,5L through the midship section
- the region located between the fore part and:
  - the machinery space, if located aft
  - the aft part, otherwise.

2.1.4 Aft part

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

2.2 Vessels made of metallic materials

2.2.1 Rules applicable to various vessel parts

For vessels made of metallic materials, the various Chapters and Sections of Part B are to be applied to vessel parts according to Tab 1.

Ch 5, Sec 6 applies, as an alternative to the relevant requirements of Part B, Chapter 5, to vessels of rule length $L < 40$ m.

2.2.2 Rules applicable to other vessel items

The various Chapters and Sections of the Rules are to be applied for the scantling and arrangement of other vessel items according to Tab 2.

Table 1 : Application to vessel parts - Metallic hulls

Part	Applicable Chapters and Sections	
	General	Specific
Fore part	Part B, Chapter 1 Part B, Chapter 2 Part B, Chapter 3 Part B, Chapter 4 Part B, Chapter 6 **(1)**, excluding: • Ch 6, Sec 1 • Ch 6, Sec 2 Part B, Chapter 8	Ch 6, Sec 1
Central part All vessels		Ch 5, Sec 1 to Ch 5, Sec 5
Central part L < 40 m		Ch 5, Sec 6 **(2)**
Aft part		Ch 6, Sec 2

(1) See also Tab 2.
(2) Ch 5, Sec 6 applies, as an alternative to the relevant requirements of Part B, Chapter 5, to vessels of rule length L < 40 m.

Table 2 : Application to other items - Metallic hulls

Item	Applicable Chapters and Sections
Machinery space	Ch 6, Sec 3
Superstructures and deckhouses	Ch 6, Sec 4
Hatch covers	Ch 6, Sec 5
Movable decks and ramps	Ch 6, Sec 6
Miscellaneous fittings	Ch 6, Sec 7
Helicopter decks and platforms	Ch 6, Sec 8
Rudders	Ch 7, Sec 1
Other hull outfitting	Part B, Chapter 7

2.3 Vessels assigned additional service feature C or W (plywood)

2.3.1 The requirements listed in Tab 3 apply also to vessels assigned additional service feature **C** or **W** (plywood).

Table 3 : Application to vessels assigned additional service features C or W

Item	Applicable requirements
General arrangement design	Part B, Chapter 1
Stability	Ch 2, Sec 2
Materials	Ch 2, Sec 3, [4]
Strength criteria- structural items in composite material or plywood	Ch 2, Sec 6
Design loads	Part B, Chapter 3
Sidescuttles, windows and skylights	Ch 6, Sec 7, [1]
Helicopter decks and platforms	Ch 6, Sec 8
Rudders	Ch 7, Sec 1
Other hull outfitting	Part B, Chapter 7
Construction and testing	Ch 8, Sec 1

3 Rounding off of scantlings - Metallic hulls

3.1 General

3.1.1 Plate thicknesses

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

a) the net thickness (see Ch 2, Sec 5, [2.1]) is calculated in accordance with the rule requirements

b) corrosion addition t_C (see Ch 2, Sec 5, [3.1]) is added to the calculated net thickness, and this gross thickness is rounded off to the nearest half-millimeter

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

3.1.2 Stiffener section moduli

Stiffener section moduli as calculated in accordance with the rule requirements are to be rounded off to the nearest standard value; however, no reduction may exceed 3%.

SECTION 2 SYMBOLS AND DEFINITIONS

Symbols

L : Rule length, in m, defined in [2.1]

B : Breadth, in m, defined in [2.2]

D : Depth, in m, defined in [2.3]

T : Scantling draught, in m, defined in [2.4]

L_{OA} : Length overall, in m, defined in [2.5]

L_{WL} : Length of waterline, in m, defined in [2.6]

Δ : Displacement, in tons, at scantling draught T

ρ : River/sea water density, in t/m^3

C_B : Block coefficient:

$$C_B = \frac{\Delta}{\rho L B T}$$

1 Units

1.1

1.1.1 Unless otherwise specified, the units used in the Rules are as indicated in Tab 1.

Table 1 : Units

Designation	Usual symbol	Units
Vessel's dimensions	see [2.1]	m
Hull girder section modulus	Z	cm^3
Density	ρ	t/m^3
Concentrated loads	P	kN
Linearly distributed loads	q	kN/m
Surface distributed loads (pressure)	p	kN/m^2
Thickness	t	mm
Span of ordinary stiffeners and primary supporting members	ℓ	m
Spacing of ordinary stiffeners and primary supporting members	s, S	m
Bending moment	M	kN.m
Stresses	σ, τ	N/mm^2
Section modulus of ordinary stiffeners and primary supporting members	w	cm^3
Sectional area of ordinary stiffeners and primary supporting members	A	cm^2
Vessel speed	V	km/h

2 Definitions

2.1 Rule length

2.1.1 The rule length L is the distance, in m, measured on the waterline at the scantling draught, from the fore side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post. L is to be not less than 96% of the extreme length on the waterline at the scantling draught.

In the case of vessels having neither a rudder post (e.g. vessels fitted with azimuth thrusters) nor a rudder (e.g. pushed barges) the rule length L is to be taken equal to the length of the load waterline.

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

2.2 Breadth

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

2.3 Depth

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

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

2.4 Scantling draught

The scantling draught T is the distance, in m, measured vertically on the midship transverse section, from the moulded base line to the waterline at which the strength requirements for the scantlings of the vessels are met. It represents the full load condition and is to be not less than that corresponding the assigned freeboard.

In the case of vessels with a solid bar keel, the moulded base line is to be taken as defined in [2.3].

2.5 Length overall

2.5.1 The length overall is the extreme length of the vessel, in m, measured from the foremost point of the stem to the aftermost part of the stern.

2.6 Length of waterline

2.6.1 The length of waterline is the length of the hull, in m, measured at the maximum draught.

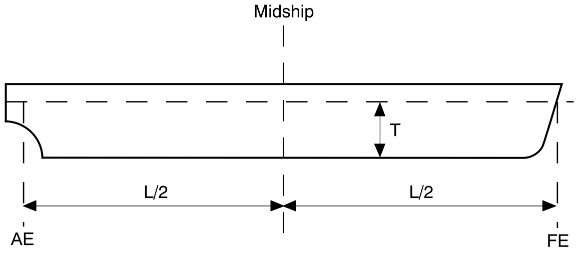
2.7 Ends of rule length and midship

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

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

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

Figure 1 : Ends and midship



2.8 Superstructure

2.8.1 A superstructure is a decked structure connected to the strength deck defined in [2.10], extending from side to side of the vessel or with the side plating not being inboard of the shell plating more than 0,04B.

2.9 Deckhouse

2.9.1 A deckhouse is a decked structure other than a superstructure, located on the strength deck defined in [2.10] or above.

2.10 Strength deck

2.10.1 The strength deck (main deck) is the uppermost continuous deck contributing to the hull girder longitudinal strength.

2.11 Weather deck

2.11.1 The weather deck is the uppermost continuous exposed deck.

2.12 Bulkhead deck

2.12.1 The bulkhead deck is the uppermost deck up to which the transverse watertight bulkheads and the shell are carried.

2.13 Cofferdam

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

2.14 Inner side

2.14.1 The inner side is the longitudinal bulkhead which limits the inner hull for vessels fitted with double hull.

2.15 Weathertight

2.15.1 "Weathertight" is the term used to a closure or structure which prevents water from penetrating into the vessel under any service conditions. Weathertight designates structural elements or devices which are so designed that the penetration of water into the inside of the vessel is prevented:

- for one minute when they are subjected to a pressure corresponding to a 1 m head of water, or
- for ten minutes when they are exposed to the action of a jet of water with a minimum pressure of 1 bar in all directions over their entire area.

Following constructions are regarded as weathertight:

- weathertight doors complying with ISO 6042
- ventilation flaps complying with ISO 5778
- airpipe heads of automatic type and of approved design.

Weathertightness shall be proven by hose tests or equivalent tests accepted by the Society before installing.

2.16 Watertight

2.16.1 "Watertight" designates structural elements or devices which meet all the conditions stated for weathertightness and also remain tight at the anticipated internal and external pressure.

Watertightness should be proven by workshop testing and where applicable by type approvals in combination with construction drawings (e.g. watertight sliding doors, cable penetrations through watertight bulkheads).

3 Reference co-ordinate system

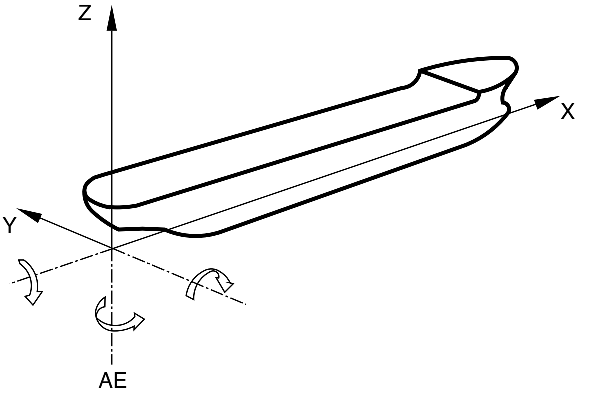
3.1 General

3.1.1 The vessel's geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 2):

- Origin: at the intersection among the longitudinal plane of symmetry of vessel, 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.

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

Figure 2 : Reference co-ordinate system



SECTION 3 DOCUMENTATION TO BE SUBMITTED

1 Documentation to be submitted for all vessels

1.1 Vessels surveyed by the Society during the construction

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

Structural plans are to show details of connections of the various parts and, in general, are to specify the materials used, including their manufacturing processes, welding procedures and heat treatments.

Furthermore, considered values of corrosion margin are to be provided for structural design of increased corrosion addition with respect to minimum values stipulated under Ch 2, Sec 5, [3].

1.1.2 The Society reserves the right to ask for further documents and drawings considered necessary.

Irrespective of this, the Rules of construction also apply to components and details not shown in the submitted drawings.

1.1.3 Any deviation from reviewed drawings is subject to the Society's approval before work is commenced.

1.1.4 The application of the Society's construction Rules does not exclude any patent claims.

1.1.5 Plans and documents to be submitted for information

In addition to those in [1.1.1], the following plans and documents are to be submitted to the Society for information:

- general arrangement
- capacity plan, indicating the volume and position of the centre of gravity of all compartments and tanks
- lines plan
- hydrostatic curves
- lightweight distribution.

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

Table 1 : Plans and documents to be submitted for review for all vessels

Plan or document	Containing also information on
Midship section Transverse sections Longitudinal sections Shell expansion Decks and profiles Double bottom Pillar arrangements Framing plan Welding table	Class characteristics Main dimensions Maximum draught Block coefficient for the length between perpendiculars at the maximum draught Frame spacing Contractual service speed Density of cargoes Setting pressure of safety relief valves, if any Assumed loading and unloading procedure Design loads on decks and double bottom Material specifications (steel grades, aluminium alloys, etc.) Location and height of air vent outlets of various compartments Corrosion protection Openings in decks and shell and relevant compensations Boundaries of flat areas in bottom and sides Details of structural reinforcements and/or discontinuities Details related to welding
Watertight subdivision bulkheads Watertight tunnels	Openings and their closing appliances, if any
Fore part structure	Location and height of air vent outlets of various compartments
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	
Aft part structure	Location and height of air vent outlets of various compartments

Plan or document	Containing also information on
Machinery space structures Foundations of propulsion machinery	Type, power and r.p.m. of propulsion machinery Mass and centre of gravity of machinery and boilers, if any Mass of liquids contained in the engine room
Superstructures and deckhouses Machinery space casing	Extension and mechanical properties of the aluminium alloy used (where applicable)
Hatch covers, if any	Design loads on hatch covers Sealing and securing arrangements, type and position of locking bolts Distance of hatch covers from the load waterline and from the fore end
Movable decks and ramps, if any	
Windows and side scuttles, arrangements and details	
Scuppers and sanitary discharges	
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the main deck and superstructure deck
Helicopter decks, if any	General arrangement Main structure Characteristics of helicopters: maximum mass, distance between landing gears or landing skids, print area of wheels or skids, distribution of landing gear loads
Rudder **(1)**	Maximum ahead service speed
Sternframe or sternpost, sterntube Propeller shaft boss and brackets **(1)**	
River/sea chests	
Hawse pipes	
Plan of outer doors and hatchways	
Plan of manholes	
Plan of access to and escape from spaces	
Plan of ventilation	Use of spaces
Plan of watertight doors and scheme of relevant manoeuvring devices	Manoeuvring devices Electrical diagrams of power control and position indication circuits
Stability documentation	See Ch 2, Sec 2, [2.1]
Equipment	List of equipment Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes

(1) Where other steering or propulsion systems are adopted (e.g. steering nozzles or azimuth propulsion systems), the plans showing the relevant arrangement and structural scantlings are to be submitted.

2 Further documentation to be submitted for vessels with specific notations

2.1 General

2.1.1 Depending on the service notation and, possibly, the additional service feature and additional class notation assigned to the vessel, other plans or documents may be required to be submitted to the Society, in addition to those in [1.1].

2.2 Service notations

2.2.1 The additional plans or documents to be submitted to the Society for review or for information are specified in relevant sections of Part D, Chapter 1.

2.3 Additional class notations

2.3.1 The additional plans or documents to be submitted to the Society for review or for information are specified in relevant sections of Part D, Chapter 2 and Part D, Chapter 3.

Part B
Hull Design and Construction

Chapter 2
HULL AND STABILITY PRINCIPLES

SECTION 1	GENERAL ARRANGEMENT DESIGN
SECTION 2	STABILITY
SECTION 3	MATERIALS
SECTION 4	STRUCTURAL DETAIL PRINCIPLES
SECTION 5	NET SCANTLING APPROACH
SECTION 6	STRENGTH CRITERIA - STRUCTURAL ITEMS IN COMPOSITE MATERIAL OR PLYWOOD
SECTION 7	BUCKLING AND ULTIMATE STRENGTH OF ORDINARY STIFFENERS AND STIFFENED PANELS
SECTION 8	DIRECT CALCULATION
APPENDIX 1	ANALYSES BASED ON THREE DIMENSIONAL MODELS
APPENDIX 2	ANALYSES OF PRIMARY SUPPORTING MEMBERS SUBJECTED TO WHEELED LOADS
APPENDIX 3	TORSION OF CATAMARANS

SECTION 1 GENERAL ARRANGEMENT DESIGN

Symbols

z_{hc} : Z co-ordinate, in m, of the top of hatch coaming

z_{LE} : Z co-ordinate, in m, of the lower edge of opening

h_2 : Reference value, in m, of the relative motion in the inclined vessel condition in Ch 3, Sec 3, [2.2.1].

1 Subdivision arrangement

1.1 Number of watertight bulkheads

1.1.1 All vessels are to have at least the following transverse watertight bulkheads:

- a collision bulkhead
- an after peak bulkhead
- two bulkheads forming the boundaries of the machinery space in vessels with machinery amidships, and one bulkhead forward of the machinery space in vessels with machinery aft. In the case of vessels with an electrical propulsion plant, both the generator room and the engine room are to be enclosed by watertight bulkheads.

1.1.2 Additional bulkheads

In the cargo space of single hull open deck vessels, additional transverse bulkheads may be recommended in order to ensure an efficient support to the topside structure.

Additional bulkheads may be required also for vessels having to comply with damage stability criteria.

In the cargo space of double hull vessels, transverse bulkheads are to be fitted in the side tanks in way of watertight floors.

1.2 Collision bulkhead

1.2.1 The collision bulkhead is to be positioned aft of the fore perpendicular at a distance d_C, in m, such that:

$0{,}04\ L_{WL} \leq d_c \leq 0{,}04\ L_{WL} + 2$

1.2.2 The Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular different from that specified in [1.2.1], on the basis of stability calculations.

1.2.3 The collision bulkhead is to extend up to the bulkhead deck.

1.3 After peak and machinery space bulkheads

1.3.1 Extension

These bulkheads are to extend up to the bulkhead deck.

1.3.2 Stern tube

The after peak bulkhead is to enclose the sterntube and the rudder trunk in a watertight compartment. Other measures to minimize the danger of water penetrating into the vessel in the case of damage to stern tube arrangements may be taken at the discretion of the Society.

For vessels less than 40 m, where the after peak bulkhead is not provided in way of the sterntube stuffing box, the stern tubes are to be enclosed in watertight spaces of moderate volume.

1.4 Tank bulkheads

1.4.1 The number and location of transverse and longitudinal watertight bulkheads in vessels intended for the carriage of liquid cargoes (tankers and similar) are to comply with the stability requirements to which the vessel is subject.

1.4.2 In general, liquid compartments extending over the full breadth of the vessel are to be fitted with at least one longitudinal bulkhead, whether watertight or not, where the mean compartment breadth is at least equal to 2B/3, where B is the vessel breadth defined in Ch 1, Sec 2, [2.2].

As a rule, where the bulkhead is perforated, the total area of the holes is generally to be about 5% of the total area of the bulkhead.

1.5 Height of transverse watertight bulkheads

1.5.1 Transverse watertight bulkheads are to extend up to the bulkhead deck.

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

1.6 Openings in watertight bulkheads

1.6.1 Collision bulkheads

Openings may not be cut in the collision bulkhead below the bulkhead deck.

The number of openings in the collision bulkhead above the bulkhead deck is to be kept to the minimum compatible with the design and proper working of the vessel.

All such openings are to be fitted with means of closing to weathertight standards.

No doors or manholes are permitted in the collision bulkhead below the bulkhead deck.

No bilge cock or similar device is to be fitted on the collision bulkhead.

A maximum of two pipes may pass through the collision bulkhead below the bulkhead deck, unless otherwise justified. Such pipes are to be fitted with suitable valves operable from above the bulkhead deck. The valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are easily accessible and the space in which they are fitted is not a cargo space.

1.6.2 Bulkheads other than collision bulkheads

Certain openings below the bulkhead deck are permitted in bulkheads other than the collision bulkhead, but these are to be kept to a minimum compatible with the design and proper working of the vessel and to be provided with watertight doors having strength such as to withstand the head of water to which they may be subjected.

1.7 Watertight doors

1.7.1 Doors cut out in watertight bulkheads are to be fitted with watertight closing appliances. The arrangements to be made concerning these appliances are to be approved by the Society.

1.7.2 The thickness of watertight doors is to be not less than that of the adjacent bulkhead plating, taking account of their actual framing spacing.

1.7.3 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

1.7.4 Watertight doors required to be open during navigation are to be of the sliding type and capable of being operated both at the door itself, on both sides, and from an accessible position above the bulkhead deck.

Means are to be provided at the latter position to indicate whether the door is open or closed, as well as arrows indicating the direction in which the operating gear is to be operated.

1.7.5 Watertight doors may be of the hinged type if they are always intended to be closed during navigation.

Such doors are to be framed and capable of being secured watertight by handle-operated wedges which are suitably spaced and operable at both sides.

2 Compartment arrangement

2.1 Cofferdams

2.1.1 Cofferdams are to be provided between:

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

2.1.2 Cofferdams separating:

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

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

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness obtained according to Ch 5, Sec 5, [2] by 2 mm in the case of tanks carrying fresh water or boiler feed water, and by 1 mm in all other cases
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to Ch 3, Sec 4, [5.1].

2.1.3 Spaces intended for the carriage of flammable liquids are to be separated from accommodation and service spaces by means of a cofferdam. Where accommodation and service spaces are arranged immediately above such spaces, the cofferdam may be omitted only where the deck is not provided with access openings and is coated with a layer of material recognized as suitable by the Society.

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

2.1.4 Where a corner to corner situation occurs, tanks are not be considered to be adjacent.

Adjacent tanks not separated by cofferdams are to have adequate dimensions to ensure easy inspection.

2.2 Compartments forward of the collision bulkhead

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

3 Access arrangement

3.1 Double bottom

3.1.1 Inner bottom manholes

Inner bottom manholes are to be not less than 0,40 m x 0,40 m. Their number and location are to be so arranged as to provide convenient access to any part of the double bottom.

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

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

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

3.1.2 Floor and girder manholes

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

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

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

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

3.2 Access to tanks

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

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

3.2.2 The dimensions of any access hatchway are to be sufficient to allow a person wearing a self-contained breathing apparatus to ascend or descend the ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the tank. In no case is the clear opening to be less than 0,36 m^2 and its length 0,50 m.

3.3 Access within tanks

3.3.1 Wash bulkheads in tanks

Where one or more wash bulkheads are fitted in a tank, they are to be provided with openings so arranged as to facilitate the access of persons wearing breathing apparatus or carrying a stretcher with a patient.

3.3.2 Manholes

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

3.4 Access to side tanks

3.4.1 Where openings allowing access to side tanks are cut in the stringer plate, they are to be arranged clear of the hatch corners and shall be of even-deck design, without obstacles causing stumbling. In order to assure the continuity of the strength, they are to be cut smooth along a well rounded design and are to be strengthened by thick plates, by doubling plates or by other equivalent structure.

3.5 Access to cargo hold

3.5.1 As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of cargo holds.

4 Freeing ports

4.1 General provisions

4.1.1 Where bulwarks on weather decks form wells, provisions are to be made for rapidly freeing the decks from water and draining them.

A well is any area on the deck exposed to the weather, where water may be entrapped.

5 Machinery space openings

5.1 Skylight hatches

5.1.1 Engine room skylights are to be fitted with weathertight hatch covers made of metallic material or any other equivalent material. The hatch covers are to be permanently secured to the sides where the lower edge of the opening is at a height above the load waterline of less than 1 m for range of navigation **IN(x ≤ 2)**, or 0,5 m for the range of navigation **IN**.

5.2 Closing devices

5.2.1 Openings in machinery space casings are to be surrounded by a metallic casing of efficient construction. The openings of the casings exposed to the weather are to be fitted with strong and weathertight doors.

5.3 Position of non-weathertight openings

5.3.1 In any case, the distance, in m, of the lower edge of a non-weathertight opening to the load waterline is to be such that:

$$z_{LE} \geq T + h_2$$

5.4 Entrances

5.4.1 The height, in m, of entrances to machinery space, h_C , above the deck is not to be less than the values given in Tab 1.

Furthermore, this height h_C, above the deck, is to be such that:

$$z_{hc} \geq T + h_2 + 0{,}15$$

Table 1 : Height of entrances to machinery space

Vessel type	Range of navigation	h_C, in m
Carriage of dangerous goods	All	0,5
Other vessels	**IN**	0,3
	IN(x ≤ 2)	0,5

6 Companionway

6.1 General

6.1.1 Companions leading under the bulkhead deck are to be protected by a superstructure or closed deckhouse, or by a companionway having equivalent strength and tightness.

6.1.2 Companion sill height

The sill height above the deck is not to be less than 0,15 m.

Furthermore, this height h_C, above the deck, is to be such that:

$z_{hC} \geq T + h_2 + 0{,}15$

7 Ventilators

7.1 General

7.1.1 Ventilator openings below main deck are to have coamings of steel or other equivalent material, substantially constructed and efficiently connected to the deck.

7.1.2 Coamings

In vessels assigned other range of navigation, the coaming height above the deck is not to be less than 0,30 m and this height is to be such that:

$z_{hC} \geq T + h_2 + 0{,}15$.

SECTION 2 STABILITY

1 General

1.1 Application

1.1.1 All vessels may be assigned class only after it has been demonstrated that their intact stability is adequate. Adequate intact stability means compliance with the relevant Society's rule requirements or with standards laid down by the relevant Administration, taking into account the vessel's size and type.

1.1.2 Approval of the Administration

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

1.2 Definitions

1.2.1 Plane of maximum draught

Plane of maximum draught is the water plane corresponding to the maximum draught at which the vessel is authorised to navigate.

1.2.2 Bulkhead deck

Bulkhead deck is defined in Ch 1, Sec 2, [2.12].

1.2.3 Freeboard

Freeboard is the distance between the plane of maximum draught and a parallel plane passing through the lowest point of the gunwale or, in the absence of a gunwale, the lowest point of the upper edge of the vessel's side.

1.2.4 Residual freeboard

Residual freeboard is the vertical clearance available, in the event of the vessel heeling over, between the water level and the upper surface of the deck at the lowest point of the immersed side or, if there is no deck, the lowest point of the upper surface of the vessel's side shell.

1.2.5 Safety clearance

Safety clearance is the distance between the plane of maximum draught and the parallel plane passing through the lowest point above which the vessel is no longer deemed to be watertight.

1.2.6 Residual safety clearance

Residual safety clearance is the vertical clearance available, in the event of the vessel heeling over, between the water level and the lowest point of the immersed side, beyond which the vessel is no longer regarded as watertight.

1.2.7 Weathertight

"Weathertight" is defined in Ch 1, Sec 2, [2.15].

1.2.8 Watertight

"Watertight" is defined in Ch 1, Sec 2, [2.16].

1.2.9 Lightship

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

1.2.10 Inclining test

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

1.2.11 Lightweight check

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

2 Examination procedure

2.1 Documents to be submitted

2.1.1 List of information

The following information is to be included in the documents to be submitted:

- general description of the vessel
- linesplan / hull definition such as offset table
- general arrangement and capacity plans indicating the assigned use of compartments and spaces (cargo, passenger, stores, accommodation, etc.)
- a sketch indicating the position of the draught marks referred to the vessel's perpendiculars
- hydrostatic curves or tables corresponding to the design trim and, if significant trim angles are foreseen during the normal operation of the vessel, curves or tables corresponding to such a range of trim are to be introduced

- cross curves or tables of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered buoyant
- tank sounding tables or curves showing capacities, centres of gravity, and free surface data for each tank
- lightship data from the inclining test, including lightship displacement, centre of gravity co-ordinates, place and date of the inclining test, as well as the Society approval details specified in the inclining test report. It is suggested that a copy of the approved test report be included.

  Where the above-mentioned information is derived from a sister ship, the reference to this sister ship is to be clearly indicated, and a copy of the approved inclining test report relevant to this sister ship is to be included
- standard loading conditions and examples for developing other acceptable loading conditions using the information contained in the trim and stability booklet
- intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria reporting a comparison between the actual and the required values) are to be available for each of the above-mentioned operating conditions
- information on loading restrictions (maximum allowable load on double bottom, maximum specific gravity allowed in liquid cargo tanks, maximum filling level or percentage in liquid cargo tanks, maximum KG or minimum GM curve or table which can be used to determine compliance with the applicable intact and damage stability criteria) when applicable
- information about openings (location, tightness, means of closure), pipes or other progressive flooding sources
- information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable.

The Society may require any other necessary guidance for the safe operation of the vessel.

2.2 Displacement and centre of gravity

2.2.1 The lightship displacement and the location of the centre of gravity shall be determined either by means of an inclining experiment (see [3]) or by detailed mass and moment calculation.

In this latter case the lightweight of the vessel shall be checked by means of a lightweight test with a tolerance limit of about 5% between the mass determined by calculation and the displacement determined by the draught readings. A tolerance limit of 0,5% between the values of the longitudinal centre of gravity may not be exceeded.

The weight and centre of gravity calculation has to be submitted before the lightweight survey will be performed.

2.3 Effects of free surfaces of liquids in tanks

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

2.3.2 Free surface effects are to be considered for any filling level of the tank. Free surface effects need not be considered where a tank is nominally full.

3 Inclining test and lightweight check

3.1 General

3.1.1 Any vessel for which a stability investigation is requested in order to comply with class requirements is to be initially subjected to an inclining test permitting the evaluation of the position of the lightship centre of gravity, or a lightweight check of the lightship displacement, so that the stability data can be determined. Cases for which the inclining test is required and those for which the lightweight check is accepted in its place are listed in [3.1.3].

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

3.1.2 Inclining test

The inclining test is required in the following cases:

- any new vessel, after its completion, except for the cases specified in [3.1.3]
- any vessel, if deemed necessary by the Society, where any alterations are made so as to materially affect the stability.

3.1.3 Lightweight check

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

- an individual vessel, provided basic stability data are available from the inclining test of a sister ship and a lightweight check is performed in order to prove that the sister ship corresponds to the leader ship. In such a case the Society is satisfied when the result of the lightweight check shows a deviation from the displacement (Δ) and a deviation from the longitudinal centre of gravity (LCG) of the leader ship not greater than the values specified in Tab 1.

  The final stability data to be considered for the sister ship in terms of displacement and position of the centre of gravity are those of the leader.
- special types of vessel, such as pontoons, provided that the vertical centre of gravity is considered at deck level.

- special types of vessel, such as catamarans, provided that:
  - a detailed list of weights and the positions of their centres of gravity is submitted
  - the lightweight check is showing accordance between the estimated values and those determined
  - adequate stability is demonstrated in all the loading conditions.

Table 1 : Maximum deviations, in %

	L ≤ 50 m	50 < L ≤ 135 m
Δ	2 **(1)**	$2,455 - \frac{L}{110}$
LCG	0,5 **(1)**	0,5
(1) Greater values may be accepted by the Society on a case by case basis.		

3.2 Detailed procedure

3.2.1 General conditions of the vessel

Prior to the test, the Society's Surveyor is to be satisfied of the following:

- the weather conditions are to be favourable
- the vessel is to be moored in a quiet, sheltered area free from extraneous forces, such as to allow unrestricted heeling. The vessel is to be positioned in order to minimise the effects of possible wind and stream
- the vessel is to be transversely upright and hydrostatic data and sounding tables are to be available for the actual trim
- cranes, derrick, lifeboats and liferafts capable of inducing oscillations are to be secured
- main and auxiliary boilers, pipes and any other system containing liquids are to be filled
- the bilge and the decks are to be thoroughly dried
- preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim. The shape of the tank is to be such that the free surface effect can be accurately determined and remain almost constant during the test. All cross connections are to be closed
- the weights necessary for the inclination are to be already on board, located in the correct place
- all work on board is suspended and crew or personnel not directly involved in the inclining test shall not be on board
- the vessel is to be as complete as possible at the time of the test. The number of weights to be removed, added or shifted is to be limited to a minimum. Temporary material, tool boxes, staging, sand, debris, etc., on board is to be reduced to an absolute minimum
- initial heeling angle shall not be greater than 0,5° prior to the start of the inclining test.

3.2.2 Inclining weights

The total weight used is preferably to be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side. The Society may, however, accept a smaller inclination angle for large vessels provided that the requirement on pendulum deflection or U-tube difference in height specified in [3.2.4] is complied with. Test weights are to be compact and of such a configuration that the VCG (vertical centre of gravity) of the weights can be accurately determined. Each weight is to be marked with an identification number and its weight. Re-certification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, shall be available during the inclining test to shift weights on the deck in an expeditious and safe manner. Water ballast is generally not acceptable as an inclining weight.

3.2.3 Water ballast as inclining weight

Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Society is required prior to the test. As a minimal prerequisite for acceptability, the following conditions are to be required:

- inclining tanks are to be wall-sided and free of large stringers or other internal structural members that create air pockets
- tanks are to be directly opposite to maintain vessel's trim
- specific gravity of ballast water is to be measured and recorded
- pipelines to inclining tanks are to be full. If the vessel's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used
- blanks must be inserted in transverse manifolds to prevent the possibility of liquids leaking during transfer. Continuous valve control must be maintained during the test
- all inclining tanks must be manually sounded before and after each shift
- vertical, longitudinal and transverse centres are to be calculated for each movement
- accurate sounding/ullage tables are to be provided. The vessel's initial heel angle is to be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard) are to be used when establishing the initial heel angle
- verification of the quantity shifted may be achieved by a flowmeter or similar device
- the time to conduct the inclining is to be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of changing environmental conditions over long periods of time.

3.2.4 Pendulums

The use of three pendulums is recommended but a minimum of two are to be used to allow identification of bad readings at each pendulum station. However, for vessels of a length equal to or less than 30 m, only one pendulum can be accepted. Each is to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, to each side from upright, of at least 10 cm. To ensure recordings from individual instruments, it is suggested that the pendulums shall be physically located as far apart as practical.

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

3.2.5 Means of communications

Efficient two-way communication are to be provided between central control and the weight handlers and between central control and each pendulum station. One person at a central control station shall have complete control over all personnel involved in the test.

3.2.6 Documentation

The person in charge of the inclining test shall have available a copy of the following plans at the time of the test:

- hydrostatic curves or hydrostatic data
- general arrangement plan of decks, holds, inner bottoms, etc.
- capacity plan showing capacities and vertical and longitudinal centres of gravity of cargo spaces, tanks, etc. When water ballast is used as inclining weights, the transverse and vertical centres of gravity for the applicable tanks, for each angle of inclination, must be available
- tank sounding tables
- draught mark locations, and
- docking drawing with keel thickness and draught mark corrections (if available).

3.2.7 Determination of the displacement

The Society's Surveyor shall carry out all the operations necessary for the accurate evaluation of the displacement of the vessel at the time of the inclining test, as listed below:

- draught mark readings are to be taken at aft, midship and forward, at starboard and port sides
- the mean draught (average of port and starboard reading) is to be calculated for each of the locations where draught readings are taken and plotted on the vessel's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot is to yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/ draughts are to be retaken
- all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the vessel's trim and the position of air pipes, and also taking into account the provisions of [3.2.1]
- it is to be checked that the bilge is dry, and an evaluation of the liquids (not included in the lightship which cannot be pumped, remaining in the pipes, boilers, condenser, etc., is to be carried out
- the entire vessel is to be surveyed in order to identify all items which need to be added, removed or relocated to bring the vessel to the lightship condition. Each item is to be clearly identified by weight and location of the centre of gravity
- the possible solid permanent ballast is to be clearly identified and listed in the report.

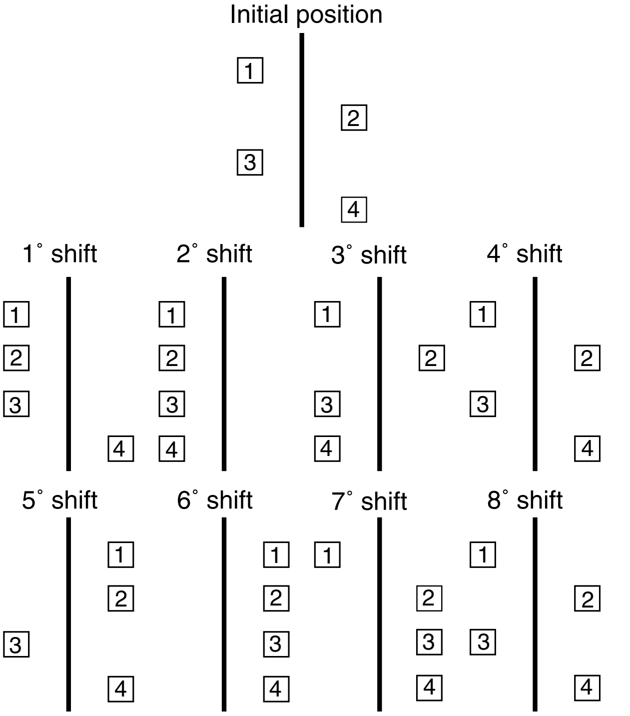
3.2.8 The incline

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

The weights are to be transversely shifted, so as not to modify the vessel's trim and vertical position of the centre of gravity.

After each weight shifting, the new position of the transverse centre of gravity of the weights is to be accurately determined.

Figure 1 : Weight shift procedure



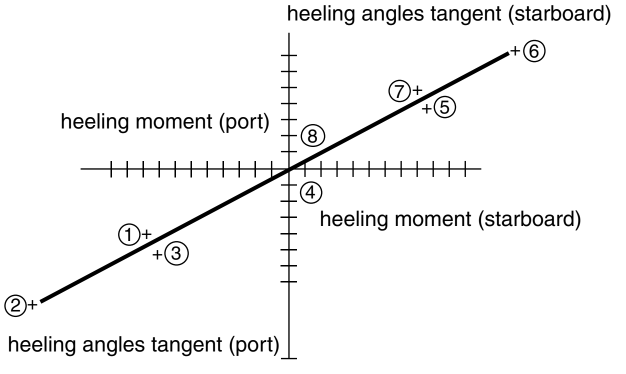
After each weight movement, the shifting distance (centre to centre) is to be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents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

The pendulum deflection is to be read when the vessel has reached a final position after each weight shifting.

During the reading, no movements of personnel are allowed.

For vessels with a length equal to or less than 30 m, six distinct weight movements may be accepted.

Figure 2 : Graph of resultant tangents



4 Intact stability design criteria

4.1 General intact stability criteria

4.1.1 The intact stability criteria specified in [4.1.2], [4.1.3] and [4.1.4] are to be complied with for all intended loading and unloading conditions, bearing in mind the influence of all free surfaces in tanks.

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

4.1.2 GZ curve area

The surface of the positive area of the righting lever curve up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel of 27°, shall not be less than 0,024 m.rad.

4.1.3 Minimum righting lever

In the positive area of the righting lever curve up to immersion of the first non-weathertight opening, there shall be a righting lever (GZ) of not less than 0,10 m.

4.1.4 Initial metacentric height

The initial metacentric height GM_0 shall not be less than 0,10 m.

SECTION 3 MATERIALS

1 General

1.1 Characteristics of materials

1.1.1 The characteristics of the materials to be used in the construction of vessels are to comply with the applicable requirements of NR216 Materials and Welding.

1.1.2 Materials with different characteristics may be accepted, provided their specification (manufacture, chemical composition, mechanical properties, welding, etc.) is submitted to the Society for approval.

1.2 Testing of materials

1.2.1 Materials are to be tested in compliance with the applicable requirements of NR216 Materials and Welding.

1.3 Manufacturing processes

1.3.1 The requirements of this Section presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and the applicable requirements of NR216 Materials and Welding. In particular:

- parent material and welding processes are to be within the limits stated for the specified type of material for which they are intended
- specific preheating may be required before welding
- welding or other cold or hot manufacturing processes may need to be followed by an adequate heat treatment.

1.4 Dimensional tolerances

1.4.1 Plates and wide flats

For plates and wide flats, an under thickness tolerance of 0,3 mm is permitted.

1.4.2 Sections and bars

For sections and bars, the under thickness tolerance is to be in accordance with the requirements of a recognized international or national standard.

2 Steels for hull structure

2.1 Application

2.1.1 Tab 1 gives the mechanical characteristics of steels currently used in the construction of inland navigation vessels.

2.1.2 Higher strength steels other than those indicated in Tab 1 are considered by the Society on a case by case basis.

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

2.1.4 When no other information is available, the minimum yield stress R_{eH} and the Young's modulus E of steels used at temperatures between 90°C and 300°C may be taken respectively equal to:

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

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

where:

R_{eH0} : Value of the minimum yield stress at ambient temperature

E_0 : Value of the Young's modulus at ambient temperature

θ : Service temperature, in °C.

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

2.2 Information to be kept on board

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

Table 1 : Mechanical properties of hull steels

Steel grades ($t \le 100$ mm)	Minimum yield stress R_{eH}, in N/mm²	Ultimate minimum tensile strength R_m, in N/mm²
A - B - D	235	400 - 520
A32 - D32	315	440 - 570
A36 - D36	355	490 - 630
A40 - D40 **(1)**	390	510 - 660
(1) $t \le 50$ mm		

Table 2 : Material factor k

R_{eH}, in N/mm²	k
235	1,00
315	0,78
355	0,72
390	0,68

2.3 Material factor k

2.3.1 General

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

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

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

2.4 Grades of steel

2.4.1 Normal strength grades A, B and D

The distribution of the steel grades used in the different regions of the vessel is indicated in Tab 3.

Steel of grade D may be required for structural members consisting in plates more than 20 mm thick in areas liable to important static or dynamic stress concentrations.

Table 3 : Distribution of steel grades in midship and holds or tanks regions

	t ≤ 15	15 < t ≤ 20	t > 20
Bilge and topside structure **(1)**	A	B	D
Side shell	A	A	A
Deck and bottom	A	A	B
Deck plates at the corners of hatches	A	B	D

Note 1:
t : Structural member gross thickness, in mm.
(1) Sheerstrake, stringer plate, longitudinal hatch coaming of open deck vessels, trunk longitudinal bulkhead.

2.4.2 High tensile strength structural steel grades AH and DH

The distribution of the steel grades used in the midship, holds or tanks regions, according to the type of vessel concerned is given in Tab 4.

Outside these regions, the thickness of high tensile strength steel must be kept unchanged until the region where the thickness of ordinary steel is the same for the vessel considered.

Table 4 : Distribution of steel grades in midship and holds or tanks regions

	t ≤ 20	t > 20
Bilge and topside structure **(1)**	AH	DH
Side shell	AH	AH
Deck and bottom	AH	DH
Deck plates at the corners of long hatches	AH	DH

Note 1:
t : Structural member gross thickness, in mm.
(1) Sheerstrake, stringer plate, longitudinal hatch coaming of open deck vessels, trunk longitudinal bulkhead

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

2.4.4 The steel grade is to correspond to the as fitted gross thickness when this is greater than the gross thickness obtained from the net thickness required by the Rules according to Ch 2, Sec 5.

2.4.5 Vessels carrying corrosive liquids

Where corrosive liquids are to be carried, the plates and sections of the hull of vessels with built-in cargo tanks and the independent cargo tanks are to be built in a material approved by the Society.

2.4.6 Vessels with ice strengthening

For vessels with ice strengthening, shell strakes in way of ice strengthening area plates are to be of a minimum grade B/AH.

2.5 Grades of steel for structures exposed to low air temperatures

2.5.1 The selection of steel grades to be used for the structural members exposed to low temperatures (–20°C or below) is to be in compliance with applicable requirements of NR216 Materials and Welding.

3 Aluminium alloys for hull structure

3.1 General

3.1.1 The characteristics of aluminium alloys are to comply with the requirements of NR216 Materials and Welding, Ch 3, Sec 2.

Series 5000 aluminium-magnesium alloys or series 6000 aluminium-magnesium-silicon alloys are generally to be used (see NR216 Materials and Welding, Ch 3, Sec 2, [2]).

3.1.2 In the case of structures subjected to low service temperatures or intended for other specific applications, the alloys to be employed are to be agreed by the Society.

3.1.3 Unless otherwise agreed, the Young's modulus for aluminium alloys is equal to 70000 N/mm^2 and the Poisson's ratio equal to 0,33.

3.1.4 Use of aluminium alloys on tankers

The use of aluminium alloys is authorized for wheelhouses located aft of the aft cofferdam or forward of the fore cofferdam.

3.2 Extruded plating

3.2.1 Extrusions with built-in plating and stiffeners, referred to as extruded plating, may be used.

3.2.2 In general, the application is limited to decks, bulkheads, superstructures and deckhouses. Other uses may be permitted by the Society on a case by case basis.

3.2.3 Extruded plating is preferably to be oriented so that the stiffeners are parallel to the direction of main stresses.

3.2.4 Connections between extruded plating and primary members are to be given special attention.

3.3 Mechanical properties of weld joints

3.3.1 Welding heat input lowers locally the mechanical strength of aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111) or by heat treatment (series 6000).

3.3.2 The as-welded properties of aluminium alloys of series 5000 are in general those of condition 0 or H111.

Higher mechanical characteristics may be taken into account, provided they are duly justified.

3.3.3 The as-welded properties of aluminium alloys of series 6000 are to be agreed by the Society.

3.4 Minimum yield stress

3.4.1 The minimum yield stress of aluminium R_y, in N/mm^2, used for the scantling criteria of the hull structure is to be taken, unless otherwise specified, equal to:

$R_y = R'_{lim}$

where:

R'_{lim} : Minimum specified yield stress of the parent metal in welded condition R'p0,2, in N/mm^2, but not to be taken greater than 70% of the minimum specified tensile strength of the parent metal in welded condition R'm, in N/mm^2.

$R'_{p0,2} = \eta_1 \, R_{p0,2}$

$R'_m = \eta_2 \, R_m$

$R_{p0,2}$: Minimum specified yield stress, in N/mm^2, of the parent metal in delivery condition

R_m : Minimum specified tensile stress, in N/mm^2, of the parent metal in delivery condition

η_1 , η_2 : Coefficients defined in Tab 5.

Table 5 : Aluminium alloys for welded construction

Aluminium alloy	η_1	η_2
Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1	1
Alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$R'_{p0,2}/R_{p0,2}$	R'_m / R_m
Alloys hardened by heat treatment (series 6000) **(1)**	$R'_{p0,2}/R_{p0,2}$	0,6

(1) When no information is available, coefficient η_1 is to be taken equal to the metallurgical efficiency coefficient β defined in Tab 6.

Note 1:

$R'_{p0,2}$: Minimum specified yield stress, in N/mm^2, of material in welded condition (see [3.3])

R'_m : Minimum specified tensile stress, in N/mm^2, of material in welded condition (see [3.3]).

Table 6 : Aluminium alloys Metallurgical efficiency coefficient β

Aluminium alloy	Temper condition	Gross thickness, in mm	β
6005 A (Open sections)	T5 or T6	$t \leq 6$	0,45
		$t > 6$	0,40
6005 A (Closed sections)	T5 or T6	All	0,50
6061 (Sections)	T6	All	0,53
6082 (Sections)	T6	All	0,45

3.5 Material factor

3.5.1 The material factor k for aluminium alloys is to be obtained from the following formula:

$$k = \frac{100}{R'_{lim}}$$

3.5.2 In the case of welding of two different aluminium alloys, the material factor k to be considered for the scantlings of welds is to be the greater material factor of the aluminium alloys of the assembly.

3.5.3 For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

4 Composite materials and plywood for hull structure

4.1 Characteristics and testing

4.1.1 The characteristics of the composite materials and plywood and their testing and manufacturing process are to comply with the applicable requirements of NR546 Composite Ships, in particular for the:

- raw materials
- laminating process
- mechanical tests and raw material homologation.

4.2 Application

4.2.1 Attention is drawn to the use of composite and/or plywood materials from the point of view of structural fire protection. Regulations of the country where the vessel is registered may entail in some cases a limitation in the use of composite and/or plywood materials.

5 Other materials

5.1 General

5.1.1 Other materials and products such as parts made of iron castings, where allowed, products made of copper and copper alloys, rivets, anchors, chain cables, cranes, masts, derricks, accessories and wire ropes are generally to comply with the applicable requirements of NR216 Materials and Welding.

5.1.2 Materials used in welding processes are to comply with the applicable requirements of NR216 Materials and Welding.

SECTION 4 STRUCTURAL DETAIL PRINCIPLES

Symbols

w : Section modulus, in cm^3, of an ordinary stiffener or primary supporting member, as the case may be, with an attached plating of width b_p

h_w : Web height, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_w : Web thickness, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

b_f : Face plate width, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_f : Face plate thickness, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_p : Thickness, in mm, of the plating attached to an ordinary stiffener or a primary supporting member, as the case may be

s : Spacing, in m, of ordinary stiffeners

S : Spacing, in m, of primary supporting members

ℓ : Span, in m, of an ordinary stiffener or a primary supporting member, as the case may be, measured between the supporting members

I : Moment of inertia, in cm^4, of an ordinary stiffener or a primary supporting member, as the case may be, without attached plating, around its neutral axis parallel to the plating

I_B : Moment of inertia, in cm^4, of an ordinary stiffener or a primary supporting member, as the case may be, with bracket and without attached plating, around its neutral axis parallel to the plating, calculated at mid-length of the bracket

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- $R_y = 235/k$ N/mm^2 for steel
- $R_y = 100/k$ N/mm^2 for aluminium alloys

unless otherwise specified

1 General

1.1 Application

1.1.1 Metallic structures

The requirements of the present Section apply to longitudinally or transversely framed structure arrangement of hulls built in metallic materials.

Any other arrangement may be considered, on a case-by-case basis.

Additional structure design principles in relation to specific notations are defined in Part D.

1.1.2 Composite and plywood structure

Equivalent arrangement for hulls built in composite materials and/or plywood is defined in NR546 Composite Ships.

2 General strength principles

2.1 Structural continuity

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

2.1.2 The structural continuity is to be ensured:

- in way of changes in the framing system
- at the connections of primary or ordinary stiffeners
- in way of the ends of the fore and aft parts and machinery space
- in way of ends of superstructures.

2.1.3 Longitudinal members contributing to the hull girder longitudinal strength, according to Ch 4, Sec 1, [2.1], are to extend continuously for a sufficient distance towards the ends of the vessel and in way of areas with changes in framing system.

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

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

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

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

Where necessary, the shape of openings is to be specially designed to reduce the stress concentration factors.

Openings are to be generally well rounded with smooth edges.

Generally, the radius of openings corners is to be not less than 50 mm. In way of highly stressed areas, the radius is to be taken as the greater of 50 mm and 8% of the opening width.

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

2.2 Structural continuity - Multihull platform

2.2.1 Attention is to be paid to the structural continuity of the primary transverse cross structure of the platform ensuring the global transverse resistance of the multihull.

The primary transverse cross structure of catamaran is generally to be continuous when crossing float structures. The general continuity principles defined in [2.1] apply also to the primary transverse cross structure of the platform.

2.3 Connections with higher strength steel

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

2.4 Connections between steel and aluminium

2.4.1 Any direct contact between steel and aluminium alloy is to be avoided (e.g. by means of zinc or cadmium plating of the steel parts and application of a suitable coating on the corresponding light alloy parts).

2.4.2 Any heterogeneous jointing system is considered by the Society on a case by case basis.

2.4.3 The use of transition joints made of aluminium/steel clad plates or profiles is considered by the Society on a case by case basis.

3 Plating

3.1 Insert plates and doublers

3.1.1 A local increase in plating thickness is generally to be achieved through insert plates. Local doublers, which are normally only allowed for temporary repair, may however be accepted by the Society on a case by case basis.

In any case, doublers and insert plates are to be made of materials of a quality at least equal to that of the plates on which they are welded.

3.1.2 On tankers for oil or chemical cargoes, doubling plates are not allowed to be fitted within the cargo tank area, i.e. from the aftermost to the foremost cofferdam bulkhead.

3.1.3 Doublers having width, in mm, greater than:

- 20 times their thickness, for thicknesses equal to or less than 15 mm
- 25 times their thickness, for thicknesses greater than 15 mm,

are to be fitted with slot welds, to be effected according to Ch 8, Sec 2, [2.6].

3.1.4 When doublers fitted on the outer shell and strength deck within 0,5 L amidships are accepted by the Society, their width and thickness are to be such that slot welds are not necessary according to the requirements in [3.1.3]. Outside this area, the possibility of fitting doublers requiring slot welds will be considered by the Society on a case by case basis.

4 Ordinary stiffeners

4.1 General

4.1.1 Stiffener not perpendicular to the attached plating

Where the stiffener is not perpendicular to the attached plating, the actual net section modulus w, in cm^3, and net shear area A_{sh}, in cm^2, and net moment of inertia I, in cm^4, may be obtained, from the following formulae:

$$w = w_0 \sin \varphi_w$$

$$A_{sh} = A_0 \sin \varphi_w$$

$$I = I_0 \sin^2 \varphi_w$$

where:

- w_0 : Actual net section modulus, in cm^3, of the stiffener assumed to be perpendicular to the plating
- A_0 : Actual net shear area, in cm^2, of the stiffener assumed to be perpendicular to the plating
- I_0 : Net moment of inertia, in cm^4, of the stiffener assumed to be perpendicular to the attached plating
- φ_w : Angle, in degree, between the attached plating and the web of the stiffener, measured at mid-span of the stiffener.

4.1.2 Bulb section: equivalent angle profile

A bulb section may be taken as equivalent to an angle profile.

The dimensions of the equivalent angle profile are to be obtained, in mm, from the following formulae:

$$h_w = h'_w - \frac{h'_w}{9,2} + 2$$

$$t_w = t'_w$$

$$b_f = \alpha\left[t'_w + \frac{h'_w}{6,7} - 2\right]$$

$$t_f = \frac{h'_w}{9,2} - 2$$

where:

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

$$\text{for } h'_w \le 120: \quad \alpha = 1,1 + \frac{(120 - h'_w)^2}{3000}$$

$$\text{for } h'_w > 120: \quad \alpha = 1,0$$

Figure 1 : Bulb section and its equivalent angle

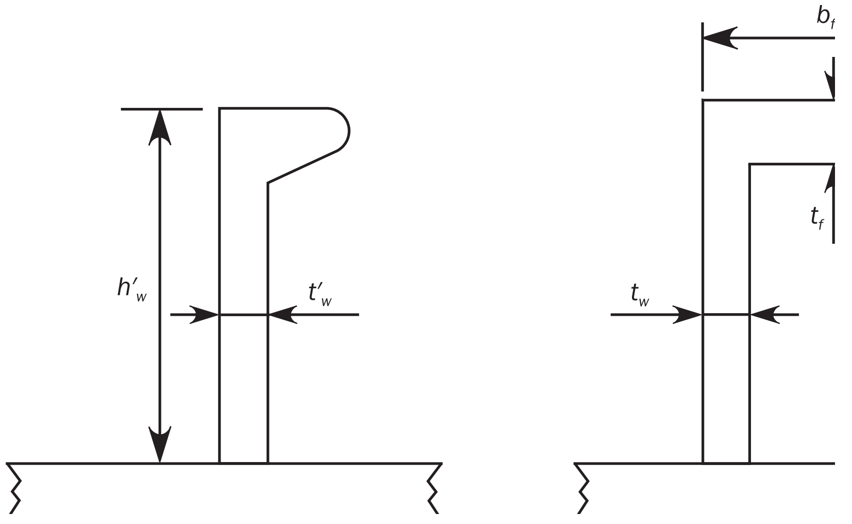


Figure 2 : Ordinary stiffener without brackets

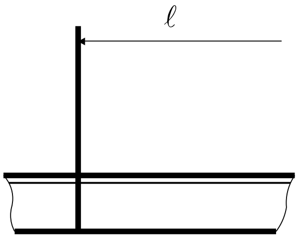


Figure 3 : Ordinary stiffener with a stiffener at one end

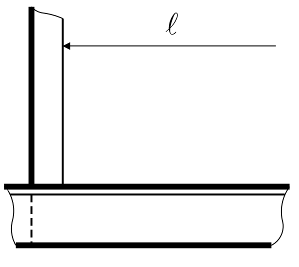


Figure 4 : Ordinary stiffener with end bracket

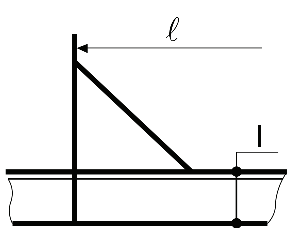
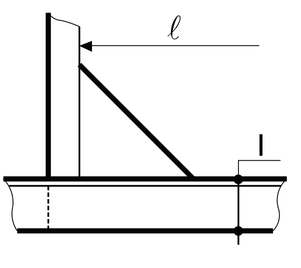


Figure 5 : Ordinary stiffener with a bracket and a stiffener at one end



4.2 Span of ordinary stiffeners

4.2.1 General

The span ℓ of ordinary stiffeners is to be measured as shown in Fig 2 to Fig 5.

4.3 Width of attached plating

4.3.1 Yielding check

The width of the attached plating to be considered for the yielding check of ordinary stiffeners is to be obtained, in m, from the following formulae:

- where the plating extends on both sides of the ordinary stiffener:

  $b_P = s$

- where the plating extends on one side of the ordinary stiffener (i.e. ordinary stiffeners bounding openings):

  $b_P = 0{,}5\ s$

4.3.2 Buckling check

The attached plating to be considered for the buckling check of ordinary stiffeners is defined in Ch 2, Sec 7, [3.1].

4.4 Geometric properties

4.4.1 Built sections

The geometric properties of built sections as shown in Fig 6 may be calculated as indicated in the following formulae.

The shear sectional area of a built section with attached plating is to be obtained, in cm², from the following formula:

$$A_{Sh} = \frac{h_w t_w}{100}$$

The section modulus of a built section with attached plating of sectional area A_a, in mm², is to be obtained, in cm³, from the following formula:

$$w = \frac{h_w t_f b_f}{1000} + \frac{t_W h_W^2}{6000}\left(1 + \frac{A_a - t_f b_f}{A_a + \frac{t_W h_W}{2}}\right)$$

The distance from mid-plate thickness of face plate to neutral axis is to be obtained, in cm, from the following formula:

$$v = \frac{h_W(A_a + 0,5t_W h_W)}{10(A_a + t_f b_f + t_W h_W)}$$

The moment of inertia of a built section with attached plating is to be obtained, in cm⁴, from the following formula:

$I = w \cdot v$

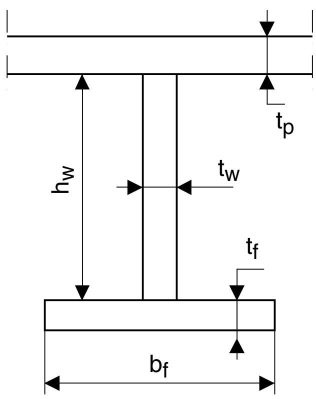
These formulae are applicable provided that:

$A_a \geq t_f b_f$

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

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

Figure 6 : Dimensions of a built section



4.4.2 Corrugations

The net section modulus of a corrugation is to be obtained, in cm³, from the following formula:

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

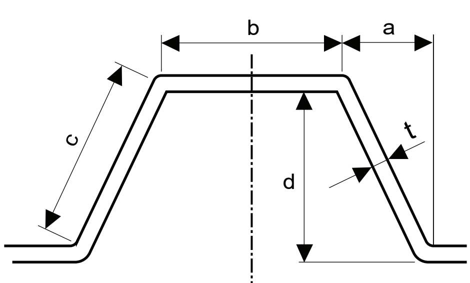
where:

t	:	Net thickness of the plating of the corrugation, in mm
d, b, c	:	Dimensions of the corrugation, in mm, shown in Fig 7.

Where the web continuity is not ensured at ends of the bulkhead, the net section modulus of a corrugation is to be obtained, in cm³, from the following formula:

$w = 0,5\ b\ t\ d\ 10^{-3}$

Figure 7 : Dimensions of a corrugation



4.5 End connections

4.5.1 Continuous ordinary stiffeners

Where ordinary stiffeners are continuous through primary supporting members, they are to be connected to the web plating so as to ensure proper transmission of loads, e.g. by means of one of the connection details shown in Fig 7 to Fig 11. In the case of high values for the design loads, additional stiffening is required.

Connection details other than those shown in Fig 7 to Fig 11 may be considered by the Society on a case by case basis. In some cases, the Society may require the details to be supported by direct calculations submitted for review.

Figure 8 : End connection of ordinary stiffener Without collar plate

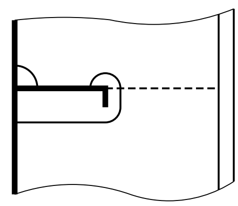


Figure 9 : End connection of ordinary stiffener Collar plate

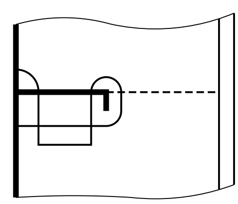


Figure 10 : End connection of ordinary stiffener One large collar plate

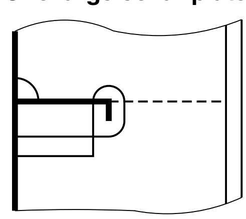
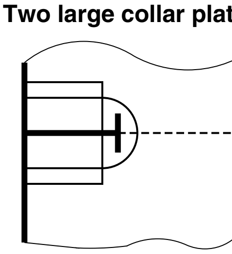


Figure 11 : End connection of ordinary stiffener Two large collar plates



4.5.2 Intercostal ordinary stiffeners

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

All brackets for which:

$$\frac{\ell_b}{t} > 60$$

where:

ℓ_b : Length, in mm, of the free edge of the bracket

t : Bracket net thickness, in mm,

are to be flanged or stiffened by a welded face plate.

The sectional area, in cm², of the flange or the face plate is to be not less than 0,01 ℓ_b.

The width of the face plate, in mm, is to be not less than 10 t.

4.5.3 Sniped ends of stiffeners

Stiffeners may be sniped at the ends if the net thickness of the plating supported by the stiffener is not less than:

$$t = c\sqrt{\frac{ps(\ell - 0,5s)}{R_y}}$$

where:

p : Stiffener design load, in kN/m², to be determined in compliance with Ch 3, Sec 4

c : Coefficient to be taken equal to:

- 12,7 for watertight bulkheads
- 15,7 for all other components.

5 Primary supporting members

5.1 General

5.1.1 Primary supporting member not perpendicular to the attached plating

Where the primary supporting member is not perpendicular to the attached plating, the actual section modulus may be obtained, in accordance with [4.1.1].

5.2 Span of primary supporting members

5.2.1 The span of primary supporting members is to be determined in compliance with [4.2].

5.3 Width of attached plating

5.3.1 General

The width of the attached plating of primary supporting members is to be obtained according to [5.3.2] or [5.3.3], depending on the type of loading, where:

S_0 : S_0 = S, for plating extending on both sides of the primary supporting member

S_0 = 0,5 S, for plating extending on one side of the primary supporting member

S_1 : S_1 = 0,2 ℓ, for plating extending on both sides of the primary supporting member

S_1 = 0,1 ℓ, for plating extending on one side of the primary supporting member.

5.3.2 Loading type 1

Where the primary supporting members are subjected to uniformly distributed loads or else by not less than 6 equally spaced concentrated loads, the width of the attached plating is to be obtained, in m, from the following formulae:

- for $\ell / S_0 \le 4$:

$$b_P = 0,36 S_0 \left(\frac{\ell}{S_0}\right)^{0,67}$$

- for $\ell / S_0 > 4$:

b_P = MIN (S_0 ; S_1)

5.3.3 Loading type 2

Where the primary supporting members are subjected to less than 6 concentrated loads, the width of the attached plating is to be obtained, in m, from the following formulae:

- for $\ell / S_0 < 8$:

$$b_P = 0,205 S_0 \left(\frac{\ell}{S_0}\right)^{0,72}$$

- for $\ell / S_0 \ge 8$:

$b_P = 0,9\ S_0$

5.3.4 Corrugated bulkheads

The width of attached plating of corrugated bulkhead primary supporting members is to be determined as follows:

- when primary supporting members are parallel to the corrugations and are welded to the corrugation flanges, the width of the attached plating is to be calculated in accordance with [5.3.2] and [5.3.3] and is to be taken not greater than the corrugation flange width
- when primary supporting members are perpendicular to the corrugations, the width of the attached plating is to be taken equal to the width of the primary supporting member face plate.

5.4 Geometric properties

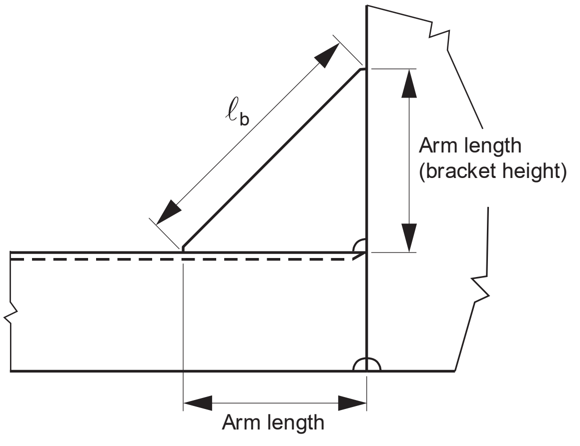
5.4.1 Standard roll sections

The geometric properties of primary supporting members made of standard roll sections may be determined in accordance with [4.4.1], reducing the web height hw by the depth of the cut-out for the passage of ordinary stiffeners, if any (see [5.7.1]).

5.4.2 Built sections

The geometric properties of primary supporting members (including primary supporting members of double hull structures, such as double bottom floors and girders) are generally determined in accordance with [4.4.1], reducing the web height h_w by the depth of the cut-outs for the passage of the ordinary stiffeners, if any (see [5.7.1]).

Figure 12 : Bracket dimensions



5.5 Bracketed end connections

5.5.1 Arm lengths of end brackets are to be equal, as far as practicable (see Fig 12).

The height of end brackets is to be not less than that of the weakest primary supporting member.

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

5.5.3 The bracket web thickness is to be not less than that of the weakest primary supporting member.

5.5.4 The face plate of end brackets is to have a width not less than the width of the primary supporting member faceplates.

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

5.5.5 In addition to the above requirements, the scantlings of end brackets are to comply with the applicable requirements given in Ch 5, Sec 1 to Ch 5, Sec 5.

5.6 Bracketless end connections

5.6.1 In the case of bracketless end connections between primary supporting members, the strength continuity is to be obtained as schematically shown in Fig 13 or by any other method which the Society may consider equivalent.

5.6.2 In general, the continuity of the face plates is to be ensured.

5.7 Cut-outs and holes

5.7.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the height of cut-outs is to be not greater than 50% of the height of the primary supporting member. Other cases are to be covered by calculations submitted to the Society.

5.7.2 Where openings such as lightening holes are cut in primary supporting members, they are to be equidistant from the face plate and corners of cut-outs and, in general, their height is to be not greater than 20% of the web height.

5.7.3 Openings may not be fitted in way of toes of end brackets.

5.7.4 Over half of the span of primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

At the ends of the span, the length of openings is to be not greater than 25% of the distance between adjacent openings.

Figure 13 : Connection of two primary supporting members

5.7.5 In the case of large openings as shown in Fig 14, the secondary stresses in primary supporting members are to be considered for the reinforcement of the openings.

The secondary stresses may be calculated in accordance with the following procedure.

Members (1) and (2) are subjected to the following forces, moments and stresses:

$$F = \frac{M_A + M_B}{2d}$$

$$m_1 = \left|\frac{M_A - M_B}{2}\right| K_1$$

$$m_2 = \left|\frac{M_A - M_B}{2}\right| K_2$$

$$\sigma_{F1} = 10\frac{F}{S_1}$$

$$\sigma_{F2} = 10\frac{F}{S_2}$$

$$\sigma_{m1} = \frac{m_1}{w_1}10^3$$

$$\sigma_{m2} = \frac{m_2}{w_2}10^3$$

$$\tau_1 = 10\frac{K_1 Q_T}{S_{w1}}$$

$$\tau_2 = 10\frac{K_2 Q_T}{S_{w2}}$$

where:

- M_A, M_B : Bending moments, in kN.m, in sections A and B of the primary supporting member
- m_1, m_2 : Bending moments, in kN.m, in (1) and (2)
- d : Distance, in m, between the neutral axes of (1) and (2)
- σ_{F1}, σ_{F2} : Axial stresses, in N/mm², in (1) and (2)
- σ_{m1}, σ_{m2} : Bending stresses, in N/mm², in (1) and (2)
- Q_T : Shear force, in kN, equal to Q_A or Q_B, whichever is greater
- τ_1, τ_2 : Shear stresses, in N/mm², in (1) and (2)
- w_1, w_2 : Net section moduli, in cm³, of (1) and (2)
- S_1, S_2 : Net sectional areas, in cm², of (1) and (2)
- S_{w1}, S_{w2} : Net sectional areas, in cm², of webs in (1) and (2)
- I_1, I_2 : Net moments of inertia, in cm⁴, of (1) and (2) with attached plating

$$K_1 = \frac{I_1}{I_1 + I_2}$$

$$K_2 = \frac{I_2}{I_1 + I_2}$$

The combined stress σ_C calculated at the ends of members (1) and (2) is to be obtained from the following formula:

$$\sigma_c = \sqrt{(\sigma_F + \sigma_m)^2 + 3\tau^2}$$

The combined stress σ_C is to comply with the checking criteria in Ch 2, Sec 8, [2.3] or Ch 2, Sec 8, [2.4], as applicable. Where these checking criteria are not complied with, the cut-out is to be reinforced according to one of the solutions shown in Fig 15 to Fig 17:

- continuous face plate (solution 1): see Fig 15
- straight face plate (solution 2): see Fig 16
- compensation of the opening (solution 3): see Fig 17
- combination of the above solutions.

Other arrangements may be accepted provided they are supported by direct calculations submitted to the Society for review.

Figure 14 : Large openings in primary supporting members - Secondary stresses

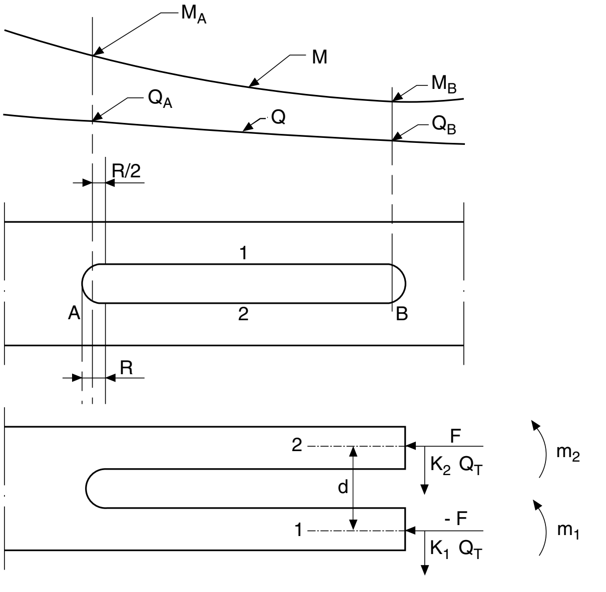


Figure 15 : Stiffening of large openings in primary supporting members - Solution 1

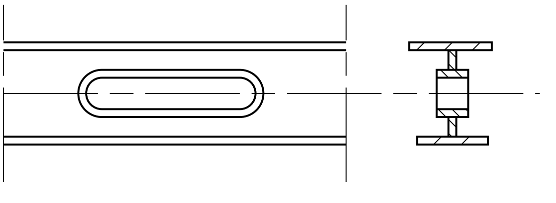


Figure 16 : Stiffening of large openings in primary supporting members - Solution 2

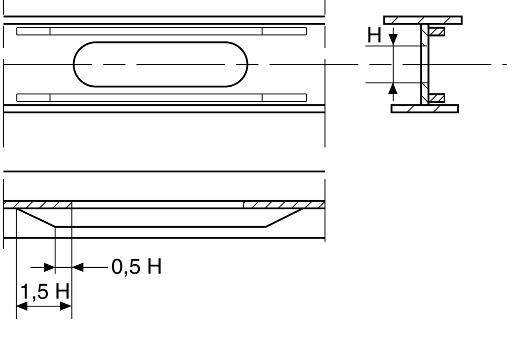
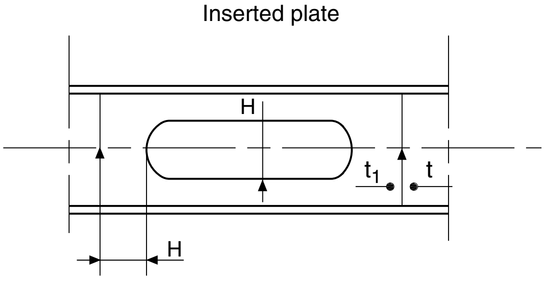


Figure 17 : Stiffening of large openings in primary supporting members - Solution 3



5.8 Stiffening arrangement

5.8.1 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.

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

$$A = 0{,}1 k_1 p s \ell$$

where:

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

- $k_1 = 0{,}30$ for connections without collar plate (see Fig 8)
- $k_1 = 0{,}225$ for connections with a collar plate (see Fig 9)
- $k_1 = 0{,}20$ for connections with one or two large collar plates (see Fig 10 and Fig 11)

p : Design pressure, in kN/m², acting on the ordinary stiffener, defined in Ch 3, Sec 4.

5.8.3 The net moment of inertia, I, of the web stiffeners of primary supporting members is not to be less than the value obtained, in cm4, from the following formula:

- for web stiffeners parallel to the flange of the primary supporting members (see Fig 18):

$$I = C \ell^2 A \frac{R_{eH}}{235}$$

- for web stiffeners normal to the flange of the primary supporting members (see Fig 19):

$$I = 11{,}4\, s t_w (2{,}5\, \ell^2 - 2 s^2) \frac{R_{eH}}{235}$$

where:

C : Slenderness coefficient to be taken as:

- $C = 1{,}43$ for longitudinal web stiffeners including sniped stiffeners
- $C = 0{,}72$ for other web stiffeners

ℓ : Length, in m, of the web stiffener

s : Spacing, in m, of web stiffeners

t_w : Web net thickness, in mm, of the primary supporting member

A : Net section area, in cm², of the web stiffener, including attached plate assuming effective breadth of 80% of stiffener spacing s

R_{eH} : Minimum specified yield stress of the material of the web plate of primary supporting member.

Figure 18 : Web stiffeners parallel to the flange

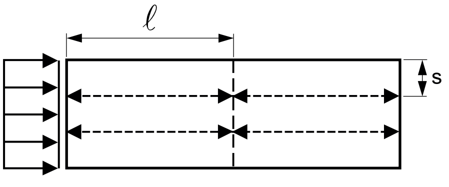
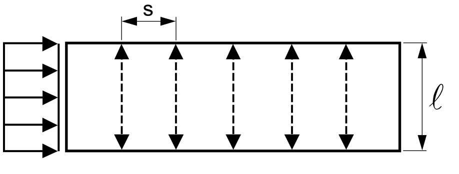


Figure 19 : Web stiffeners normal to the flange



5.8.4 Tripping brackets (see Fig 20) welded to the face plate are generally to be fitted:

- every fourth spacing of ordinary stiffeners, without exceeding 4 m
- in way of concentrated loads.

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

5.8.5 In general, the width of the primary supporting member face plate is to be not less than one tenth of the depth of the web, where tripping brackets are spaced as specified in [5.8.4].

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

$$d = 0{,}38 b$$

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

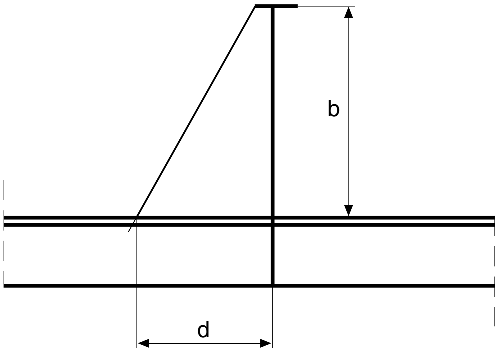
where:

b : Height, in m, of tripping brackets (see Fig 20)

s_t : Spacing, in m, of tripping brackets

t : Net thickness, in mm, of tripping brackets.

Figure 20 : Primary supporting member: web stiffener in way of ordinary stiffener



5.8.7 Tripping brackets with a net thickness, in mm, less than 15 L_b (where L_b is the length, in m, of the free edge of the bracket) are to be flanged or stiffened by a welded face plate.

The net sectional area, in cm², of the flanged edge or the face plate is to be not less than 10 L_b.

6 Structural modeling

6.1 Calculation point

6.1.1 General

The calculation point is to be considered with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [3.1].

6.1.2 Plating

The elementary plate panel is the smallest unstiffened part of plating.

Unless otherwise specified, the loads are to be calculated:

- for longitudinal framing, at the lower edge of the elementary plate panel or, in the case of horizontal plating, at the point of minimum y-value among those of the elementary plate panel considered
- for transverse framing, at the lower edge of the strake.

6.1.3 Ordinary stiffeners

a) Lateral pressure

   Unless otherwise specified, the loads are to be calculated at mid-span of the ordinary stiffener considered

b) Hull girder stresses

   For longitudinal ordinary stiffeners contributing to the hull girder longitudinal strength, the hull girder normal stresses are to be calculated in way of the attached plating of the stiffener considered.

6.1.4 Primary supporting members

a) Lateral pressure

   Unless otherwise specified, the loads are to be calculated at mid-span of the primary supporting member considered

b) Hull girder stresses

   For longitudinal ordinary stiffeners contributing to the hull girder longitudinal strength, the hull girder normal stresses are to be calculated in way of the neutral axis of the primary supporting member with attached plating.

6.2 Span correction coefficients

6.2.1 Ordinary stiffeners

These Rules apply to ordinary stiffeners without end brackets, with a bracket at one end or with two equal end brackets.

The span correction coefficients β_b and β_s of ordinary stiffeners are to be determined using the following formulae:

$$\beta_b = \left(1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}\right)^2$$

$$\beta_s = \left(1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}\right)$$

where:

ℓ : Span, in m, of ordinary stiffener, defined in [4.2]

$\ell_{bi} = 0{,}5\ \ell_b$

$\ell_b = \text{MIN}\ (d\ ;\ b)$

d, b : Length, in m, of bracket arms

n : Number of end brackets.

6.2.2 Primary supporting members

Conventional parameters of end brackets are given in Fig 21. Special consideration is to be given to conditions different from those shown.

The span correction coefficients β_b and β_s of primary supporting members are to be determined using the following formulae:

$$\beta_b = \left(1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}\right)^2$$

$$\beta_s = \left(1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}\right)$$

where:

ℓ : Span, in m, of primary supporting member, defined in [5.2.1]

$\ell_{bi} = \ell_b - 0{,}25\ h_W$

$\ell_b = \text{MIN}\ (d\ ;\ b)$

d, b : Lengths, in m, of bracket arms, defined in Fig 21

h_W : Height, in m, of the primary supporting member (see Fig 21)

n : Number of end brackets.

6.3 Coefficients for pressure distribution correction

6.3.1 The scantlings of non-horizontal structural members are to be determined using the coefficients for pressure distribution correction λ_b and λ_S defined as follows:

$$\lambda_s = 2\,\lambda_b - 1$$

$$\lambda_b = 1 + 0{,}2\left|\frac{p_d - p_u}{p_d + p_u}\right|$$

where:

p_u : Pressure, in kN/m², at the upper end of the structural member considered

$p_u = p_{su} + p_{wu}$

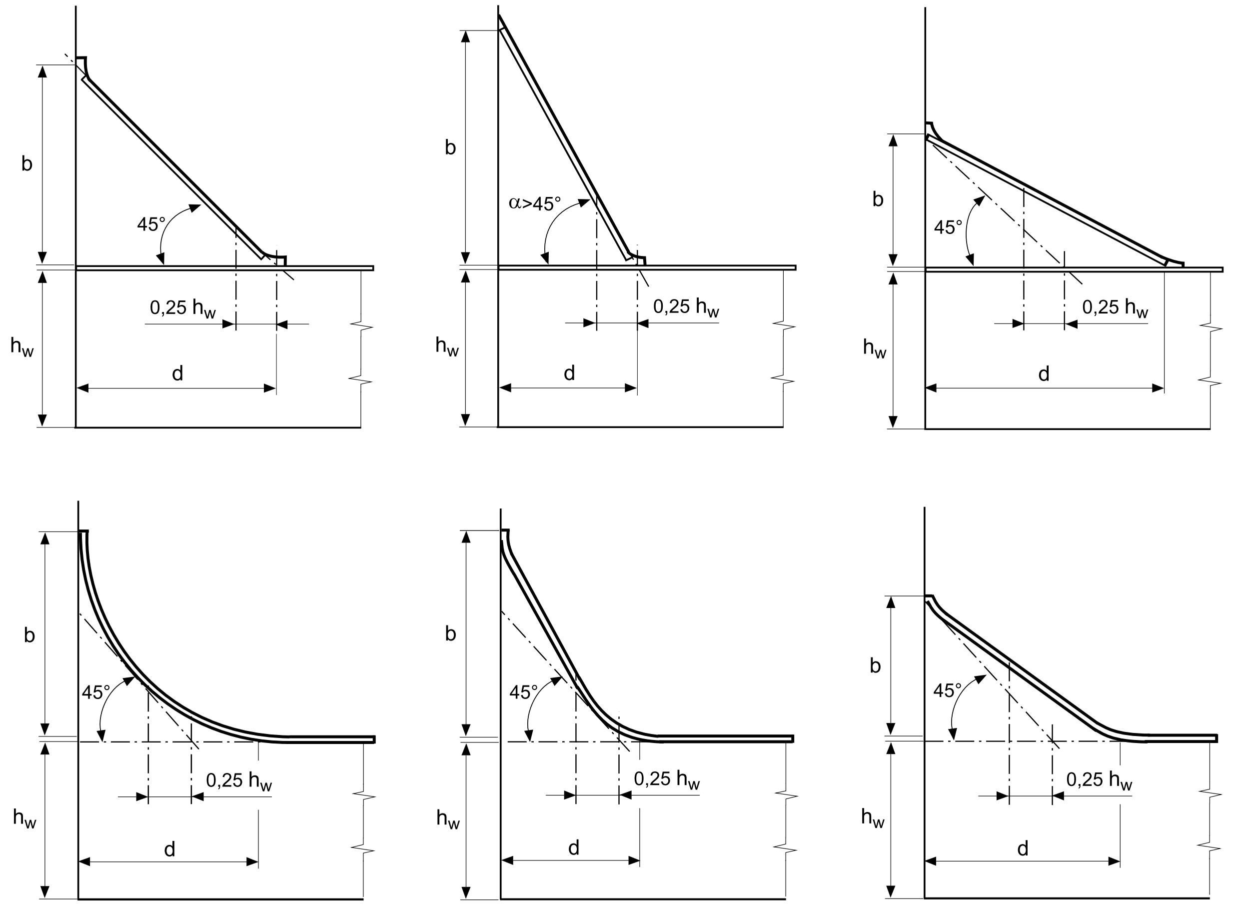
p_d : Pressure, in kN/m², at the lower end of the structural member considered

$p_d = p_{sd} + p_{wd}$

p_{su}, p_{wu} : Still water pressure and wave pressure respectively, in kN/m², at the upper end of the structural member considered

p_{sd}, p_{wd} : Still water pressure and wave pressure respectively, in kN/m², at the lower end of the structural member considered.

Figure 21 : Characteristics of primary supporting member brackets



SECTION 5 NET SCANTLING APPROACH

1 Application criteria

1.1 General

1.1.1 The scantlings of metallic hull structural members obtained by applying the criteria specified in these Rules are net scantlings, i.e. those which provide the strength characteristics required to sustain the loads, excluding any addition for corrosion. Exceptions are the scantlings of:

- rudder structures and hull appendages in Part B, Chapter 7
- massive pieces made of steel forgings, steel castings or iron castings.

1.1.2 The required strength characteristics are:

- thickness, for plating including that which constitutes primary supporting members
- section modulus, shear sectional area, moments of inertia and local thickness, for ordinary stiffeners and, as the case may be, primary supporting members
- section modulus, moments of inertia and single moment for the hull girder.

1.1.3 The vessel is to be built at least with the gross scantlings obtained by reversing the procedure described in [2.1].

2 Net strength characteristic calculation

2.1 Designer's proposal based on gross scantlings

2.1.1 General criteria

If the designer provides the gross scantlings of each structural element, the structural checks are to be carried out on the basis of the net strength characteristics, derived as specified in [2.1.2] to [2.1.5].

2.1.2 Plating

The net thickness is to be obtained by deducting the corrosion addition t_c from the gross thickness.

2.1.3 Ordinary stiffeners

The net transverse section is to be obtained by deducting the corrosion addition t_C from the gross thickness of the elements which constitute the stiffener profile.

The net strength characteristics are to be calculated for the net transverse section. As an alternative, the net section modulus of bulb profiles may be obtained from the following formula:

$$w = w_G (1 - \alpha t_C) - \beta t_C$$

where:

w_G : Stiffener gross section modulus, in cm^3

α, β : Coefficients defined in Tab 1.

Table 1 : Coefficients α and β for bulb profiles

Range of w_G	α	β
$w_G \le 200$ cm³	0,070	0,4
$w_G > 200$ cm³	0,035	7,4

2.1.4 Primary supporting members

The net transverse section is to be obtained by deducting the corrosion addition t_C from the gross thickness of the elements which constitute the primary supporting members.

The net strength characteristics are to be calculated for the net transverse section.

2.1.5 Hull girder

For the hull girder, the net hull transverse sections are to be considered as being constituted by plating and stiffeners having net scantlings calculated on the basis of the corrosion additions t_C, according to [2.1.2] to [2.1.4].

2.2 Designer's proposal based on net scantlings

2.2.1 Net strength characteristics and corrosion additions

If the designer provides the net scantlings of each structural element, the structural checks are to be carried out on the basis of the proposed net strength characteristics.

The designer is also to provide the corrosion additions or the gross scantlings of each structural element. The proposed corrosion additions are to be not less than the values specified in [3.1].

2.2.2 Hull girder net strength characteristic calculation

For the hull girder, the net hull girder transverse sections are to be considered as being constituted by plating and stiffeners having the net scantlings proposed by the designer.

3 Corrosion additions

3.1 Values of corrosion additions

3.1.1 General

The values of the corrosion additions specified in this Article are to be applied in relation to the relevant corrosion protection measures prescribed in Ch 8, Sec 3, [1].

The designer may define values of corrosion additions greater than those specified in [3.1.2] and [3.1.3].

3.1.2 Corrosion additions for steel other than stainless steel

The corrosion addition for each of the two sides, t_{C1} or t_{C2}, of a structural member is specified in Tab 2.

The total corrosion addition t_C, in mm, for both sides of a structural member, is equal to:

- for a plating with a gross thickness greater than 10 mm:

  $t_C = t_{C1} + t_{C2}$
- for a plating with a gross thickness less than or equal to 10 mm:
  - t_C = 20% of the gross thickness of the plating, or
  - $t_C = t_{C1} + t_{C2}$

  whichever is smaller.

For an internal member within a given compartment, the total corrosion addition t_C is to be determined as follows:

- for a plating or a stiffener plating with a gross thickness greater than 10 mm:

  $t_C = 2\ t_{C1}$
- for a plating or a stiffener plating with a gross thickness less than or equal to 10 mm:
  - t_C = 20% of the gross thickness of the plating considered, or
  - $t_C = 2\ t_{C1}$

  whichever is smaller,

where t_{C1} is the value of the corrosion addition specified in Tab 2 for one side exposure to that compartment.

3.1.3 Corrosion additions for stainless steel and aluminium alloys

For structural members made of stainless steel or aluminium alloys, the corrosion addition is to be taken equal to 0,25 mm, for one side exposure ($t_{C1} = t_{C2}$ = 0,25 mm).

Table 2 : Corrosion additions, in mm, for one side exposure (t_{C1} or t_{C2}) - steel other than stainless steel

Compartment type		Corrosion addition **(1)**
Ballast tank		1,00
Cargo tank and fuel oil tank	Plating of horizontal surfaces	0,75
	Plating of non-horizontal surfaces	0,50
	Ordinary stiffeners Primary supporting members	0,75
Dry bulk cargo hold	General	1,00
	Inner bottom plating Side plating for single hull vessel Inner side plating for double hull vessel Transverse bulkhead plating	1,75
	Frames Ordinary stiffeners Primary supporting members	1,00
Hopper well of dredging vessels		2,00
Accommodation space		0,00
Compartment and area other than those mentioned above		0,50
(1) Corrosion additions are applicable to all the members of the considered item.		

SECTION 6 STRENGTH CRITERIA - STRUCTURAL ITEMS IN COMPOSITE MATERIAL OR PLYWOOD

Symbols

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

p_{SE} : External still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.1]

p_S : Still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{WE} : External wave pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.2]

p_W : Inertial pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{ST} : Test pressure, in kN/m^2, defined in Ch 3, Sec 4, [5.1.1]

p_E : External design pressure, in kN/m^2

$p_E = p_{SE} + \gamma_{W2}\, p_{WE}$

p_C : Cargo design pressure, in kN/m^2

$p_C = p_S + \gamma_{W2}\, p_W$

p_B : Ballast design pressure, in kN/m^2

$p_B = p_S + \gamma_{W2}\, p_W$

p_D : External design pressure, in kN/m^2

$p_D = p_S + \gamma_{W2}\, p_W$

p_{WD} : Wind pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.3]

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

- $\gamma_{W1} = 1{,}0$ for **IN**
- $\gamma_{W1} = 1{,}15$ for **IN($x \le 2$)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- $\gamma_{W2} = 1{,}0$ for **IN**
- $\gamma_{W2} = 1{,}2$ for **IN($x \le 2$)**

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

z : Z co-ordinate, in m, of the calculation point of a structural element.

1 General

1.1 Application

1.1.1 The requirements of the present Section define the strength criteria to be considered for the strength check of structural items in composite material or plywood.

The hull strength check is to be carried out according to the applicable requirements of NR546 Composite Ships.

1.2 Gross scantling approach

1.2.1 The scantlings obtained by applying the criteria specified in the present Rules for composite structures include a rule partial safety factor C_V which takes into account the ageing effect on the laminate mechanical characteristics.

2 Local scantling analysis

2.1 Application

2.1.1 The local scantling of panels, secondary and primary stiffeners is to be reviewed according to:

- local loads as defined in [2.3] and [2.4]
- rule analysis as defined in NR546, Sec 6 for panels and in NR546, Sec 7 for stiffeners
- minimum rule safety factors as defined in [4.3] for laminates and in [5.2] for plywood structure.

2.2 Local load calculation point

2.2.1 Unless otherwise specified, the local loads are to be calculated:

- for plate panels:
  - at the lower edge of the plate panels for monolithic, and
  - at the middle of the plate panels for sandwich.
- for horizontal stiffeners: at mid-span of the stiffeners
- for vertical stiffeners: at the lower and upper vertical points of the stiffeners.

2.2.2 Superstructures and deckhouses

For superstructures and deckhouses, the lateral pressures are to be calculated, for all type of materials:

- for plating: at mid-height of the bulkhead
- for horizontal and vertical stiffeners: at mid-span of the stiffeners.

2.3 Design lateral pressure

2.3.1 The design lateral pressure, p, to be used for hull scantling is defined in Tab 1.

2.4 Forces induced by wheeled and dry unit cargoes

2.4.1 The force transmitted to the hull structure by wheeled cargoes and dry unit cargoes are given by the formula:

$F = F_S + \gamma_{W2} F_W$

where:

F_S, F_W : Still water and wave forces defined in Ch 3, Sec 4, [3].

3 Global strength scantling analysis

3.1 Application

3.1.1 Global hull girder longitudinal strength

As a rule, the global hull girder longitudinal strength of vessels assigned the range of navigation **IN(x ≤ 2)**, is to be examined for monohull vessels and for floats of catamarans, in the following cases:

- vessels with length greater than 30 m, or
- vessels having large openings in decks or significant geometrical structure discontinuity at bottom or deck, or
- vessels with a transverse framing system, or
- vessels with deck structure made of panels with small thicknesses and stiffeners with large spacings, or
- vessels with important deadweight, or
- where deemed appropriate by the Society.

The hull girder longitudinal strength of vessels not covered by the above cases is considered satisfied when the local scantlings are in accordance with the requirements defined in [2].

For vessels assigned the range of navigation **IN**, the global hull girder longitudinal strength will be examined on a case by case basis, where deemed appropriate by the Society.

3.1.2 Global strength and local scantling analysis

When deemed necessary by the Society, the hull scantling may be checked taking into account a combination between the global hull girder and local stresses.

3.1.3 Global transverse strength of catamaran

As a rule, the global transverse strength of catamaran is to be examined for all types of catamaran.

3.1.4 Finite element calculation

The global strength analysis may also be examined with a Finite Element Analysis submitted by the designer. In this case and where large openings are provided in side shell and/or in transverse cross bulkhead of catamaran, a special attention is to be paid to ensure a realistic modeling of the bending and shear strengths of the window jambs between windows.

3.2 Vertical overall longitudinal bending moment

3.2.1 The vertical overall longitudinal bending moment M_V to be considered for the scantling analysis is to be obtained from the following formulae:

- In sagging condition

$$M_V = M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}$$

- In hogging condition

$$M_V = M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}$$

where:

γ_W : Coefficient defined as follows:

- for global hull girder longitudinal strength analysis (see [3.1.1]): $\gamma_W = 1,0$
- for global strength and local scantling analysis (see [3.1.2]):
  - $\gamma_W = 1,0$ for **IN**
  - $\gamma_W = 0,625$ for **IN(x ≤ 2)**

C_{FV} : Combination factors defined in Tab 2

Table 1 : Design lateral pressure, p, in kN/m²

	Structure	In service conditions	In testing conditions	In flooding conditions
In general	Shell structure	p_E $p_C - p_{Em}$ $p_B - p_{Em}$	p_{ST} $p_{ST} - p_{SE}$ **(1)**	–
	Deck structure	p_E **(2)** p_C p_B p_D	p_{ST}	–
	Hatch coaming	$2+p_{WD}$	–	–
	Internal structure	p_C p_B	p_{ST}	p_{FL}
Superstructures & deckhouses	Wall structure	p_{WE}	–	–
	Deck structure	p_D	–	–

(1) Testing afloat
(2) External deck pressure defined in Ch 3, Sec 4, [2.2.1]

Table 2 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c"	Except vessels assigned a range of navigation **IN(x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
"d"	

4 Structural items in composite material

4.1 Application

4.1.1 The requirements of the present Article define the permissible stresses considered for the strength check of composite structures.

4.2 General

4.2.1 Principle of design review

The design review of composite structures is based on safety factors which are to be in compliance with the following criteria:

- minimum stress criteria in layers:

$$\frac{\sigma_{bri}}{\sigma_{iapp}} \geq SF$$

- critical buckling stress criteria:

$$\frac{\sigma_c}{\sigma_A} \geq SF_B$$

- combined stress criteria in layers:

$$SF_{CS} \geq SF_{CSiapp}$$

where:

σ_{bri} : In-plane theoretical individual layer breaking stresses defined in NR546 Composite Ships, Sec 5, [5]

σ_C : Critical buckling stress of the composite element considered calculated as defined in NR546, Composite Ships, Sec 6, [4].

σ_{iapp} : In-plane individual layer applied stresses

σ_A : Compressive stress applied to the whole laminate considered

SF, SF_B , SF_{CS}:Rule safety factors defined in [4.3.3]

SF_{CSiapp} : Actual combined stress applied in layer as calculated in NR546 Composite ships, Sec 2, [1.3.3].

Note 1: The breaking stresses directly deduced from mechanical tests (as requested in NR546 Composite Ships) may be taken over from the theoretical breaking stresses if the mechanical test results are noticeably different from the expected values.

4.2.2 Types of stress considered

The following different types of stress are considered, corresponding to the different loading modes of the fibres:

a) Principal stresses in the individual layers

- stress σ_1

  These stresses, parallel to the fibre (longitudinal direction), may be tensile or compressive stresses and are mostly located as follows:

  - in 0° direction of unidirectional tape or fabric reinforcement systems
  - in 0° and 90° directions of woven roving.

- stress σ_2

  These stresses, perpendicular to the fibre (transverse direction), may be tensile or compressive stresses and are mostly located as follows:

  - in 90° direction of unidirectional tape or combined fabrics when the fibres of the set are stitched together without criss-crossing.

- shear stress τ_{12} (in the laminate plane)

  These shear stresses, parallel to the fibre, may be found in all type of reinforcement systems

- shear stresses τ_{13} and τ_{23} (through the laminate thickness)

  These shear stresses, parallel or perpendicular to the fibre, are the same stresses than the interlaminar shear stresses τ_{IL2} and τ_{IL1}

- combined stress (Hoffman criteria).

b) Stresses in the whole laminate

- compressive and shear stresses in the whole laminate inducing buckling.

4.2.3 Theoretical breaking criteria

Three theoretical breaking criteria are used in the present Rules:

a) the maximum stress criteria leading to the breaking of the component resin/fibre of one elementary layer of the full lay-up laminate

b) the Hoffman combined stress criteria with the hypothesis of in-plane stresses in each layer

c) the critical buckling stress criteria applied to the laminate.

The theoretical breaking criteria defined in items a) and b) are to be checked for each individual layer.

The theoretical breaking criteria defined in item c) is to be checked for the global laminate.

4.2.4 First ply failure

It is considered that the full lay-up laminate breaking strength is reached as soon as the lowest breaking strength of any elementary layer is reached. This is referred to as "first ply failure".

4.3 Rule safety factors

4.3.1 General

a) General consideration:

   The rule safety factors to be considered for the composite structure check are defined in [4.3.3], according to the partial safety factors defined in [4.3.2].

b) Additional considerations:

Rule safety factors other than those defined in [4.3.3] may be accepted for one elementary layer when the full lay-up laminate exhibits a sufficient safety margin between the theoretical breaking stress of this elementary layer and the theoretical breaking stress of the other elementary layers.

Finite Element Model analyses are examined on a case by case basis by the Society. As a rule, when the structure is checked with a Finite Element Model, the rule safety factors defined in [4.3.3] and [4.3.4] may be reduced by ten per cent.

4.3.2 Partial safety factors

As a general rule, the minimum partial safety factors considered are to be as follows:

a) Ageing effect factor C_V

C_V takes into account the ageing effect of the composites and is generally taken equal to:

C_V = 1,2 for monolithic laminates (or for face-skins laminates of sandwich)

C_V = 1,1 for sandwich core materials

b) Fabrication process factor C_F

C_F takes into account the fabrication process and the reproducibility of the fabrication and is generally taken equal to:

C_F = 1,10 in case of a prepreg process

C_F = 1,15 in case of infusion and vacuum process

C_F = 1,25 in case of a hand lay-up process

C_F = 1,00 for the core materials of sandwich composite

c) Type of load factor C_i

C_i takes into account the type of loads and is generally taken equal to:

C_i = 1,0 for local external pressures and internal pressures or concentrated forces

C_i = 0,8 for test pressures and flooding loads

d) Type of stress factor C_R

C_R takes into account the type of stress in the fibres of the reinforcement fabrics and the cores and is generally taken equal to:

1) For fibres of the reinforcement fabrics

- for tensile or compressive stress parallel to the continuous fibre of the reinforcement fabric:

  C_R = 2,1 for unidirectional tape, bi-bias, three-unidirectional fabric

  C_R = 2,4 for woven roving

- for tensile or compressive stress perpendicular to the continuous fibre of the reinforcement fabric:

  C_R = 1,25 for unidirectional tape, bi-bias, three-unidirectional fabric

- for shear stress parallel to the fibre in the elementary layer and for interlaminar shear stress in the laminate:

  C_R = 1,6 for unidirectional tape, bi-bias, three-unidirectional fabric

  C_R = 1,8 for woven roving

- for mat layer:

  C_R = 2,0 for tensile or compressive stress in the layer

  C_R = 2,2 for shear stress in the layer and for interlaminar shear stress

2) For core materials

- for tensile or compressive stress for cores:
  - in the general case:

    C_R = 2,1 for tensile or compressive stress
  - for balsa:

    C_R = 2,1 for tensile or compressive stress parallel to the wood grain

    C_R = 1,2 for tensile or compressive stress perpendicular to the wood grain

- for shear stress, whatever the type of core material:

  C_R = 2,5

3) For wood materials for strip planking

C_R = 2,4 for tensile or compressive stress parallel to the continuous fibre of the strip planking

C_R = 1,2 for tensile or compressive stress perpendicular to the continuous fibre of the strip planking

C_R = 2,2 for shear stress parallel to the fibre and for interlaminar shear stress in the strip planking.

4.3.3 Rule safety factors

The rule safety factors SF, SF_{CS} and SF_B to be considered for the composite structure check are defined according to the type of hull structure calculation, as follows:

a) For structure checked under local loads:

1) Minimum stress criterion in layers:

$SF = C_V\ C_F\ C_R\ C_i$

with:

C_V, C_F, C_R, C_i: Partial safety factors defined in [4.3.2]

2) Combined stress criterion in layers:

$SF_{CS} = C_{CS}\ C_V\ C_F\ C_i$

with:

C_{CS} : Partial safety factor, to be taken equal to:

- C_{CS} = 1,7 for unidirectional tape, bi-bias, three-unidirectional fabric
- C_{CS} = 2,1 for the other types of layer

C_V, C_F, C_i: Partial safety factors defined in [4.3.2]

b) For structure element contributing to the global strength checked under global hull girder loads:

The minimum stress criterion in layers and the combined stress criterion in layers are to be taken as defined in a) with a value of C_i equal to 1,4.

The critical buckling stress criterion is to be taken equal to:

$SF_B = C_{buck}\ C_V,\ C_F,\ C_i$

with:

C_{buck} : Partial safety factors to be taken equal to 1,45

C_V, C_F : Partial safety factors defined in [4.3.2]

C_i : Partial safety factors to be taken equal to 1,2

c) For structure element contributing to the global strength checked under global loads combined with local loads:

The minimum stress criterion in layers and the combined stress criterion in layers are to be taken as defined in a) with a value of C_i equal to 0,8.

The critical buckling stress criterion is to be taken as defined in b) with a value of C_i equal to 0,8.

4.3.4 Rule safety factor for structural adhesive joints

The structural adhesive characteristics are to be as defined in NR546 Composite Ships.

As a general rule, the rule safety factor SF considered in the present Rules and applicable to the maximum shear stress in adhesive joints is to be calculated as follows:

$SF = 2,4\ C_F\ C_i$

where:

C_F : Factor taking into account the gluing process and generally taken as follows:

- C_F = 1,4 in case of a vacuum process with rising curing temperature
- C_F = 1,5 in case of vacuum process
- C_F = 1,7 in the other cases.

5 Structural items in plywood

5.1 General

5.1.1 Principle of design review

As a rule, plywood structures are checked according to an homogeneous material approach, or by a “ply by ply” approach as defined in NR546 Composite Ships.

5.2 Rule safety factors

5.2.1 Homogeneous material approach

As a general rule, the rule safety factor SF to be taken into account in the global formula used to determine the plating thickness or the permissible stress in stiffeners is to be equal to, or greater than, 4,0.

5.2.2 Ply by ply approach

As a general rule, the rule safety factor SF applicable to the maximum stress in each layer of the plywood is to be calculated as follows:

a) Minimum stress criterion in layers

$SF = C_R\ C_i\ C_V$

with:

C_R : Factor taking into account the type of stress in the grain of the plywood layer. Generally:

- C_R = 3,7

  for a tensile or compressive stress parallel to the grain of the ply considered
- C_R = 2,4

  for tensile or compressive stress perpendicular to the grain of the ply considered
- C_R = 2,9

  for a shear stress parallel to the grain of the ply considered

C_i : Factor taking into account the type of loads. Generally:

- C_i = 1,0

  for local external pressures and internal pressures or concentrated forces
- C_i = 0,8

  for test pressures and flooding loads

C_V : Factor taking into account the ageing effect of the plywood, to be taken at least equal to 1,2

b) Critical buckling stress criterion

As a general rule, the rule safety factor SFB applicable to the critical buckling stress criterion is to be calculated as follows:

$SF_B = C_{buck}\ C_V\ C_i$

with:

C_{buck}, C_V : Partial safety factors, to be taken equal to:

- C_{buck} =1,45 and C_V = 1,2

  for the check of the structure under local loads
- C_{buck} = 1,35 and C_V = 1,0

  for the check of the global hull girder structure, if required.

C_i : Partial safety factor defined in [4.3.2].

SECTION 7 BUCKLING AND ULTIMATE STRENGTH OF ORDINARY STIFFENERS AND STIFFENED PANELS

Symbols

a : Length of single or partial plate field, in mm (see Fig 1)

b : Breadth of single plate field, in mm (see Fig 1)
In general, the ratio plate field breadth to plate thickness shall not exceed b / t = 100

E : Young's modulus, in N/mm^2:
- $E = 2,06 \cdot 10^5$ for steel, in general
- $E = 1,95 \cdot 10^5$ for stainless steel
- $E = 7,00 \cdot 10^4$ for aluminium alloys

F_1 : Correction factor for boundary condition of stiffeners on the longer side of elementary plate panels:
- F_1 = 1,00 for stiffeners sniped at both ends
- F_1 = 1,05 for flat bar
- F_1 = 1,10 for bulb sections
- F_1 = 1,20 for angle or T-sections
- F_1 = 1,30 for girders of high rigidity (e.g. bottom transverses).

K : Buckling factor according to Tab 1.

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

I_z : Net moment of inertia, in cm^4, of the hull transverse section defined in Ch 4, Sec 1, [2.1] around the vertical neutral axis

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

M_{WH} : Horizontal wave bending moment, in kN.m, to be determined according to Ch 3, Sec 2, [3.3]

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

n_S : Number of single plate field breadths within the partial or total plate field

p_B : Ballast design pressure, in kN/m^2
$p_B = p_S + \gamma_{WB} p_W$

p_C : Cargo design pressure, in kN/m^2
$p_C = p_S + \gamma_{WB} p_W$

p_D : External design pressure, in kN/m^2
$p_D = p_S + \gamma_{WB} p_W$

p_E : External design pressure, in kN/m^2
$p_E = p_{SE} + \gamma_{WB} p_{WE}$

p_S : Still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{SE} : External still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.1]

p_{ST} : Test pressure, in kN/m^2, defined in Ch 3, Sec 4, [5.1.1]

p_W : Inertial pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{WD} : Wind pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.3]

p_{WE} : External wave pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.2]

R_{eH} :
- for hull structural steels:
  Minimum yield stress, in N/mm^2
- for aluminium alloys:
  - in general
    Minimum yield stress of the parent metal in delivery condition $R_{P0,2}$, in N/mm^2
  - for buckling of pillars
    Minimum yield stress of the parent metal in welded condition $R'_{P0,2}$, in N/mm^2

S_F : Safety factor:
- structural items in the vessel central part
  S_F= 1,10 for steel
  S_F= 1,20 for constructions in aluminium alloys
- structural items elsewhere
  S_F= 1 for steel
  S_F= 1,10 for constructions in aluminium alloys

t : Net plate thickness, in mm

y : Y co-ordinate, in m, of the calculation point

z : Z co-ordinate, in m, of the calculation point of a structural element

α : Aspect ratio of single plate field: $\alpha = a / b$

γ_{WB} : Factor taken as:

- $\gamma_{WB} = 1$ for **IN**
- $\gamma_{WB} = 1,6$ for **IN(x ≤ 2)**

λ : Reference degree of slenderness

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

σ_E : Reference stress, in N/mm²

- for plating:

$$\sigma_E = 0,9E\left(\frac{t}{b}\right)^2$$

- for pillars

$$\sigma_E = \pi^2 E \frac{I}{A(f\ell)^2} 10^{-4}$$

σ_X : Membrane stress in x-direction, in N/mm²

σ_y : Membrane stress in y-direction, in N/mm²

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

where:

σ_1 : Maximum compressive stress

σ_2 : Minimum compressive stress or tensile stress

τ : Shear stress in the x-y plane, in N/mm².

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the buckling check of metallic structural members and plating.

1.1.2 Buckling and ultimate strength assessment application guide is given in [7].

1.1.3 Other buckling rules can be accepted if agreed with the Society.

2 Proof of single plate fields

2.1 Verification of a single plate field in a transverse section analysis

2.1.1 Load cases

The buckling load cases to be applied to the buckling panel under evaluation are defined in Tab 1 and Tab 2, depending on the stress distribution and the panel geometry.

2.1.2 Checking criteria

Proof is to be provided that the following conditions are complied with for the single plate field a x b:

- load case 1 and load case 3:

$$\frac{|\sigma_X| S_F}{\kappa_X R_{eH}} \leq 1$$

- load case 2 and load case 4:

$$\frac{|\sigma_Y| S_F}{\kappa_Y R_{eH}} \leq 1$$

where

κ_x, κ_y : Reduction factors as given in Tab 1 and/or Tab 2, with:

- $\kappa_x = 1,0$ when $\sigma_x \leq 0$ (tension stress)
- $\kappa_y = 1,0$ when $\sigma_y \leq 0$ (tension stress).

2.2 Verification of a single plate field within FEM analysis

2.2.1 General

The FEM analysis is to be carried out according Ch 2, App 1. The determination of the buckling and reduction factors is made for each relevant case of Tab 1 according to the stresses calculated in [2.2.2] loading the considered single plate field.

2.2.2 Stresses

The buckling stresses are to be determined according to Tab 1 and Tab 2 including their stress ratio ψ for the required loading conditions and according to Ch 2, App 1, [6].

2.2.3 Boundary conditions

Buckling load cases 1, 2, 5 or 6 of Tab 1 are to be applied to the buckling panel under evaluation, depending on the stress distribution and geometry of openings.

If the actual boundary conditions are significantly different from simple support condition, another case in Tab 1can be applied.

2.2.4 Safety factor

The safety factor S_F for the buckling and ultimate strength assessment of the single plate field is to be taken equal to:.

- $S_F = 1$ for steel
- $S_F = 1,1$ for aluminium alloys

2.2.5 Checking criteria

Proof is to be provided that the following condition, in which each term is not to exceed 1,0, is complied with for the single plate field a · b:

$$\left(\frac{|\sigma_x| S_F}{\kappa_x R_{eH}}\right)^{e1} + \left(\frac{|\sigma_y| S_F}{\kappa_y R_{eH}}\right)^{e2} - B\left(\frac{\sigma_x \sigma_y S_F^2}{R_{eH}^2}\right) + \left(\frac{|\tau| S_F \sqrt{3}}{\kappa_\tau R_{eH}}\right)^{e3} \leq 1,0$$

where:

B : Factor taken equal to:

- for σ_x and σ_y positive (compression stress):

  $B = (\kappa_x \kappa_y)^5$

- for σ_x or σ_y negative (tension stress):

  $B = 1,00$

$e_1 = 1 + \kappa_x^4$

$e_2 = 1 + \kappa_y^4$

$e_3 = 1 + \kappa_x \kappa_y \kappa_\tau^2$

κ_x, κ_y, κ_τ : Reduction factors as given in Tab 1 and/or Tab 2 with:

- $\kappa_x = 1,0$ when $\sigma_x \leq 0$ (tension stress)
- $\kappa_y = 1,0$ when $\sigma_y \leq 0$ (tension stress).

3 Effective width of plating

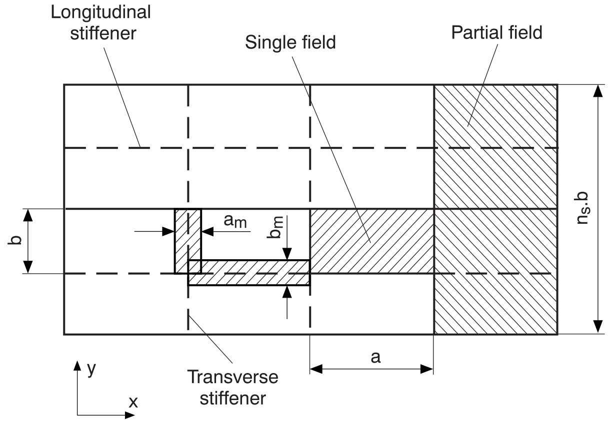
3.1 General

3.1.1 The effective width of plating may be determined by the following formulae (see Fig 1):

- for longitudinal stiffeners: $b_m = \kappa_X b$
- for transverse stiffeners: $a_m = \kappa_Y a$

The effective width of plating is not to be taken greater than the value obtained from Ch 2, Sec 4, [4.3] or Ch 2, Sec 4, [5.3].

Figure 1 : Structural elements



4 Webs and flanges

4.1 General

4.1.1 For non-stiffened webs and flanges of sections and girders, proof of sufficient buckling strength as for single plate fields is to be provided according to [2.1].

Within 0,5 L amidships, the following guidance values are recommended for the ratio web depth to web thickness and/or flange breadth to flange thickness:

- flat bars:

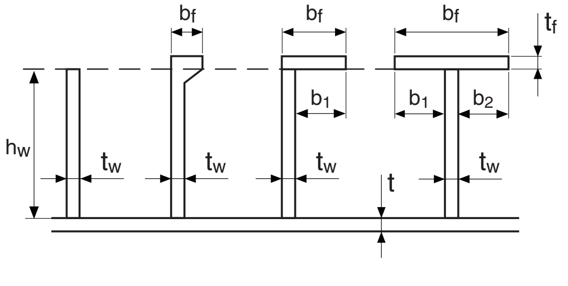
  $h_W / t_W \leq 19{,}5\ (k_0 k)^{0,5}$
- angles, tees and bulb sections:
  - for web: $h_W / t_W \leq 60\ (k_0 k)^{0,5}$
  - for flange: $b_i / t_f \leq 19{,}5\ (k_0 k)^{0,5}$

  where:

  b_i : Parameter defined in Fig 2 and equal to:

  $b_i = \text{MAX}\ (b_1\ ;\ b_2)$

Figure 2 : Section dimensions



5 Proof of partial and total fields

5.1 Longitudinal and transverse stiffeners

5.1.1 Proof is to be provided that the continuous longitudinal and transverse stiffeners of partial (see Fig 1) and total plate fields comply with the condition set out in [5.2] and [5.3].

5.2 Lateral buckling

5.2.1 The following relation is to be complied with:

$$\frac{\sigma_a + \sigma_b}{R_{eH}} S_F \leq 1$$

where:

σ_a : Uniformly distributed compressive stress, in N/mm², in the direction of the stiffener axis:

$\sigma_a = \sigma_X$ for longitudinal stiffeners

$\sigma_a = \sigma_Y$ for transverse stiffeners.

σ_b : Bending stress, in N/mm², in the stiffeners:

$$\sigma_b = \frac{M_0 + M_1}{w_{St} 10^3}$$

with:

M_0 : Bending moment due to deformation w_d of stiffener, in N.mm:

$$M_0 = F_{Ki} \frac{p_Z w_d}{c_f - p_Z}$$

with $(c_f - p_Z) > 0$

F_{Ki} : Ideal buckling force of the stiffener, in N:

- for longitudinal stiffeners:

$$F_{KiX} = \frac{\pi^2}{a^2} E I_X \cdot 10^4$$

- for transverse stiffeners:

$$F_{KiY} = \frac{\pi^2}{(n_S \cdot b)^2} E I_Y \cdot 10^4$$

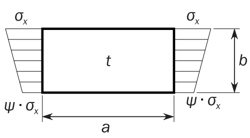
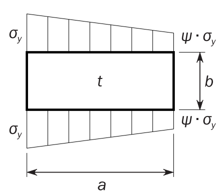
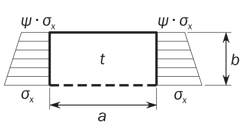
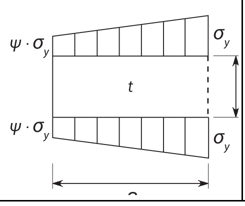
I_X : Moment of inertia, in cm⁴, of the longitudinal stiffener including effective width of plating according to [3.1]:

$$I_X \geq \frac{bt^3}{12 \cdot 10^4}$$

I_Y : Moment of inertia, in cm⁴, of the transverse stiffener including effective width of plating according to [3.1]:

$$I_Y \geq \frac{at^3}{12 \cdot 10^4}$$

Table 1 : Buckling and reduction factors for plane elementary plate panels

Load case	Edge stress ratio ψ	Aspect ratio $\alpha = a/b$	Buckling factor K	Reduction factor κ
Case 1 	$1 \geq \psi \geq 0$	$\alpha > 1$	$K = \dfrac{8,4}{\psi + 1,1}$	$\kappa_X = 1$ for $\lambda \leq \lambda_C$ $\kappa_X = c\left(\dfrac{1}{\lambda} - \dfrac{0,22}{\lambda^2}\right)$ for $\lambda > \lambda_C$
	$0 > \psi > -1$		$K = 7,63 - \psi\,(6,26 - 10\,\psi)$	$c = (1,25 - 0,12\,\psi) \leq 1,25$
	$\psi \leq -1$		$K = 5,975\,(1 - \psi)^2$	$\lambda_C = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0,88}{c}}\right)$
Case 2 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = F_1\left(1 + \dfrac{1}{\alpha^2}\right)^2 \dfrac{2,1}{\psi + 1,1}$	$\kappa_Y = c\left[\dfrac{1}{\lambda} - \dfrac{R + F^2(H - R)}{\lambda^2}\right]$ $c = (1,25 - 0,12\,\psi) \leq 1,25$
	$0 > \psi > -1$	$1,0 \leq \alpha \leq 1,5$	$K = F_1\left[\left(1 + \dfrac{1}{\alpha^2}\right)^2 \dfrac{2,1(\psi + 1)}{1,1} - \dfrac{\psi}{\alpha^2}(13,9 - 10\psi)\right]$	$R = \lambda\left(1 - \dfrac{\lambda}{c}\right)$ for $\lambda < \lambda_C$ $R = 0,22$ for $\lambda \geq \lambda_C$ $\lambda_C = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0,88}{c}}\right)$
		$\alpha > 1,5$	$K = F_1\left[\left(1 + \dfrac{1}{\alpha^2}\right)^2 \dfrac{2,1(\psi + 1)}{1,1} - \dfrac{\psi}{\alpha^2}\left(5,87 + 1,87\alpha^2 + \dfrac{8,6}{\alpha^2} - 10\psi\right)\right]$	$F = \left(1 - \dfrac{\dfrac{K}{0,91} - 1}{\lambda_P^2}\right) c_1 \geq 0$
	$\psi \leq -1$	$1 \leq \alpha \leq \dfrac{3(1 - \psi)}{4}$	$K = 5,975 F_1\left(\dfrac{1 - \psi}{\alpha}\right)^2$	$\lambda_P^2 = \lambda^2 - 0,5$ with $1 \leq \lambda_P^2 \leq 3$ c_1 is equal to: • for σ_Y due to direct loads: $c_1 = 1$ • for σ_Y due to bending (in general): $c_1 = (1 - F_1 / \alpha) \geq 0$ • for σ_Y due to bending in extreme load cases (e.g. watertight bulkheads): $c_1 = 0$
		$\alpha > \dfrac{3(1 - \psi)}{4}$	$K = F_1\left[3,9675\left(\dfrac{1 - \psi}{\alpha}\right)^2 + 0,5375\left(\dfrac{1 - \psi}{\alpha}\right)^4 + 1,87\right]$	$H = \lambda - \dfrac{2\lambda}{c(\Gamma + \sqrt{\Gamma^2 - 4})} \geq R$ $\Gamma = \lambda + \dfrac{14}{15\lambda} + \dfrac{1}{3}$
Case 3 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = \left(0,425 + \dfrac{1}{\alpha^2}\right)\dfrac{(3 - \psi)}{2}$	$\kappa_X = 1$ for $\lambda \leq 0,7$ $\kappa_X = \dfrac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
Case 4 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = (0,425 + \alpha^2)\dfrac{(3 - \psi)}{2\alpha^2}$	$\kappa_Y = 1$ for $\lambda \leq 0,7$ $\kappa_Y = \dfrac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$

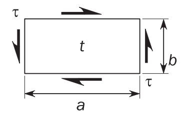
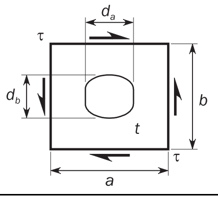
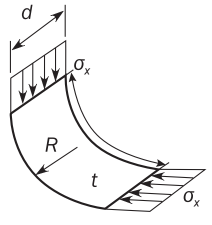
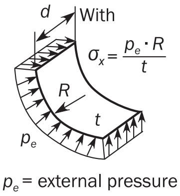
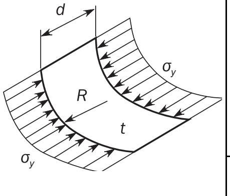
Load case	Edge stress ratio ψ	Aspect ratio α = a/b	Buckling factor K	Reduction factor κ
Case 5 			$K = K_\tau\sqrt{3}$	$\kappa_\tau = 1$ for $\lambda \le 0,84$ $\kappa_\tau = \dfrac{0,84}{\lambda}$ for $\lambda > 0,84$
		$\alpha \ge 1$	$K_\tau = 5,34 + \dfrac{4}{\alpha^2}$	
		$0 < \alpha < 1$	$K_\tau = 4 + \dfrac{5,34}{\alpha^2}$	
Case 6 			$K = K'r$ K' = K according to load case 5 r = Opening reduction factor $r = \left(1 - \dfrac{d_a}{a}\right)\left(1 - \dfrac{d_b}{b}\right)$ with $\dfrac{d_a}{a} \le 0,7$ and $\dfrac{d_b}{b} \le 0,7$	

Table 2 : Buckling and reduction factors for curved plate panel with R/t ≤ 2500

Load case	Aspect ratio b/R	Buckling factor K	Reduction factor κ
Case 1a 	$\dfrac{b}{R} \le 1,63\sqrt{\dfrac{R}{t}}$	$K = \dfrac{b}{\sqrt{Rt}} + 3\dfrac{(Rt)^{0,175}}{b^{0,35}}$	• for general application: $\kappa_x = 1,00$ for $\lambda \le 0,4$ $\kappa_x = 1,274 - 0,686\,\lambda$ for $0,4 < \lambda \le 1,2$ $\kappa_x = \dfrac{0,65}{\lambda^2}$ for $\lambda > 1,2$ • for curved single fields, e.g. bilge strakes, which are bounded by plane panels: $\kappa_x = \dfrac{0,8}{\lambda^2} \le 1,0$
Case 1b  p_e = external pressure in [N/mm²]	$\dfrac{b}{R} > 1,63\sqrt{\dfrac{R}{t}}$	$K = 0,3\dfrac{b^2}{R^2} + 2,25\left(\dfrac{R^2}{b\,t}\right)^2$	
Case 2 	$\dfrac{b}{R} \le 0,5\sqrt{\dfrac{R}{t}}$	$K = 1 + \dfrac{2}{3}\dfrac{b^2}{Rt}$	• for general application: $\kappa_x = 1,00$ for $\lambda \le 0,25$ $\kappa_x = 1,233 - 0,933\,\lambda$ for $0,25 < \lambda \le 1,0$ $\kappa_y = \dfrac{0,30}{\lambda^3}$ for $1,0 < \lambda \le 1,5$ $\kappa_y = \dfrac{0,20}{\lambda^2}$ for $\lambda > 1,5$ • for curved single fields, e.g. bilge strakes, which are bounded by plane panels: $\kappa_y = \dfrac{0,65}{\lambda^2} \le 1,0$
	$\dfrac{b}{R} > 0,5\sqrt{\dfrac{R}{t}}$	$K = 0,267\dfrac{b^2}{Rt}\left[3 - \dfrac{b}{R}\sqrt{\dfrac{t}{R}}\right] \ge 0,4\dfrac{b^2}{Rt}$	

Edge boundary conditions:

- - - - - - - - - Plate edge free.

——————— Plate edge simply supported

━━━━━━━ Plate edge clamped.

p_Z : Nominal lateral load of the stiffener due to σ_X and σ_Y, in N/mm²:

- for longitudinal stiffeners:

$$p_{ZX} = \frac{t}{b}\left[\sigma_{X1}\left(\frac{\pi b}{a}\right)^2 + 2 c_Y \sigma_Y\right]$$

- for transverse stiffeners:

$$p_{ZY} = \frac{t}{a}\left[2 c_X \sigma_{X1} + \sigma_Y\left(\frac{\pi a}{n_S b}\right)^2\left(1 + \frac{A_Y}{at}\right)\right]$$

with:

$$\sigma_{X1} = \sigma_X\left(1 + \frac{A_X}{bt}\right)$$

A_X, A_Y : Sectional area, in mm², of the longitudinal or transverse stiffener respectively, without attached plating

c_X, c_Y : Factors taking into account the stresses vertical to the stiffener's axis and distributed variable along the stiffener's length:

c_X, c_Y = 0,5 (1 + ψ) for $0 \le \psi \le 1$

c_X, c_Y = 0,5 / (1 − ψ) for $\psi < 0$

w_d : Value calculated as follows:

$w_d = w_{d0} + w_{d1}$

with:

w_{d0} : Assumed imperfection, in mm, taken equal to:

- for longitudinal stiffeners:

$$w_{d0} = \text{MIN}\left(\frac{a}{250}\ ;\ \frac{b}{250}\ ;\ 10\right)$$

- for transverse stiffeners:

$$w_{d0} = \text{MIN}\left(\frac{a}{250}\ ;\ \frac{n_S b}{250}\ ;\ 10\right)$$

For stiffeners sniped at both ends w_{d0} is not to be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating

w_{d1} : Deformation of stiffener due to lateral load p (in kN/m²) at midpoint of stiffener span, in mm.

In case of uniformly distributed load, the following values for w_{d1} may be used:

- for longitudinal stiffeners:

$$w_{d1} = \frac{pba^4}{384 \cdot 10^7 E I_X}$$

- for transverse stiffeners:

$$w_{d1} = \frac{5ap(n_S b)^4}{384 \cdot 10^7 E I_Y c_S^2}$$

c_f : Elastic support provided by the stiffener, in N/mm²:

- for longitudinal stiffeners:

$$c_{fX} = F_{KiX}\frac{\pi^2}{a^2}(1 + c_{PX})$$

with:

$$c_{PX} = \frac{1}{1 + \dfrac{0,91\left(\dfrac{12 \cdot 10^4 I_X}{t^3 b} - 1\right)}{c_{X\alpha}}}$$

$$c_{X\alpha} = \left(\frac{a}{2b} + \frac{2b}{a}\right)^2 \qquad \text{for} \quad a \ge 2b$$

$$c_{X\alpha} = \left[1 + \left(\frac{a}{2b}\right)^2\right]^2 \qquad \text{for} \quad a < 2b$$

- for transverse stiffeners:

$$c_{fY} = c_S F_{KiY}\frac{\pi^2}{(n_S b)^2}(1 + c_{PY})$$

with:

c_S : As defined hereafter for M_1

$$c_{PY} = \frac{1}{1 + \dfrac{0,91\left(\dfrac{12 \cdot 10^4 I_Y}{t^3 a} - 1\right)}{c_{Y\alpha}}}$$

$$c_{Y\alpha} = \left(\frac{n_S b}{2a} + \frac{2a}{n_S b}\right)^2 \qquad \text{for} \quad n_S b \ge 2a$$

$$c_{Y\alpha} = \left[1 + \left(\frac{n_S b}{2a}\right)^2\right]^2 \qquad \text{for} \quad n_S b < 2a$$

w_{St} : Net section modulus of stiffener (longitudinal or transverse), in cm³, including effective width of plating according to [3.1], taken equal to:

- if a lateral pressure is applied on the stiffener:

  w_{St} is the net section modulus calculated at flange if the lateral pressure is applied on the same side as the stiffener

  w_{St} is the net section modulus calculated at attached plate if the lateral pressure is applied on the side opposite to the stiffener

- if no lateral pressure is applied on the stiffener:

  w_{St} is the minimum net section modulus among those calculated at flange and attached plate

M_1 : Bending moment due to the lateral load p, in N.mm:

- for continuous longitudinal stiffeners:

$$M_1 = \frac{pba^2}{24 \cdot 10^3}$$

- for transverse stiffeners:

$$M_1 = \frac{pa(n_S b)^2}{c_S \cdot 8 \cdot 10^3}$$

c_S : Factor accounting for the boundary conditions of the transverse stiffener:

- for simply supported stiffeners: c_S = 1,0
- for partially constraint stiffeners: c_S = 2,0

p : Lateral load, in kN/m², defined in **[7.2.3]**, determined at the calculation point as defined in Ch 2, Sec 4, [6.1].

If no lateral load p is acting, the bending stress σ_b is to be calculated at the midpoint of the stiffener span for that fibre which results in the largest stress value.

If a lateral load p is acting, the stress calculation is to be carried out for both fibres of the stiffener's cross sectional area (if necessary for the bi-axial stress field at the plating side).

5.3 Stiffeners not subjected to lateral load

5.3.1 Longitudinal and transverse stiffeners not subjected to lateral load p have sufficient scantlings if their moments of inertia I_X and I_Y, in cm⁴, are not less than obtained by the following formulae:

$$I_X = \frac{p_{ZX} a^2}{\pi^2 10^4}\left(\frac{w_{d0X} h_W}{\frac{R_{eH}}{\Sigma} - \sigma_X} + \frac{a^2}{\pi^2 E}\right)$$

$$I_Y = \frac{p_{ZY}(n_S b)^2}{\pi^2 10^4}\left[\frac{w_{d0Y} h_W}{\frac{R_{eH}}{\Sigma} - \sigma_Y} + \frac{(n_S b)^2}{\pi^2 E}\right]$$

6 Buckling check of pillars

6.1 Compression axial load

6.1.1 Where pillars are in line, the compression axial load in a pillar is obtained, in kN, from the following formula:

$$F_A = A_D(p_S + \gamma_{W2} p_W) + \sum_{i=1}^{N} r_i(Q_{i,S} + \gamma_{W2} Q_{i,W})$$

where:

A_D : Area, in m², of the portion of the deck or platform supported by the pillar considered

r_i : Coefficient which depends on the relative position of each pillar above the one considered, to be taken equal to:

- $r_i = 0,9$ for the pillar immediately above that considered (i = 1)
- $r_i = 0,9^i$ for the i[th] pillar of the line above the pillar considered, to be taken not less than 0,478.

$Q_{i,S}$, $Q_{i,W}$: Still water and wave loads, respectively, in kN, from the i[th] pillar of the line above the pillar considered

p_S : Still water pressure, in kN/m², on the deck supported by the pillar, see Ch 3, Sec 4

p_W : Wave pressure, in kN/m², on the deck supported by the pillar, see Ch 3, Sec 4

γ_{W2} : Partial safety factor covering uncertainties regarding wave loads:

- $\gamma_{W2} = 1,0$ for **IN**
- $\gamma_{W2} = 1,2$ for **IN(x ≤ 2)**

6.2 Critical column buckling of pillars

6.2.1 Steel pillars

The critical column buckling stress of pillars is to be obtained, in N/mm2, from the following formulae:

$$\sigma_{cB} = \sigma_{E1} \quad \text{for} \quad \sigma_{E1} \le \frac{R_{eH}}{2}$$

$$\sigma_{cB} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_{E1}}\right) \quad \text{for} \quad \sigma_{E1} > \frac{R_{eH}}{2}$$

where:

σ_{E1} : Euler column buckling stress, to be obtained, in N/mm²: $\sigma_{E1} = \sigma_E$

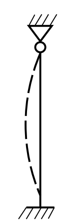
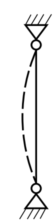
I : Minimum net moment of inertia, in cm⁴, of the pillar

A : Net cross-sectional area, in cm², of the pillar

ℓ : Span, in m, of the pillar

f : Coefficient, to be obtained from Tab 3.

Table 3 : Coefficient f

Boundary conditions of the pillar	Both ends fixed 	One end fixed, one end pinned 	Both ends pinned 
f	0,5	$\frac{\sqrt{2}}{2}$	1

6.2.2 Aluminium alloy pillars

The critical column buckling stress σ_{CB} of pillars made of aluminium alloy is to be obtained, in N/mm², from the following formula:

$$\sigma_{CB} = 2 R_{eH} \cdot C$$

where:

C : Coefficient to be taken equal to one of the following formulae or deduced from Fig 3:

- for alloys series5000:

$$\frac{1}{1 + \lambda_1 + \sqrt{(1+\lambda_1)^2 - 0,68 \cdot \lambda_1}}$$

- for alloys series 6000:

$$\frac{1}{1 + \lambda_1 + \sqrt{(1+\lambda_1)^2 - 3,2 \cdot \lambda_1}}$$

where:

$$\lambda_1 = \frac{R_{eH}}{\sigma_E}$$

6.3 Critical local buckling stress of built-up pillars

6.3.1 Steel pillars

The critical local buckling stress of built-up pillars is to be obtained, in N/mm², from the following formulae:

$$\sigma_{cL} = \sigma_{E3} \quad \text{for} \quad \sigma_{E3} \le \frac{R_{eH}}{2}$$

$$\sigma_{cL} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_{E3}}\right) \quad \text{for} \quad \sigma_{E3} > \frac{R_{eH}}{2}$$

where:

σ_{E3} : Euler local buckling stress, to be taken equal to the lesser of the values obtained, in N/mm², from the following formulae:

- $\sigma_{E3} = 78\left(\frac{t_W}{h_W}\right)^2 10^4$
- $\sigma_{E3} = 32\left(\frac{t_F}{b_F}\right)^2 10^4$

h_W : Web height of built-up section, in mm

t_W : Net web thickness of built-up section, in mm

b_F : Face plate width of built-up section, in mm

t_F : Net face plate thickness of built-up section, in mm.

6.3.2 Aluminium alloy pillars

The critical local buckling stress σ_{CL} of pillars made of aluminium alloy is to be obtained, in N/mm², from the following formula:

$\sigma_{CL} = 2\ R_{eH}\ C$

where:

C : Coefficient as defined in [6.2.2], with:

$$\lambda = \frac{R_{eH}}{\sigma_{Ei}}$$

σ_{Ei} : Euler local buckling stress, in N/mm², to be taken equal to:

for built up pillars, the lesser of:

$$\sigma_{Ei} = 78\left(\frac{E}{206000}\right)\left(\frac{t_W}{h_W}\right)^2 10^4$$

$$\sigma_{Ei} = 32\left(\frac{E}{206000}\right)\left(\frac{t_F}{b_F}\right)^2 10^4$$

where, t_W, t_F, h_W and b_F are defined in [6.3.1].

6.4 Critical local buckling stress of pillars having hollow rectangular section

6.4.1 Steel pillars

The critical local buckling stress of pillars having hollow rectangular section is to be obtained, in N/mm², from the following formulae:

$$\sigma_{cL} = \sigma_{E4} \quad \text{for} \quad \sigma_{E4} \le \frac{R_{eH}}{2}$$

$$\sigma_{cL} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_{E4}}\right) \quad \text{for} \quad \sigma_{E4} > \frac{R_{eH}}{2}$$

where:

σ_{E4} : Euler local buckling stress, to be taken equal to the lesser of the values obtained, in N/mm², from the following formulae:

- $\sigma_{E4} = 78\left(\frac{t_2}{b}\right)^2 10^4$
- $\sigma_{E4} = 78\left(\frac{t_1}{h}\right)^2 10^4$

b : Length, in mm, of the shorter side of the section

t_2 : Net web thickness, in mm, of the shorter side of the section

h : Length, in mm, of the longer side of the section

t_1 : Net web thickness, in mm, of the longer side of the section.

6.4.2 Aluminium alloy pillars

The critical local buckling stress σ_{CL} of pillars having hollow rectangular section made of aluminium alloy is to be obtained, in N/mm², from the following formula:

$\sigma_{CL} = 2\ R_{eH}\ C$

where:

C : Coefficient as defined in [6.2.2], with:

$$\lambda_1 = \frac{R_{eH}}{\sigma_{Ei}}$$

σ_{Ei} : Euler local buckling stress, in N/mm², to be taken equal to:

for built up pillars, the lesser of:

$$\sigma_{Ei} = 78\left(\frac{E}{206000}\right)\left(\frac{t_2}{h}\right)^2 10^4$$

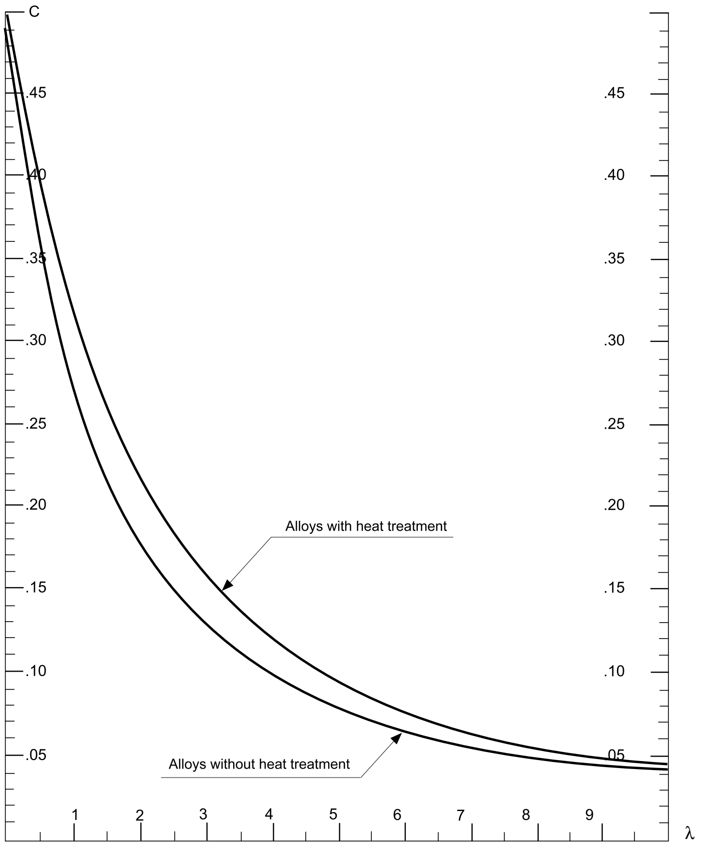
$$\sigma_{Ei} = 78\left(\frac{E}{206000}\right)\left(\frac{t_1}{b}\right)^2 10^4$$

where, t_W, t_F, h_W and b_F are defined in [6.4.1].

6.5 Checking criteria

6.5.1 The net scantlings of the pillar loaded by the compression axial stress F_A defined in [6.1.1] are to comply with the formulae in Tab 4.

Figure 3 : Coefficient C



7 Buckling and ultimate strength assessment - application guide

7.1 General application

7.1.1 Change of thickness within an elementary plate panel

If the plate thickness of an elementary plate panel varies over the width *b*, the buckling check may be performed for an equivalent elementary plate panel $a \times b_{eq}$ having a thickness equal to the smaller plate thickness t_1. The width of this equivalent elementary plate panel is defined by the following formula:

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

where:

ℓ_1 : Width of the part of the plate panel with the smaller net plate thickness t_1, in mm, as defined in Fig 4

ℓ_2 : Width of the part of the plate panel with the greater net plate thickness t_2, in mm, as defined in Fig 4.

7.1.2 Assessment of floors, transverses or other high girders with holes

The following procedure may be used to assess high girders with holes:

a) Divide the plate field in sub-elementary plate panels according to Fig 5

b) Assess the elementary plate panel and all sub-elementary plate panels separately with the following boundary conditions:
   - For sub-panels 1 to 4: all edges are simply supported (load cases 1 and 2 in Tab 1)
   - For sub-panels 5 to 6: simply supported, one side free (load case 3 in Tab 1).

7.2 Application to hull transverse section analysis

7.2.1 Membrane stresses

The membrane stresses to be considered for the buckling strength check of plating and ordinary stiffeners are obtained, in N/mm², from the following formula:

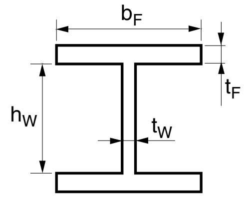
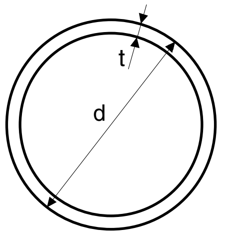
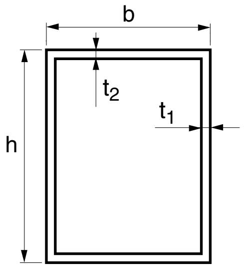
$$\sigma_{X1} = \sigma_{S1} + \gamma_{W1}(C_{FV}\sigma_{WV1} + C_{FH}\sigma_{WH})$$

where:

σ_{S1}, σ_{WV1}, σ_{WH} : Hull girder normal stresses, in N/mm², defined in Tab 7

C_{FV}, C_{FH} : Combination factors defined in Tab 5.

Table 4 : Buckling check of pillars subject to compression axial load

Pillar cross-section		Column buckling check	Local buckling check	Geometric condition
Built-up		$\frac{\sigma_{cB}}{\gamma_m \gamma_R} \geq 10 \frac{F_A}{A}$	$\frac{\sigma_{cL}}{\gamma_m \gamma_R} \geq 10 \frac{F_A}{A}$	• $\frac{b_F}{t_F} \leq 40$
Hollow tubular		$\frac{\sigma_{cB}}{\gamma_m \gamma_R} \geq 10 \frac{F_A}{A}$	Not required	• $\frac{d}{t} \leq 55$ • $t \geq 5{,}5$ mm
Hollow rectangular		$\frac{\sigma_{cB}}{\gamma_m \gamma_R} \geq 10 \frac{F_A}{A}$	$\frac{\sigma_{cL}}{\gamma_m \gamma_R} \geq 10 \frac{F_A}{A}$	• $\frac{b}{t_2} \leq 55$ • $\frac{h}{t_1} \leq 55$ • $t_1 \geq 5{,}5$ mm • $t_2 \geq 5{,}5$ mm

Note 1:

σ_{cB} : Critical column buckling stress, in N/mm^2, defined in [6.2.1]

σ_{cL} : Critical local buckling stress, in N/mm^2, defined in [6.3.1] for built-up section or in [6.4.1] for hollow rectangular section

γ_R : Partial safety factor covering uncertainties regarding resistance

- $\gamma_R = 1{,}15$ for column buckling
- $\gamma_R = 1{,}05$ for local buckling

γ_m : Partial safety factor covering uncertainties regarding material
$\gamma_m = 1{,}02$

F_A : Compression axial load in the pillar, in kN, defined in [6.1.1]

A : Net sectional area, in cm^2, of the pillar.

Figure 4 : Plate thickness change over the width b

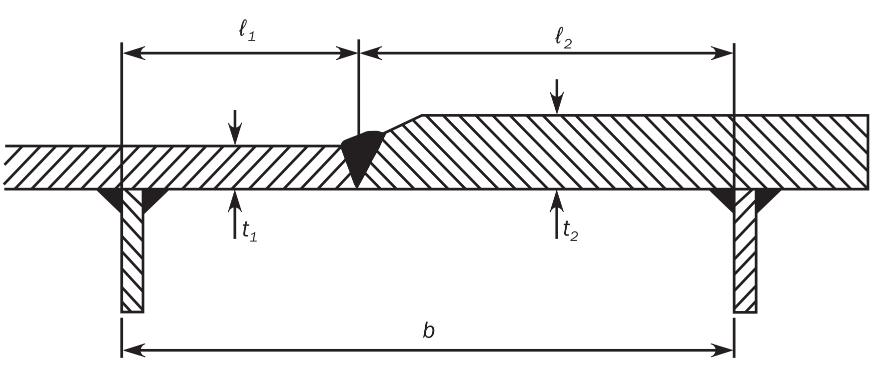


Figure 5 : Elementary plate panels of high girder with hole

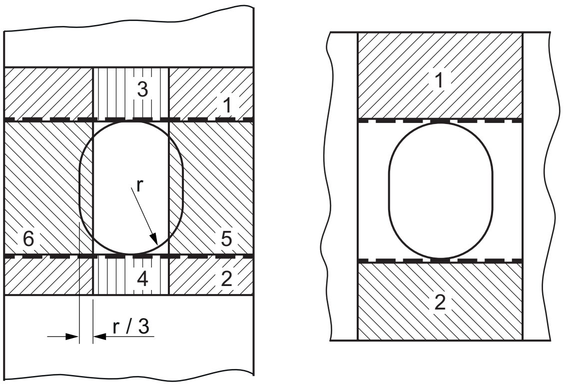


Table 5 : Combination factors C_{FV} and C_{FH}

Load case	Application	C_{FV}	C_{FH}
"a"	-	0	0
"b"	-	1,0	0
"c"	in general	0	0
	IN(1,2 < x ≤ 2)	0,4	1,0
"d"	in general	0	0
	IN(1,2 < x ≤ 2)	0,4	1,0
Flooding	-	0,6	0

7.2.2 Design lateral pressure

The design lateral pressure, p, to be used for hull scantling is defined in Tab 6.

7.2.3 Idealisation of elementary plate panel

The structural members at a considered hull transverse section are to be checked for buckling criteria under the stresses defined in [7.2.1], according to [2.1].

The determination of the buckling and reduction factors is made according to Tab 1 for the plane plate panel and Tab 2 for the curved plate panel.

For the determination of the buckling and reduction factors in Tab 1, the following cases are to be used according to the framing system:

- Buckling load case 1 for longitudinally framed plating, the membrane stress in x-direction σ_x being the hull girder normal stress σ_{x1} defined in [7.2.1]
- Buckling load case 2 for transversely framed plating, the membrane stress in y-direction σ_y being the hull girder normal stress σ_{x1} defined in [7.2.1], and the values of a and b exchanged to obtain α value greater than 1 as it is considered in load case 2.

7.2.4 Ordinary stiffeners

The buckling check of the longitudinal and transverse ordinary stiffeners of partial or total plate panels is to be performed under the loads in defined in [7.2.1] with:

- $\sigma_x = \sigma_{x1}$
- $\sigma_y = 0$

The effective width of the attached plating of the stiffeners is to be determined in accordance with [3]. A constant stress is to be assumed corresponding to the greater of the following values:

- stress at half length of the stiffener
- 0,5 of the maximum compressive stress of the adjacent elementary plate panels.

7.3 Additional application to FEM analysis

7.3.1 Non uniform compressive stresses along the length of the buckling panel

If compressive stresses are not uniform along the length of the unloaded plate edge (e.g. in case of girders subjected to bending), the compressive stress value is to be taken at a distance of b/2 from the transverse plate edge having the largest compressive stress (see Fig 6). This value is not to be less than the average value of the compressive stress along the longitudinal edge.

Table 6 : Design lateral pressure, p, in kN/m²

Structure	In service conditions	In testing conditions	In flooding conditions
Shell structure	p_E $p_C - p_{Em}$ $p_B - p_{Em}$	p_{ST} $p_{ST} - p_{SE}$ **(1)**	–
Deck structure	p_E **(2)** p_C p_B p_D	p_{ST}	–
Hatch coaming	$2 + p_{WD}$	–	–
Internal structure	p_C p_B	p_{ST}	p_{FL}
(1) Testing afloat **(2)** External deck pressure defined in Ch 3, Sec 4, [2.2.1]			

7.3.2 Buckling stress calculation of non rectangular elementary plate panels

a) Quadrilateral panels

According to Fig 7, rectangles that completely surround the irregular buckling panel are searched. Among several possibilities the rectangle with the smallest area is taken. This rectangle is shrunk to the area of the original panel, where the aspect ratio and the centre are maintained.This leads to the final rectangular panel with the dimensions a, b.

b) Trapezoidal elementary plate panel

A rectangle is derived with a being the mean value of the bases and b being the height of the original panel. See Fig 8.

c) Right triangle

The legs of the right triangle are reduced by $0{,}5^{1/2}$ to obtain a rectangle of same area and aspect ratio. See Fig 9.

d) General triangle

General triangle is treated according to a) above.

Table 7 : In-plane hull girder normal stresses

	Condition	σ_{S1} , in N/mm²	σ_{WV1} , in N/mm²	σ_{WH} , in N/mm²
Compressive stresses	$z \geq N$	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WH}}{I_Z}y\right\rvert 10^{-3}$
	$z < N$	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
Tensile stresses	$z \geq N$	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
	$z < N$	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	

Figure 6 : Non uniform compressive stress along longitudinal edge a

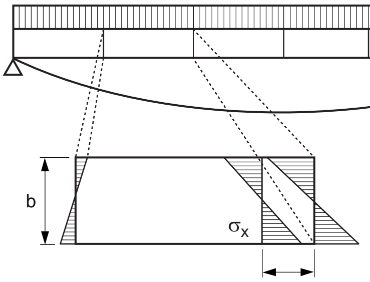


Figure 7 : Approximation of non rectangular elementary plate panels

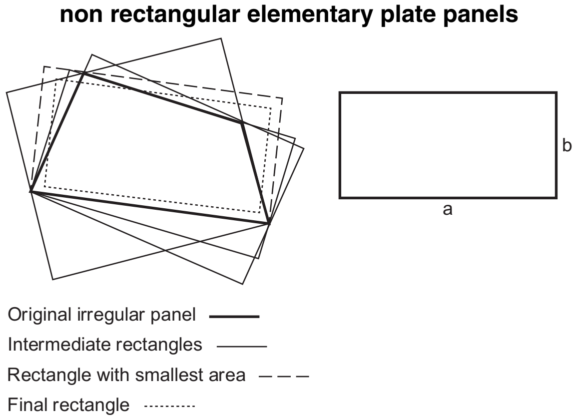


Figure 8 : Approximation of trapezoidal elementary plate panel

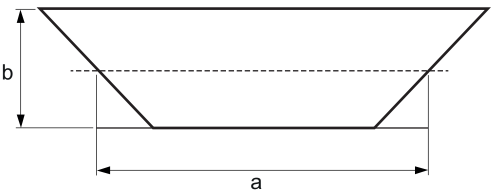
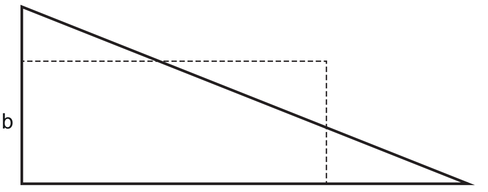


Figure 9 : Approximation of right triangle



7.3.3 Buckling assessment of side shell plates

In order to assess the buckling criteria for vertically stiffened side shell plating, the following cases have to be considered.

In case vertical and shear stresses are approximately constant along the height of the elementary plate panel:

- Buckling load cases 1, 2 and 5, according to Tab 1
- $\psi = f(\sigma_1, \sigma_2)$ for horizontal stresses
- $\psi = 1$ for vertical stresses
- $t = t_{min}$(elementary plate panel)

In case of distributed horizontal, vertical and shear stresses along the height of the elementary plate panel, the following stress situations are to be considered separately:

a) Pure vertical stress

- The size of buckling field to be considered is b times b ($\alpha = 1$)
- $\psi = 1$
- The maximum vertical stress in the elementary plate panel is to be considered in applying the criteria.

b) Shear stress associated to vertical stress

- The size of buckling field to be considered is 2b times b ($\alpha = 2$)
- $\psi = 1$
- The following stress combinations are to be considered:
  - The maximum vertical stress in the elementary plate panel plus the shear stress and longitudinal stress at the location where maximum vertical stress occurs
  - The maximum shear stress in the elementary plate panel plus the vertical stress and longitudinal stress at the location where maximum shear stress occurs
- The plate thickness t to be considered is the one at the location where the maximum vertical/shear stress occurs

c) Distributed longitudinal stress associated with vertical and shear stress
   - The actual size of the elementary plate panel is to be used (α = f(a, b))
   - The actual edge factor ψ for longitudinal stress is to be used
   - The average values for vertical stress and shear stress are to be used
   - $t = t_{min}$(elementary plate panel)

7.3.4 Buckling assessment of corrugated bulkheads

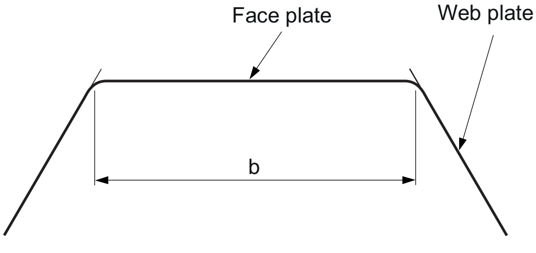
The transverse elementary plate panel (face plate) is to be assessed using the normal stress parallel to the corrugation. The slanted elementary plate panel (web plate) is to be assessed using the combination of normal and shear stresses.

The plate panel breadth b is to be measured according to Fig 10.

a) Face plate assessment
   - The buckling load case 1, according to Tab 1
   - The size of buckling field to be considered is b times b (α = 1)
   - ψ = 1
   - The maximum vertical stress in the elementary plate panel is to be considered in applying the criteria.
   - The plate thickness t to be considered is the one at the location where the maximum vertical stress occurs

b) Web plate assessment
   - The buckling load case 1 and 5, according to Tab 1
   - The size of buckling field to be considered is 2b times b (α = 2)
   - ψ = 1
   - The following two stress combinations are to be considered:
     - The maximum vertical stress in the elementary plate panel plus the shear stress and longitudinal stress at the location where maximum vertical stress occurs
     - The maximum shear stress in the elementary plate panel plus the vertical stress and longitudinal stress at the location where maximum shear stress occurs
   - The plate thickness t to be considered is the one at the location where the maximum vertical/shear stress occurs

Figure 10 : Measuring b of corrugated bulkheads



SECTION 8 DIRECT CALCULATION

Symbols

k : Material factor defined in Ch 2, Sec 3, [2.3], for steel and Ch 2, Sec 3, [3.5], for aluminium alloys

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

1 General

1.1 Application

1.1.1 The requirements of this Section give direct calculation guidance related to:

- yielding and buckling checks of structural members
- calculation of fillet welds.

Direct calculation may be adopted instead of Rule scantling formulae or for the analysis of structural items not covered by the Rules.

2 Strength check of structural members

2.1 General

2.1.1 Net scantlings

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

The gross scantlings are obtained as specified in Ch 2, Sec 5, [2].

2.1.2 Partial safety factors

The partial safety factors covering uncertainties regarding wave hull girder loads (γ_{W1}), wave local loads (γ_{W2}), material (γm) and resistance (γ_R) to be considered for checking structural members are specified in:

- Tab 1 for analyses based on isolated beam models
- Tab 2 for analyses based on three dimensional models.

2.1.3 Yielding check

The yielding check is to be carried out according to:

- [2.3] for structural members analysed through isolated beam models
- [2.4] for structural members analysed through three dimensional beam or finite element models.

2.1.4 Buckling check

The buckling check is to be carried out according to Ch 2, Sec 7, on the basis of the stresses in primary supporting members calculated according to [2.3] or [2.4], depending on the structural model adopted.

2.2 Analysis documentation

2.2.1 The following documents are to be submitted to the Society for review of the three dimensional beam or finite element structural analyses:

- reference to the calculation program used with identification of the version number and results of the validation test, if the results of the program have not been already submitted to the Society approval
- extent of the model, element types and properties, material properties and boundary conditions
- loads given in print-out or suitable electronic format. In particular, the method used to take into account the interaction between the overall, primary and local loadings is to be described. The direction and intensity of pressure loads, concentrated loads, inertia and weight loads are to be provided
- stresses given in print-out or suitable electronic format
- buckling checks
- identification of the critical areas, where the results of the checkings exceed 97,5% of the permissible rule criteria in [2.4.4] and Ch 2, Sec 7.

2.2.2 According to the results of the submitted calculations, the Society may request additional runs of the model with structural modifications or local mesh refinements in highly stressed areas.

Table 1 : Primary supporting members analysed through isolated beam models - Partial safety factors

Limit state	Condition	γ_{W1} **(3)**	γ_{W2} **(3)**	γ_R	γ_m
Yielding check	General	1,15	1,20	1,02 **(1)**	1,02
	Bottom and side girders **(4)**	1,15	1,20	1,15	1,02
	Flooding	1,15	1,20	1,02 **(2)**	1,02
	Testing	NA	NA	1,02	1,02
Buckling check	Pillars column buckling	1,15	1,20	1,15	1,02
	Pillars local buckling	1,15	1,20	1,05	1,02

(1) For primary supporting members of the fore peak and aft peak structures, γ_R =1,60.
(2) For primary supporting members of the collision bulkhead, γ_R =1,25.
(3) For range of navigation **IN**, $\gamma_{W1} = \gamma_{W2}$ = 1,00
(4) Includes bottom girders, bottom transverses, reinforced floors, side stringers, side transverses and web frames.
Note 1: NA = not applicable.

Table 2 : Primary supporting members analysed through three dimensional models - Partial safety factors

Limit state	Condition	γ_{W1} **(2)**	γ_{W2} **(2)**	γ_R	γ_m
Yielding check	General	1,05	1,10	See Tab 3	1,02
	Flooding **(1)**	1,05	1,10		1,02
	Testing	NA	NA	1,02	1,02
Buckling check	Pillars: column buckling	1,05	1,10	1,15	1,02
	Pillars: local buckling	1,05	1,10	1,05	1,02

(1) Applies only to primary supporting members to be checked in flooding conditions.
(2) For range of navigation **IN**, $\gamma_{W1} = \gamma_{W2}$ = 1,00

Table 3 : Primary supporting members analysed through three dimensional model Resistance partial safety factor γ_R

Calculation model	Yielding check	
	General	Flooding condition
Beam	1,20	1,02
Coarse mesh finite element	1,20	1,02
Fine mesh and standard finite element	1,05	1,02

2.3 Yielding check of structural members analysed through an isolated beam structural model

2.3.1 General

The requirements of this Sub-article apply to the yielding check of structural members subjected to lateral pressure or to wheeled loads and, for those contributing to the hull girder longitudinal strength, to hull girder normal stresses, which may be analysed through an isolated beam model.

The yielding check is also to be carried out for structural members subjected to specific loads, such as concentrated loads.

2.3.2 Load point

Unless otherwise specified, lateral pressure is to be calculated at mid-span of the structural member considered.

For longitudinal structural members contributing to the hull girder longitudinal strength, the hull girder normal stresses are to be calculated in way of the neutral axis of the structural member with attached plating.

2.3.3 Load model

The structural members are to be checked under the combination of loads defined in Part B, Chapter 3.

The external pressure and the pressures induced by the various types of cargoes and ballast are to be considered, depending on the location of the structural member under consideration and the type of compartments adjacent to it, in accordance with Ch 3, Sec 4.

The pressure load in service conditions is to be determined according to Ch 3, Sec 4, [2] and Ch 3, Sec 4, [3].

For structural members subjected to wheeled loads, the yielding check may be carried out according to [2.3.4] considering uniform pressures equivalent to the distribution of vertical concentrated forces, when such forces are closely located, taking into account the most unfavourable case.

2.3.4 Checking criteria

It is to be checked that the normal stress, the shear stress and the Von Mises equivalent stress are in compliance with the following conditions:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0{,}5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma_{VM}$$

where:

σ : Normal stress, in N/mm², in the direction of the structural member axis

τ : Shear stress, in N/mm², in the direction of the local loads applied to the structural member.

σ_{VM} : Von Mises equivalent stress, in N/mm²

$$\sigma_{VM} = \sqrt{\sigma^2 + 3\tau^2}$$

2.4 Yielding check of structural members analysed through a three dimensional structural model

2.4.1 General

The requirements of this Sub-article apply to the yielding check of structural members subjected to lateral pressure or to wheeled loads and, for those contributing to the hull girder longitudinal strength, to hull girder normal stresses, which are to be analysed through a three dimensional structural model.

The yielding check is also to be carried out for structural members subjected to specific loads, such as concentrated loads.

2.4.2 Analysis criteria

The analysis of structural members based on three dimensional models is to be carried out according to the requirements in:

- Ch 2, App 1 for structural members subjected to lateral pressure
- Ch 2, App 2 for structural members subjected to wheeled loads.

These requirements apply for:

- the structural modelling
- the load modelling
- the stress calculation.

2.4.3 Checking criteria for beam model analyses

For beam model analyses, according to Ch 2, App 1, [3.5], it is to be checked that the equivalent stress σ_{VM}, in N/mm², calculated according to Ch 2, App 1, [5.2] is in compliance with the following formula:

$$\sigma_{VM} \leq \frac{R_y}{\gamma_R \gamma_m}$$

where the partial safety factors are to be taken as given in **Ch 2, Sec 5, [2.4].**

2.4.4 Checking criteria for finite element model analyses

a) Master allowable stress

The master allowable stress, σ_{MASTER}, in N/mm², is to be obtained from the following formula:

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

b) General

For all types of analysis (see Ch 2, App 1, [3.4]), it is to be checked that the equivalent Von Mises stress σ_{VM}, calculated according to Ch 2, App 1, [5] is in compliance with the following formula:

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

c) Structural detail analysis based on very fine mesh finite elements models

In a fine mesh model as defined in Ch 2, App 1, [3.4.4], high stress areas for which σ_{VM} exceeds 0,95 σ_{MASTER} are to be investigated through a very fine mesh structural detail analysis according to Ch 2, App 1, [3.4.4], and the both following criteria are to be checked:

- the average Von Mises equivalent stress σ_{VM-av} as defined in item d) here below is to comply with the following formula:

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

- the equivalent stress σ_{VM} of each element is to comply with the following formulae:
  - for elements not adjacent to the weld:

    $$\sigma_{VM} \leq 1{,}53\,\sigma_{MASTER}$$

  - for elements adjacent to the weld:

    $$\sigma_{VM} \leq 1{,}34\,\sigma_{MASTER}$$

  In the case of mesh finer than (50 mm x 50 mm), the equivalent stress σ_{VM} is to be obtained by averaging over an equivalent area of (50 mm x 50 mm), based on the methodology given in item d).

d) Stress averaging on very fine mesh

The average Von Mises equivalent stress σ_{VM-av}, in N/mm², is to be obtained from the following formula:

$$\sigma_{VM-av} = \frac{\sum_{1}^{n} A_i \sigma_{VM-i}}{\sum_{1}^{n} A_i}$$

where:

σ_{VM-i} : Von Mises stress at the centre of the i-th element within the considered area, in N/mm²

A_i : Area of the i-th element within the considered area, in mm²

n : Number of elements within the considered area.

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 very 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 greater than the relevant spacing of ordinary stiffeners (see Fig 1 and Fig 2)
- 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.

e) Particular requirements

For very 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 the second bullet point of item d).

Other structural details having shapes not allowing the stress averaging as required in item d) are to be specially considered by the Society, on a case by case basis.

Figure 1 : Example of stress averaging area at opening rounded edge

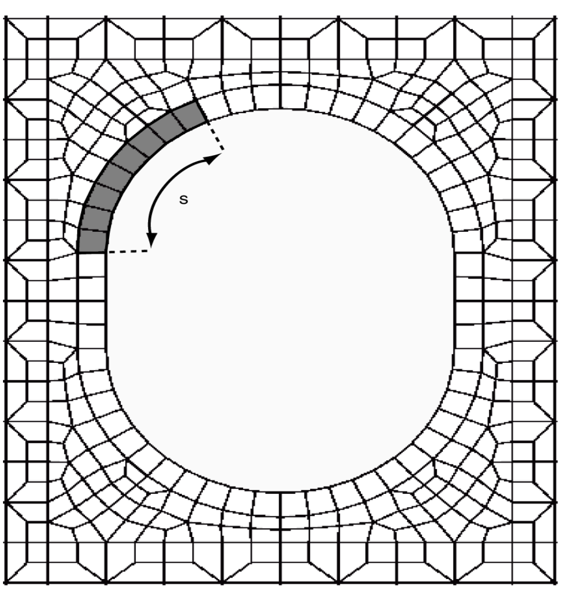
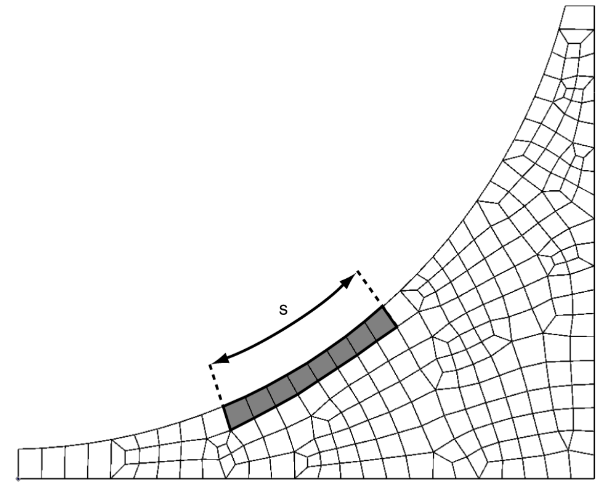


Figure 2 : Example of stress averaging area at rounded bracket edge



3 Calculation of fillet welds

3.1 General

3.1.1 As an alternative to the determination of the necessary fillet weld throat thicknesses in accordance with Ch 8, Sec 2, [2.3], a mathematical calculation may be performed, e.g. in order to optimize the weld thicknesses in relation to the loads. This Article describes general stress analysis for mainly static loads. For welded joints subjected to loads dynamic in character, e.g. those at the shell connection of single-strut shaft brackets, proof of fatigue strength in compliance with the Society's Rules is to be submitted where necessary.

3.1.2 Definition

For the purposes of calculation, the following stresses in a fillet weld are defined (see also Fig 3):

$\sigma_\perp$: Normal stress perpendicular to direction of seam

$\tau_\perp$: Shear stress perpendicular to direction of seam

τ_{II} : Shear stress parallel to direction of seam.

Normal stresses parallel to the seam are disregarded in the calculation.

The calculated weld seam area is $(a \cdot \ell)$.

For reasons of equilibrium, for the flank of the weld lying vertically to the shaded calculated weld seam area:

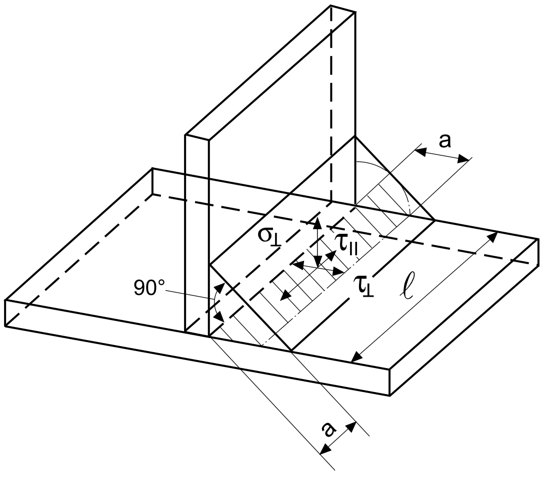
$\tau_\perp = \sigma_\perp$

For a composite stress the equivalent stress is to be calculated by the following formula:

$$\sigma_V = \sqrt{\sigma^2_\perp + \tau^2_\perp + \tau^2_{II}}$$

Fillet welds are to be so dimensioned that the stresses determined by the formulae do not exceed the permissible stresses stated in Tab 4.

Figure 3 : Definition



3.2 Fillet welds stressed by normal and shear forces

3.2.1 Flank and frontal welds are regarded as being equal for the purposes of stress analysis. In view of this, normal and shear stresses, in N/mm², are calculated as follows:

$$\sigma = \tau = \frac{P}{\Sigma a \ell}$$

where:

a, ℓ : Thickness and length, in mm, of the fillet weld

P : Force acting on the weld joint, in N.

- for a joint as shown in Fig 4, this produces:

  Stresses in frontal fillet welds, in N/mm²:

$$\tau_{\perp} = \frac{P_1}{2a(\ell_1 + \ell_2)}$$

$$\tau_{II} = \frac{P_2}{2a(\ell_1 + \ell_2)} \pm \frac{P_2 e}{2aF_t}$$

  Stresses in flank fillet welds:

$$\tau_{\perp} = \frac{P_2}{2a(\ell_1 + \ell_2)}$$

$$\tau_{II} = \frac{P_1}{2a(\ell_1 + \ell_2)} \pm \frac{P_2 e}{2aF_t}$$

  Equivalent stresses for frontal and flank fillet welds:

$$\sigma_V = \sqrt{\sigma^2{}_{\perp} + \tau^2{}_{II}} \leq \sigma_{Vzul}$$

  where:

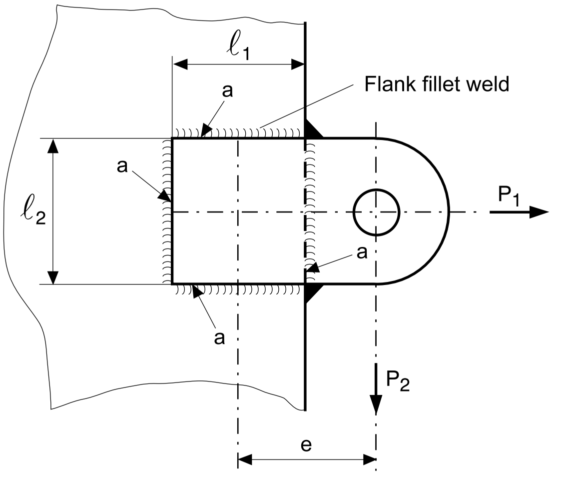
  F_t : Parameter, in mm², equal to:

  $F_t = (\ell_2 + a)(\ell_1 + a)$.

  P_1, P_2 : Forces, in N

  a_1, ℓ_1, ℓ_2 : Weld joint dimensions, in mm.

Figure 4 : Fillet welds stressed by normal and shear forces



- for a joint as shown in Fig 5, this produces:

$$\tau_{\perp} = \frac{P_2}{2a\ell} + \frac{3P_1 e}{a\ell^2}$$

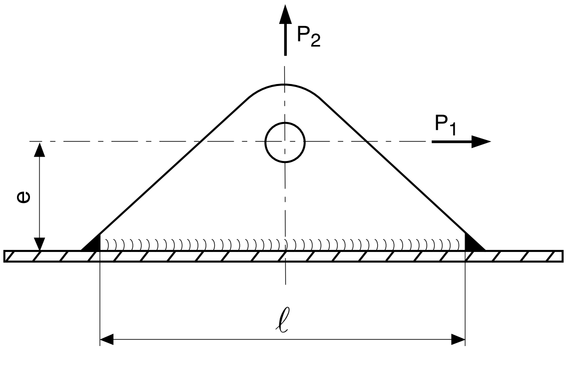
$$\tau_{II} = \frac{P_1}{2a\ell}$$

  Equivalent stress:

$$\sigma_V = \sqrt{\sigma^2{}_{\perp} + \tau^2{}_{II}} \leq \sigma_{Vzul}$$

where σ_{Vzul} is given in Tab 4.

Figure 5 : Fillet welds stressed by normal and shear forces



3.3 Fillet welds stressed by bending moments and shear forces

3.3.1 The stresses at the fixing point of a girder (a cantilever beam is given as an example in Fig 6) are calculated as follows:

a) Normal stress due to bending, in N/mm²:

$$\sigma_{\perp}(z) = \frac{M}{J_S} z$$

$$\sigma_{\perp max} = \frac{M}{J_S} e_u \text{ for } e_u > e_0$$

$$\sigma_{\perp max} = \frac{M}{J_S} e_0 \text{ for } e_u < e_0$$

b) Shear stress due to shear force, in N/mm²:

$$\tau_{II}(z) = \frac{QS_{S(z)}}{10 J_S \sum a}$$

$$\tau_{II}(z) = \frac{QS_{S(z)}}{10 J_S \cdot 2a}$$

c) Equivalent stress:

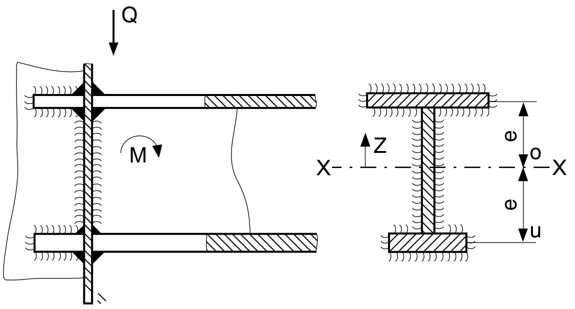
It has to be proved that neither $\tau_{\perp max}$ in the region of the flange nor $\tau_{II max}$ in the region of the neutral axis nor the equivalent stress σ_V exceed the permitted limits given in Tab 4 at any given point. The equivalent stress σ_V should always be calculated at the web-flange connection.

$$\sigma_V = \sqrt{\sigma^2_{\perp} + \tau^2_{II}}$$

where:

- M : Bending moment in way of the welded joint, in N·m
- Q : Shear force at the point of the welded joint, in N
- J_S : Moment of inertia of the welded joint relative to the x-axis, in cm⁴
- $S_{S(z)}$: First moment of the connected weld section at the point under consideration, in cm³
- z : Distance from the neutral axis, in cm.

Figure 6 : Fillet welds stressed by bending moments and shear forces



3.4 Fillet welds stressed by bending and torsional moments and shear forces

3.4.1 For the normal and shear stresses, in N/mm², resulting from bending, see [3.3]. Torsional stresses resulting from the torsional moment M_T are to be calculated as follows:

$$\tau_T = \frac{M_T \cdot 10^3}{2 a_m A_m}$$

where:

- M_T : Torsional moment, in N.m
- a_m : Mean fillet weld throat thickness, in mm
- A_m : Mean area enclosed by weld seam, in mm².

The equivalent stress composed of all three components (bending, shear and torsion) is calculated by the following formulae:

- where τ_{II} and $\tau_{\perp}$ do not have the same direction:

$$\sigma_V = \sqrt{\sigma^2_{\perp} + \tau^2_{\perp} + \tau^2_{II}}$$

- where τ_{II} and $\tau_{\perp}$ have the same direction:

$$\sigma_V = \sqrt{\sigma^2_{\perp} + (\tau_{\perp} + \tau_{II})^2}$$

3.5 Continuous fillet welded joints between web and flange of bending girders

3.5.1 The stress analysis has to be performed in the area of maximum shear forces.

In the case of continuous double fillet weld connections, the shear stress, in N/mm², is to be calculated as follows:

$$\tau_{II} = \frac{QS}{10J \cdot 2a}$$

where:

- Q : Shear force at the point considered, in N
- S : First moment of the cross sectional area of the flange connected by the weld to the web in relation to the neutral beam axis, in cm³
- J : Moment of inertia of the girder section, in cm⁴
- a : Thickness of the fillet weld, in mm.

The fillet weld thickness required, in mm, is:

$$a_{erf} = \frac{QS}{10J \cdot 2\tau_{zul}}$$

3.6 Intermittent fillet welded joints between web and flange of bending girders

3.6.1 The shear stress, in N/mm², is to be calculated as follows (see Fig 7):

$$\tau_{II} = \frac{QS\alpha}{10J \cdot 2a} \cdot \frac{b}{\ell}$$

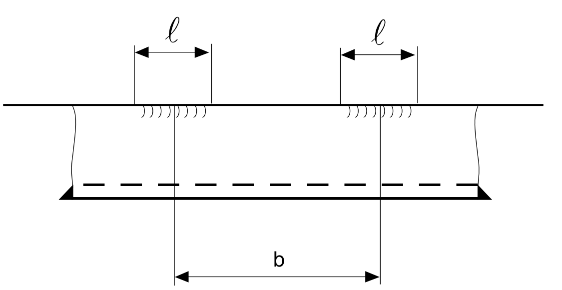
where:

- ℓ : Length of the fillet weld
- b : Interval
- α : Stress concentration factor which takes into account increases in shear stress at the ends of the lengths of fillet weld seam ℓ: $\alpha = 1,1$

The fillet weld thickness required, in mm, is:

$$a_{erf} = \frac{1,1QS}{10J \cdot 2\tau_{zul}} \cdot \frac{b}{\ell}$$

Figure 7 : Intermittent fillet welded joints between web and flange of bending girders



3.7 Fillet weld connections on overlapped profile joints

3.7.1 Profiles joined by means of two flank fillet welds (see Fig 8):

$$\tau_{\perp} = \frac{Q}{2ad}$$

$$\tau_{II} = \frac{M \cdot 10^3}{2acd}$$

The equivalent stress is:

$$\sigma_V = \sqrt{\tau^2{}_{\perp} + \tau^2{}_{II}}$$

where:

Q : Shear force to be transmitted, in N

M : Bending moment to be transmitted, in N.m

c, d, ℓ_1, ℓ_2, r: Dimensions, in mm, defined in Fig 8

$$c = r + \frac{(3\ell_1 - \ell_2)}{4}$$

As the influence of the shear force can generally be neglected, the required fillet weld thickness, in mm, is:

$$a_{erf} = \frac{M \cdot 10^3}{2cd\tau_{zul}}$$

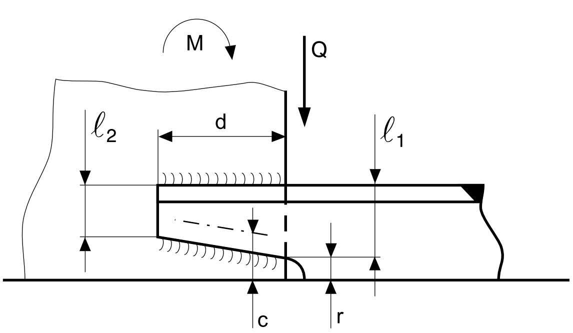
or

$$a_{erf} = \frac{w \cdot 10^3}{1,5cd}$$

where:

w : Section modulus of the joined profile, in cm^3.

Figure 8 : Fillet weld connections on overlapped profile joints: case a



3.7.2 Profiles joined by means of two flank and two front fillet welds (all-round welding as shown in Fig 9):

$$\tau_{\perp} = \frac{Q}{a(2d + \ell_1 + \ell_2)}$$

$$\tau_{II} = \frac{M \cdot 10^3}{ac(2d + \ell_1 + \ell_2)}$$

The equivalent stress is:

- where τ_{II} and $\tau_{\perp}$ do not have the same direction:

$$\sigma_V = \sqrt{\tau^2{}_{\perp} + \tau^2_{II}}$$

- where τ_{II} and $\tau_{\perp}$ have the same direction:

$$\sigma_V = \tau_{\perp} + \tau_{II}$$

As the influence of the shear force can generally be neglected, the required fillet weld thickness, in mm, is:

$$a_{erf} = \frac{M10^3}{2cd\left(1 + \frac{\ell_1 + \ell_2}{2d}\right)\tau_{zul}}$$

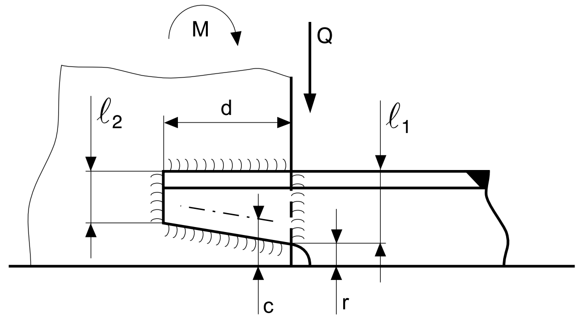
or

$$a_{erf} = \frac{W10^3}{1,5cd\left(1 + \frac{\ell_1 + \ell_2}{2d}\right)}$$

where:

c, d, ℓ_1, ℓ_2, r: Dimensions, in mm, defined in Fig 9.

Figure 9 : Fillet weld connections on overlapped profile joints: case b



3.8 Bracket joints

3.8.1 Where profiles are joined to brackets as shown in Fig 10, the average shear stress, in N/mm^2, is:

$$\tau = \frac{3M \cdot 10^3}{4ad^2} + \frac{Q}{4ad}$$

where:

M : Moment of constraint, in N.m

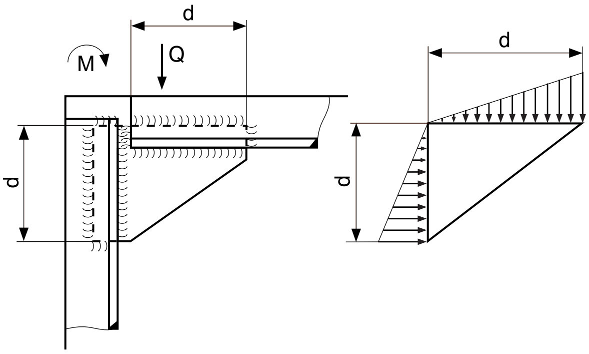
Q : Shear force, in N

d : Length of overlap, in mm.

The required fillet weld thickness, in mm, is to be calculated from the section modulus of the profile, w, as follows:

$$a_{erf} = \frac{w \cdot 10^3}{d^2}$$

Figure 10 : Bracket joint with idealized stress distribution resulting from moment M and shear Q



3.9 Admissible stresses

3.9.1 Both, the individual and the reference stresses calculated in accordance with the formulae in [3.1.2] and [3.2] to [3.8], must not exceed the admissible stresses as indicated in Tab 4 for various materials mainly exposed to static loading. The values stated for high tensile steels, stainless austenitic steels and aluminium alloys are applicable only if the strength properties of the weld material employed are at least equal to those of the base material. Where this is not the case, the "a"-values calculated are to be increased accordingly.

Table 4 : Permissible stresses in fillet welded joint

Material		R_{eH} or $R_{p0,2}$ (N/mm²)	Equivalent stress, shear stress $\sigma_{V\,zul}$, τ_{zul} (N/mm²)
Normal hull structural steel	A, B, D **(1)**	235	115
Higher tensile hull structural steel	AH 32 / DH 32 AH 36 / DH 36 **(2)**	315 355	145 160
High tensile steel	St E 460 St E 690	460 685	200 290
Austenitic stainless steels	1.4306/304L 1.4404/316L 1.4435/316L 1.4438/317L 1.4541/321 1.4571/316 Ti	180 190 190 195 205 215	110
Aluminium alloys	Al Mg 3 Al Mg 4,5 Al Mg Si 0,5 Al Mg Si 1	80 **(3)** 125 **(3)** 65 **(4)** 11 **(4)**	35 **(5)** 56 **(6)** 30 **(7)** 45 **(8)**

(1) Also applies to structural steel S 235 JR according to EN 10025-2, rimming steel not permitted
(2) Also applies to structural steel S 355 J2 according to EN 10025-2
(3) Plates, soft condition
(4) Profiles, cold hardened
(5) Welding consumables: S-Al Mg 3, S-Al Mg 5 or S-Al Mg 4,5 Mn
(6) Welding consumables: S-Al Mg 4,5 Mn
(7) Welding consumables: S-Al Mg 3, S-Al Mg 5, S-Al Mg 4,5 Mn or SAl Si 5
(8) Welding consumables: S-Al Mg 5 or S-Al Mg 5, S-Al Mg 4,5 Mn.

APPENDIX 1 ANALYSES BASED ON THREE DIMENSIONAL MODELS

1 General

1.1 Application

1.1.1 The requirements of this Appendix apply to the analysis criteria, structural modeling, load modeling and stress calculation of primary supporting members which are to be analysed through three dimensional structural models, according to Ch 2, Sec 8, [2.3].

1.1.2 This Appendix deals with that part of the structural analysis which aims at calculating the stresses in the primary supporting members in the midship area and, when necessary, in other areas, which are to be used in the yielding and buckling check.

1.1.3 The strength checks of primary supporting members are to be carried out according to:

- Ch 2, Sec 8, [2.4], for yielding
- Ch 2, Sec 7, for buckling, using the procedure defined in [6] for panel stresses calculation.

2 Analysis criteria

2.1 General

2.1.1 All primary supporting members in the midship regions are normally to be included in the three dimensional model, with the purpose of calculating their stress level and verifying their scantlings.

When the primary supporting member arrangement is such that the Society can accept that the results obtained for the midship region are extrapolated to other regions, no additional analyses are required. Otherwise, analyses of the other regions are to be carried out.

2.2 Finite element model analyses

2.2.1 The analysis of primary supporting members is to be carried out on fine mesh models, as defined in [3.4.4].

2.2.2 Areas which appear, from the primary supporting member analysis, to be highly stressed may be required to be further analysed through appropriately meshed structural models, as defined in [3.4.4].

2.3 Beam model analyses

2.3.1 Beam models may be adopted provided that:

- primary supporting members are not so stout that the beam theory is deemed inapplicable by the Society
- their behaviour is not substantially influenced by the transmission of shear stresses through the shell plating.

In any case, finite element models are to be adopted when deemed necessary by the Society on the basis of the vessel's structural arrangement.

3 Primary supporting members structural modeling

3.1 Model construction

3.1.1 Elements

The structural model is to represent the primary supporting members with the plating to which they are connected.

Ordinary stiffeners are also to be represented in the model in order to reproduce the stiffness and inertia of the actual hull girder structure. The way ordinary stiffeners are represented in the model depends on the type of model (beam or finite element), as specified in [3.4] and [3.5].

3.1.2 Net scantlings

All the elements in [3.1.1] are to be modeled with their net scantlings according to Ch 2, Sec 5, [2]. Therefore, also the hull girder stiffness and inertia to be reproduced by the model are those obtained considering the net scantlings of the hull structures.

3.2 Model extension

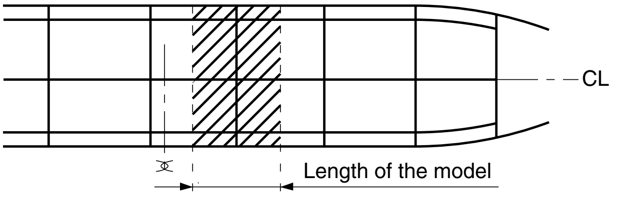
3.2.1 The longitudinal extension of the structural model is to be such that:

- the hull girder stresses in the area to be analysed are properly taken into account in the structural analysis
- the results in the areas to be analysed are not influenced by the unavoidable inaccuracy in the modeling of the boundary conditions.

3.2.2 The model may be limited to one cargo tank/hold length (one half cargo tank/hold length on either side of the transverse bulkhead; see Fig 1).

However, larger models may need to be adopted when deemed necessary by the Society on the basis of the vessel's structural arrangement.

Figure 1 : Model longitudinal extension



3.2.3 In the case of structural symmetry with respect to the vessel's centreline longitudinal plane, the hull structures may be modeled over half the vessel's breadth.

3.3 Finite element modeling criteria

3.3.1 Modelling of primary supporting members

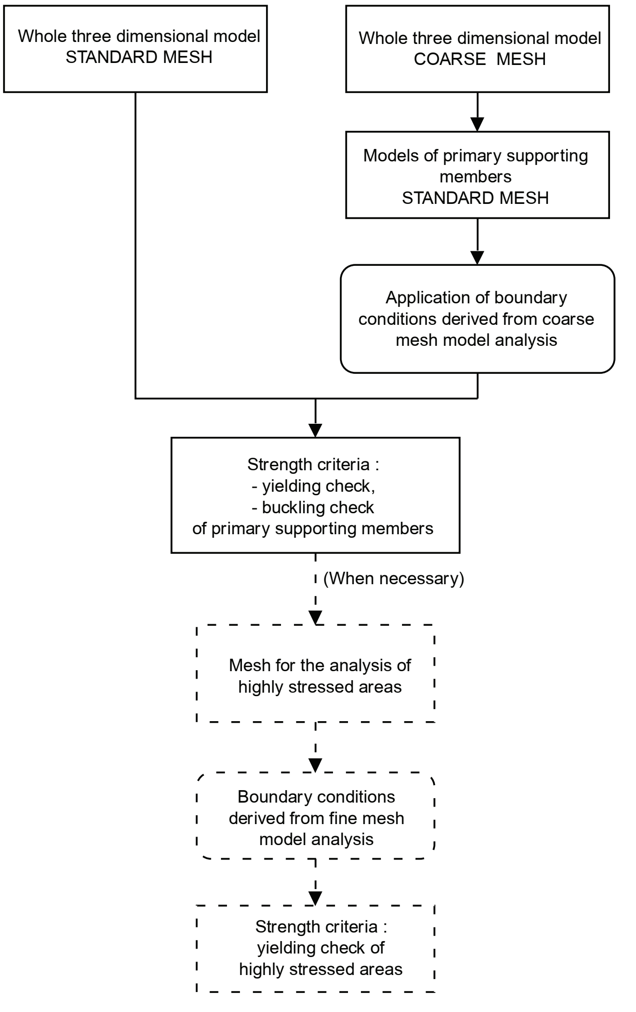
The analysis of primary supporting members based on fine mesh models, as defined in [3.4.4], is to be carried out by applying one of the following procedures (see Fig 2), depending on the computer resources:

- an analysis of the whole three dimensional model based on a fine mesh
- an analysis of the whole three dimensional model based on a coarse mesh, as defined in [3.4.2], from which the nodal displacements or forces are obtained to be used as boundary conditions for analyses based on fine mesh models of primary supporting members, e.g.:
  - transverse rings
  - double bottom girders
  - side girders
  - deck girders
  - primary supporting members of transverse bulkheads
  - primary supporting members which appear from the analysis of the whole model to be highly stressed.

3.3.2 Modeling of the most highly stressed areas

The areas which appear from the analyses based on fine mesh models to be highly stressed may be required to be further analysed, using the mesh accuracy specified in [3.4.4].

Figure 2 : Finite element modeling criteria



3.4 Finite element models

3.4.1 General

Finite element models are generally to be based on linear assumptions. The mesh is to be executed using membrane or shell elements, with or without mid-side nodes.

Meshing is to be carried out following uniformity criteria among the different elements.

Most of quadrilateral elements are to be such that the ratio between the longer side length and the shorter side length does not exceed 2. Some of them may have a ratio not exceeding 4.Their angles are to be greater than 60° and less than 120°. The triangular element angles are to be greater than 30° and less than 120°.

Further modeling criteria depend on the accuracy level of the mesh, as specified in [3.4.2] to [3.4.4].

3.4.2 Coarse mesh

The number of nodes and elements is to be such that the stiffness and inertia of the model properly represent those of the actual hull girder structure, and the distribution of loads among the various load carrying members is correctly taken into account.

To this end, the structural model is to be built on the basis of the following criteria:

- ordinary stiffeners contributing to the hull girder longitudinal strength and which are not individually represented in the model are to be modeled by rod elements and grouped at regular intervals
- webs of primary supporting members may be modeled with only one element on their height
- face plates may be simulated with bars having the same cross-section
- the plating between two primary supporting members may be modeled with one element stripe
- holes for the passage of ordinary stiffeners or small pipes may be disregarded
- manholes (and similar discontinuities) in the webs of primary supporting members may be disregarded, but the element thickness is to be reduced in proportion to the hole height and the web height ratio.

In some specific cases, some of the above simplifications may not be deemed acceptable by the Society in relation to the type of structural model and the analysis performed.

3.4.3 Standard mesh

The vessel's structure may be considered as finely meshed when each longitudinal ordinary stiffener is modeled; as a consequence, the standard size of finite elements used is based on the spacing of ordinary stiffeners.

The structural model is to be built on the basis of the following criteria:

- webs of primary members are to be modeled with at least three elements on their height
- the plating between two primary supporting members is to be modeled with at least two element strips
- the ratio between the longer side and the shorter side of elements is to be less than 3 in the areas expected to be highly stressed
- holes for the passage of ordinary stiffeners may be disregarded.

In some specific cases, some of the above simplifications may not be deemed acceptable by the Society in relation to the type of structural model and the analysis performed.

3.4.4 Fine mesh for the analysis of structural details

In order to obtain an accurate representation of stresses in the area of interest, the structural model is to be built on the basis of the following criteria:

- the mesh dimensions are to be such as to enable a faithful representation of the stress gradients
- the size of elements in the area of interest is not to be greater than 50 mm x 50 mm
- the extent of the refined area is to be at least of 10 elements in any direction around its centre
- the use of membrane elements is only allowed when significant bending effects are not present; in the other cases, elements with general behaviour are to be used
- the use of linear triangular elements is to be avoided as much as possible in high stress area; quadrilateral elements are to have 90° angles as much as possible, or angles between 60° and 120°; the aspect ratio is to be close to 1; when the use of a linear triangular element cannot be avoided, its edges are to have the same length
- the local fine mesh can either be included directly into the global model or belong to a separate sub-model; the gradient of mesh size must be reasonably low.

3.5 Beam models

3.5.1 Beams representing primary supporting members

Primary supporting members are to be modeled by beam elements with shear strain, positioned on their neutral axes.

3.5.2 Variable cross-section primary supporting members

In the case of variable cross-section primary supporting members, the inertia characteristics of the modeling beams may be assumed as a constant and equal to their average value along the length of the elements themselves.

3.5.3 Modelling of primary supporting members ends

The presence of end brackets may be disregarded; in such case their presence is also to be neglected for the evaluation of the beam inertia characteristics.

Rigid end beams are generally to be used to connect ends of the various primary supporting members, such as:

- floors and side vertical primary supporting members
- bottom girders and vertical primary supporting members of transverse bulkheads
- cross ties and side/longitudinal bulkhead primary supporting members.

3.5.4 Beams representing hull girder characteristics

The stiffness and inertia of the hull girder are to be taken into account by longitudinal beams positioned as follows:

- on deck and bottom in way of side shell and longitudinal bulkheads, if any, for modeling the hull girder bending strength
- on deck, side shell, longitudinal bulkheads, if any, and bottom for modeling the hull girder shear strength.

3.6 Boundary conditions of the whole three dimensional model

3.6.1 Structural model extended over at least three cargo tank/hold lengths

The whole three dimensional model is assumed to be fixed at one end, while shear forces and bending moments are applied at the other end to ensure equilibrium (see [4]).

At the free end section, rigid constraint conditions are to be applied to all nodes located on longitudinal members, in such a way that the transverse section remains plane after deformation.

When the hull structure is modeled over half the vessel's breadth (see [3.2.3]), in way of the vessel's centreline longitudinal plane, symmetry or anti-symmetry boundary conditions as specified in Tab 1 are to be applied, depending on the loads applied to the model (symmetrical or anti-symmetrical, respectively).

Table 1 : Symmetry and anti-symmetry conditions in way of the vessel's centreline longitudinal plane

Boundary conditions	DISPLACEMENTS in directions **(1)**		
	X	Y	Z
Symmetry	free	fixed	free
Anti-symmetry	fixed	free	fixed

Boundary conditions	ROTATION around axes **(1)**		
	X	Y	Z
Symmetry	fixed	free	fixed
Anti-symmetry	free	fixed	free

(1) X, Y and Z directions and axes are defined with respect to the reference co-ordinate system in Ch 1, Sec 2, [3.1].

3.6.2 Structural models extended over one cargo tank/hold length

Symmetry conditions are to be applied at the fore and aft ends of the model, as specified in Tab 2.

When the hull structure is modeled over half the vessel's breadth (see [3.2.3]), in way of the vessel's centreline longitudinal plane, symmetry or anti-symmetry boundary conditions as specified in Tab 1 are to be applied, depending on the loads applied to the model (symmetrical or anti-symmetrical, respectively).

Vertical supports are to be fitted at the nodes positioned in way of the connection of the transverse bulkheads with longitudinal bulkheads, if any, or with sides.

Table 2 : Symmetry conditions at the model fore and aft ends

DISPLACEMENTS in directions: **(1)**			ROTATION around axes: **(1)**		
X	Y	Z	X	Y	Z
fixed	free	free	free	fixed	fixed
(1) X, Y and Z directions and axes are defined with respect to the reference co-ordinate system in Ch 1, Sec 2, [3.1].					

4 Primary supporting members load model

4.1 General

4.1.1 Loading conditions

The loads are to be calculated for loading conditions defined in Part D for specific vessel notation.

4.1.2 Partial safety factors

The partial safety factors to be applied for hull made totally of steel or hull made of steel with parts (superstructure or deckhouse) made of aluminium, are defined in Ch 2, Sec 5, [2].

4.1.3 Lightweight

The structure weight of the modelled portion of the hull is to be included in the static loads. In order to obtain the actual longitudinal distribution of the still water bending moment, the lightweight is to be uniformly distributed over the length of the model.

4.1.4 Models extended over half vessel's breadth

When the vessel is symmetrical with respect to its centreline longitudinal plane and the hull structure is modeled over half the vessel's breadth, non-symmetrical loads are to be broken down into symmetrical and anti-symmetrical loads and applied separately to the model with symmetry and anti-symmetry boundary conditions in way of the vessel's centreline longitudinal plane (see [3.6]).

4.2 Local loads

4.2.1 General

Still water loads include:

- the still water external pressure, defined in Ch 3, Sec 4, [2]
- the still water internal loads, defined in Ch 3, Sec 4, [3] for the various types of cargoes and for ballast.

Wave loads include:

- the wave pressure, defined in Ch 3, Sec 4, [2.1.2]
- the inertial loads, defined in Ch 3, Sec 4, [3] for the various types of cargoes and for ballast.

4.2.2 Distributed loads

Distributed loads are to be applied to the plating panels.

In the analyses carried out on the basis of membrane finite element models or beam models, the loads distributed perpendicularly to the plating panels are to be applied on the ordinary stiffeners proportionally to their areas of influence. When ordinary stiffeners are not modeled or are modeled with rod elements (see [3.4]), the distributed loads are to be applied to the primary supporting members actually supporting the ordinary stiffeners.

4.2.3 Concentrated loads

When the elements directly supporting the concentrated loads are not represented in the structural model, the loads are to be distributed on the adjacent structures according to the actual stiffness of the structures which transmit them.

In the analyses carried out on the basis of coarse mesh finite element models or beam models, concentrated loads applied in five or more points almost equally spaced inside the same span may be applied as equivalent linearly distributed loads.

4.2.4 Cargo in sacks, bales and similar packages

The vertical loads are comparable to distributed loads. The loads on vertical walls may be disregarded.

4.2.5 Other cargoes

The modeling of cargoes other than those mentioned under [4.2.2] to [4.2.4] will be considered by the Society on a case by case basis.

4.3 Hull girder loads

4.3.1 Structural model extended over at least three cargo tank/hold lengths

The hull girder loads are constituted by:

- the still water and wave vertical bending moments
- the wave horizontal bending moment
- the still water and wave vertical shear forces,

and are to be applied at the model free end section. The shear forces are to be distributed on the plating according to the theory of bidimensional flow of shear stresses.

These loads are to be applied for the following two conditions:

- maximal bending moments at the middle of the central tank/hold within 0,4 L amidships
- maximal shear forces in way of the aft transverse bulkhead of the central tank/hold.

When the assessment of the foremost or aftmost cargo tank/hold is required, the following two conditions are to be considered:

- maximal bending moment for a given studied region along the length of the foremost/aftmost cargo tank/hold
- maximal shear force for a given studied region along the length of foremost/aftmost cargo tank/hold.

4.3.2 Structural model extended over one cargo tank/hold length

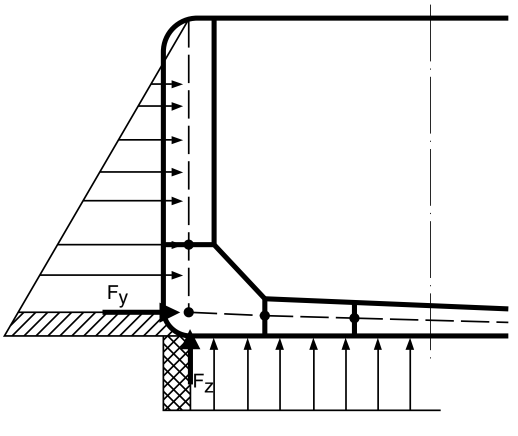
The normal and shear stresses induced by the hull girder loads are to be added to the stresses induced in the primary supporting members by local loads.

4.4 Additional requirements for the load assignment to beam models

4.4.1 Vertical and transverse concentrated loads are to be applied to the model, as shown in Fig 3, to compensate the portion of distributed loads which, due to the positioning of beams on their neutral axes, are not modeled.

In Fig 3, F_Y and F_Z represent concentrated loads equivalent to the dashed portion of the distributed loads which is not directly modeled.

Figure 3 : Concentrated loads equivalent to non-modelled distributed loads



5 Stress calculation

5.1 Analyses based on finite element models

5.1.1 Stresses induced by local and hull girder loads

When finite element models extend over at least three cargo tank/hold lengths, both local and hull girder loads are to be directly applied to the model, as specified in [4.3.1]. In this case, the stresses calculated by the finite element program include the contribution of both local and hull girder loads.

When finite element models extend over one cargo tank/hold length, only local loads are directly applied to the structural model, as specified in [4.3.2]. In this case, the stresses calculated by the finite element program include the contribution of local loads only. Hull girder stresses are to be calculated separately and added to the stresses induced by local loads.

5.1.2 Stress components

Stress components are generally identified with respect to the element co-ordinate system, as shown, by way of example, in Fig 4. The orientation of the element co-ordinate system may or may not coincide with that of the reference co-ordinate system in Ch 1, Sec 2, [3.1].

The following stress components are to be calculated at the centroid of each element:

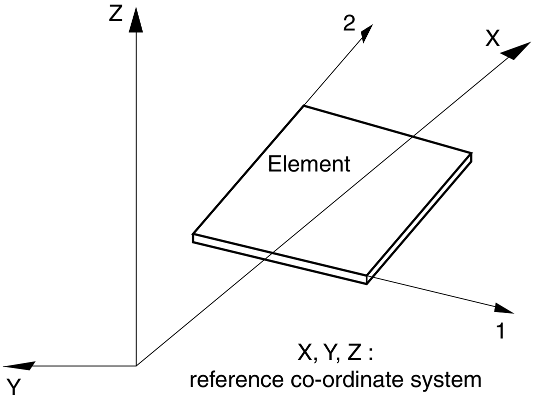
- the normal stresses σ_1 and σ_2 in the directions of the element co-ordinate system axes
- the shear stress τ_{12} with respect to the element co-ordinate system axes
- the Von Mises equivalent stress, obtained from the following formula:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \sigma_2 + 3\tau_{12}^2}$$

5.1.3 Stress calculation points

Stresses are generally calculated by the computer programs for each element. The values of these stresses are to be used for carrying out the checks required.

Figure 4 : Reference and element co-ordinate systems



5.2 Analyses based on beam models

5.2.1 Stresses induced by local and hull girder loads

Since beam models generally extend over one cargo tank/hold length (see [2.3.1] and [3.2.2]), only local loads are directly applied to the structural model, as specified in [4.3.2]. Therefore, the stresses calculated by the beam program include the contribution of local loads only. Hull girder stresses are to be calculated separately and added to the stresses induced by local loads.

5.2.2 Stress components

The following stress components are to be calculated:

- the normal stress σ_1 in the direction of the beam axis
- the shear stress τ_{12} in the direction of the local loads applied to the beam
- the Von Mises equivalent stress, obtained from the following formula:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + 3\tau_{12}^2}$$

5.2.3 Stress calculation points

Stresses are to be calculated at least in the following points of each primary supporting member:

- in the primary supporting member span where the maximum bending moment occurs
- at the connection of the primary supporting member with other structures, assuming as resistant section that formed by the member, the bracket (if any and if represented in the model) and the attached plating
- at the toe of the bracket (if any and if represented in the model) assuming as resistant section that formed by the member and the attached plating.

The values of the stresses are to be used for carrying out the checks required.

6 Buckling and ultimate strength assessment

6.1 General

6.1.1 Buckling and ultimate strength assessment is to be performed for the panels according to Ch 2, Sec 7, [2.2].

6.2 Stresses of panel

6.2.1 The stresses in each single plate field are to be obtained according to the following procedure:

a) When the mesh model differs from the single plate field geometry, the stresses acting on the single plate field are to be evaluated by extrapolation and/or interpolation of surrounding meshes using the elements stresses or using a displacement based method.

b) If the stresses in the x- and y-directions already contain the Poisson-effect (calculated using finite element analysis), the following modified stress values may be used. Both stresses σx^* and σy^* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:

$$\sigma x = (\sigma x^* - \nu\, \sigma y^*) / 0{,}91$$

$$\sigma y = (\sigma y^* - \nu\, \sigma x^*) / 0{,}91$$

with:

σx^*, σy^* : Stresses containing the Poisson-effect.

ν : Poisson's ratio:

- $\nu = 0{,}30$ for steel
- $\nu = 0{,}33$ for aluminium alloy

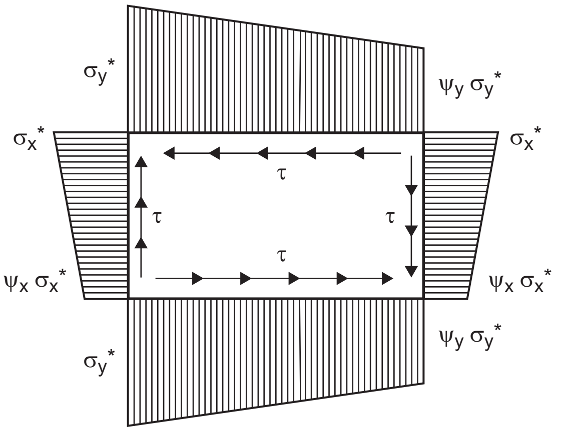
where the compressive stress fulfills the condition:

- $\sigma y^* < \nu\, \sigma x^*$, then: $\sigma y = 0$ and $\sigma x = \sigma x^*$
- $\sigma x^* < \nu\, \sigma y^*$, then: $\sigma x = 0$ and $\sigma y = \sigma y^*$

c) Determine stress distributions along edges of the considered buckling panel by introducing proper linear approximation as shown in Fig 5.

d) Calculate edge stress ratio.

Figure 5 : Stresses of panel for buckling assessment



APPENDIX 2 ANALYSES OF PRIMARY SUPPORTING MEMBERS SUBJECTED TO WHEELED LOADS

Symbols

E : Young's modulus, in N/mm^2:

- $E = 2{,}06 \cdot 10^5$ for steel, in general
- $E = 1{,}95 \cdot 10^5$ for stainless steel
- $E = 7{,}00 \cdot 10^4$ for aluminium alloys.

1 General

1.1 Scope

1.1.1 The requirements of this Appendix apply to the analysis criteria, structural modeling, load modeling and stress calculation of primary supporting members subjected to wheeled loads which are to be analysed through three dimensional structural models, according to Ch 2, Sec 8, [2].

1.1.2 The purpose of these structural analyses is to determine:

- the distribution of the forces induced by the vertical acceleration acting on wheeled cargoes, among the various primary supporting members of decks, sides and possible bulkheads
- the behaviour of the above primary supporting members under the racking effects due to the transverse forces induced by the transverse acceleration acting on wheeled cargoes, when the number or location of transverse bulkheads are not sufficient to avoid such effects,

and to calculate the stresses in primary supporting members.

The above calculated stresses are to be used in the yielding and buckling checks.

In addition, the results of these analyses may be used, where deemed necessary by the Society, to determine the boundary conditions for finer mesh analyses of the most highly stressed areas.

1.1.3 When the behaviour of primary supporting members under the racking effects, due to the transverse forces induced by the transverse acceleration, is not to be determined, the stresses in deck primary supporting members may be calculated according to the simplified analysis in [6], provided that the conditions for its application are fulfilled (see [6.1]).

1.1.4 The yielding and buckling checks of primary supporting members are to be carried out according to Ch 2, Sec 8, [2.4.4].

1.2 Application

1.2.1 The requirements of this Appendix apply to vessels whose structural arrangement is such that the following assumptions may be considered as being applicable:

- primary supporting members of side and possible bulkheads may be considered fixed in way of the double bottom (this is generally the case when the stiffness of floors is at least three times that of the side primary supporting members)
- under transverse inertial forces, decks behave as beams loaded in their plane and supported at the vessel ends; their effect on the vessel transverse rings (side primary supporting members and deck beams) may therefore be simulated by means of elastic supports in the transverse direction or transverse displacements assigned at the central point of each deck beam.

1.2.2 When the assumptions in [1.2.1] are considered by the Society as not being applicable, the analysis criteria are defined on a case by case basis, taking into account the vessel's structural arrangement and loading conditions.

1.3 Information required

1.3.1 To perform these structural analyses, the following characteristics of vehicles loaded are necessary:

- load per axle
- arrangement of wheels on axles
- tyre dimensions.

1.4 Lashing of vehicles

1.4.1 The presence of lashing for vehicles is generally to be disregarded, but may be given consideration by the Society, on a case by case basis, at the request of the interested parties.

2 Analysis criteria

2.1 Finite element model analyses

2.1.1 Finite element models may need to be adopted when deemed necessary by the Society on the basis of the vessel's structural arrangement.

2.2 Beam model analyses

2.2.1 Beam models, built according to Ch 2, App 1, [3.5], may be adopted in lieu of the finite element models, provided that:

- primary supporting members are not so stout that the beam theory is deemed inapplicable by the Society
- their behaviour is not substantially influenced by the transmission of shear stresses through the shell plating.

3 Primary supporting members structural modelling

3.1 Model construction

3.1.1 Elements

The structural model is to represent the primary supporting members with the plating to which they are connected. In particular, the following primary supporting members are to be included in the model:

- deck beams
- side primary supporting members
- primary supporting members of longitudinal and transverse bulkheads, if any
- pillars
- deck beams, deck girders and pillars supporting ramps and deck openings, if any.

3.1.2 Net scantlings

All the elements in [3.1.1] are to be modeled with their net scantlings according to Ch 2, Sec 5, [2].

3.2 Model extension

3.2.1 The structural model is to represent a hull portion which includes the zone under examination and which is repeated along the hull. The non-modeled hull parts are to be considered through boundary conditions as specified in [3.3].

In addition, the longitudinal extension of the structural model is to be such that the results in the areas to be analysed are not influenced by the unavoidable inaccuracy in the modeling of the boundary conditions.

3.2.2 Double bottom structures are not required to be included in the model, based on the assumptions in [1.2.1].

3.3 Boundary conditions of the three dimensional model

3.3.1 Boundary conditions at the lower ends of the model

The lower ends of the model (i.e. the lower ends of primary supporting members of side and possible bulkheads) are to be considered as being clamped in way of the inner bottom.

3.3.2 Boundary conditions at the fore and aft ends of the model

Symmetry conditions are to be applied at the fore and aft ends of the model, as specified in Tab 1.

Table 1 : Symmetry conditions at the model fore and aft ends

DISPLACEMENTS in directions: **(1)**			ROTATION around axes: **(1)**		
X	Y	Z	X	Y	Z
fixed	free	free	free	fixed	fixed
(1) X, Y and Z directions and axes are defined with respect to the reference co-ordinate system in Ch 1, Sec 2, [3.1].					

3.3.3 Additional boundary conditions at the fore and aft ends of models subjected to transverse loads

When the model is subjected to transverse loads, i.e. when the loads in inclined vessel conditions are applied to the model, the transverse displacements of the deck beams are to be obtained by means of a racking analysis and applied at the fore and aft ends of the model, in way of each deck beam.

For vessels with a traditional arrangement of fore and aft parts, a simplified approximation may be adopted, when deemed acceptable by the Society, defining the boundary conditions without taking into account the racking calculation and introducing springs, acting in the transverse direction, at the fore and aft ends of the model, in way of each deck beam (see Fig 1). Each spring, which simulates the effects of the deck in way of which it is modeled, has a stiffness obtained, in kN/m, from the following formula:

$$R_D = \frac{24 E J_D s_a 10^3}{2x^4 - 4L_D x^3 + L_D^2\left(x^2 + 15{,}6\frac{J_D}{A_D}\right) + L_D^3 x}$$

where:

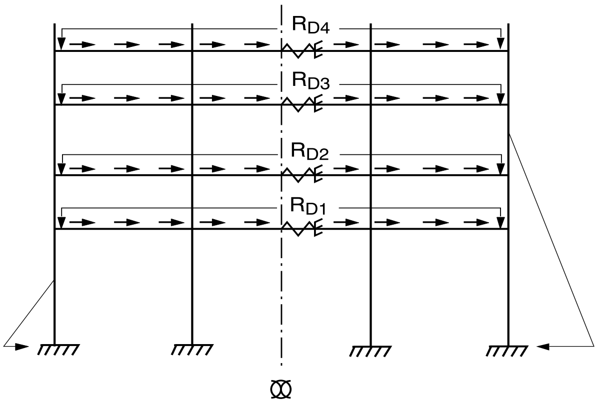
J_D : Net moment of inertia, in m^4, of the average cross-section of the deck, with the attached side shell plating

A_D : Net area, in m^2, of the average cross-section of deck plating

s_a : Spacing of side vertical primary supporting members, in m x : Longitudinal distance, in m, measured from the transverse section at mid-length of the model to any deck end

L_D : Length of the deck, in m, to be taken equal to the vessel's length. Special cases in which such value may be reduced will be considered by the Society on a case by case basis.

Figure 1 : Springs at the fore and aft ends of models subjected to transverse loads



4 Load model

4.1 General

4.1.1 Hull girder and local loads

Only local loads are to be directly applied to the structural model.

The stresses induced by hull girder loads are to be calculated separately and added to the stresses induced by local loads.

4.1.2 Loading conditions and load cases: wheeled cargoes

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in primary supporting members.

The loads transmitted by vehicles are to be applied taking into account the most severe axle positions for the vessel structures.

4.1.3 Loading conditions and load cases: dry uniform cargoes

When the vessel's decks are also designed to carry dry uniform cargoes, the loading conditions which envisage the transportation of such cargoes are also to be considered. The still water and wave loads induced by these cargoes are to be calculated for the most severe loading conditions, with a view to maximising the stresses in primary supporting members.

4.2 Local loads

4.2.1 General

Still water loads include:

- the still water external pressure, defined in Ch 3, Sec 4, [2]
- the still water forces induced by wheeled cargoes, defined in Ch 3, Sec 4, [3.5].

Wave loads include:

- the wave pressure, defined in Ch 3, Sec 4, [2.1.2]
- the inertial forces induced by wheeled cargoes, defined in Ch 3, Sec 4, [3.5].

The partial safety factors to be applied for hull made totally of steel or hull made of steel with parts (superstructure or deckhouse) made of aluminium, are defined in Ch 2, Sec 5, [2].

4.2.2 Tyred vehicles

For the purpose of primary supporting members analyses, the forces transmitted through the tyres may be considered as concentrated loads in the tyre print centre.

The forces acting on primary supporting members are to be determined taking into account the area of influence of each member and the way ordinary stiffeners transfer the forces transmitted through the tyres.

4.2.3 Non-tyred vehicles

The requirements in [4.2.2] also apply to tracked vehicles. In this case, the print to be considered is that below each wheel or wheelwork.

For vehicles on rails, the loads transmitted are to be applied as concentrated loads.

4.2.4 Distributed loads

In the analyses carried out on the basis of beam models or membrane finite element models, the loads distributed perpendicularly to the plating panels are to be applied on the primary supporting members proportionally to their areas of influence.

4.3 Hull girder loads

4.3.1 The normal stresses induced by the hull girder loads are to be added to the stresses induced in the primary supporting members by local loads.

5 Stress calculation

5.1 Stresses induced by local and hull girder loads

5.1.1 Only local loads are directly applied to the structural model, as specified in [4.1.1]. Therefore, the stresses calculated by the program include the contribution of local loads only. Hull girder stresses are to be calculated separately and added to the stresses induced by local loads.

5.2 Analyses based on finite element models

5.2.1 Stress components

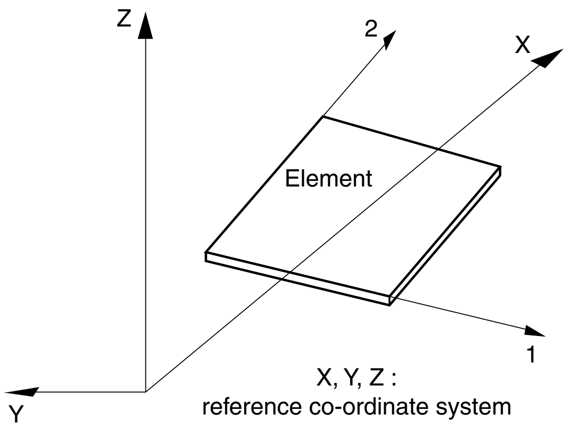
Stress components are generally identified with respect to the element co-ordinate system, as shown, by way of example, in Fig 2. The orientation of the element co-ordinate system may or may not coincide with that of the reference co-ordinate system in Ch 1, Sec 2, [3.1].

The following stress components are to be calculated at the centroid of each element:

- the normal stresses σ_1 and σ_2 in the directions of element co-ordinate system axes
- the shear stress τ_{12} with respect to the element co-ordinate system axes
- the Von Mises equivalent stress, obtained from the following formula:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 + 3\tau_{12}^2}$$

Figure 2 : Reference and element co-ordinate systems



5.2.2 Stress calculation points

Stresses are generally calculated by the computer programs for each element. The values of these stresses are to be used for carrying out the checks required.

5.3 Analyses based on beam models

5.3.1 Stress components

The following stress components are to be calculated:

- the normal stress σ_{11} in the direction of the beam axis
- the shear stress τ_{12} in the direction of the local loads applied to the beam
- the Von Mises equivalent stress, obtained from the following formula:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + 3\tau_{12}^2}$$

5.3.2 Stress calculation points

Stresses are to be calculated at least in the following points of each primary supporting member:

- in the primary supporting member span where the maximum bending moment occurs
- at the connection of the primary supporting member with other structures, assuming as resistant section that formed by the member, the bracket (if any and if represented in the model) and the attached plating
- at the toe of the bracket (if any and if represented in the model) assuming as resistant section that formed by the member and the attached plating.

The values of the stresses calculated in the above points are to be used for carrying out the checks required.

6 Grillage analysis of primary supporting members of decks

6.1 Application

6.1.1 For the sole purpose of calculating the stresses in deck primary supporting members, due to the forces induced by the vertical accelerations acting on wheeled cargoes, these members may be subjected to the simplified two dimensional analysis described in [6.2].

This analysis is generally considered as being acceptable for usual structural typology, where there are neither pillar lines, nor longitudinal bulkheads.

6.2 Analysis criteria

6.2.1 Structural model

The structural model used to represent the deck primary supporting members is a beam grillage model.

6.2.2 Model extension

The structural model is to represent a hull portion which includes the zone under examination and which is repeated along the hull. The non-modeled hull parts are to be considered through boundary conditions as specified in [3.3].

6.3 Boundary conditions

6.3.1 Boundary conditions at the fore and aft ends of the model

Symmetry conditions are to be applied at the fore and aft ends of the model, as specified in Tab 1.

6.3.2 Boundary conditions at the connections of deck beams with side vertical primary supporting members

Vertical supports are to be fitted at the nodes positioned in way of the connection of deck beams with side primary supporting members.

The contribution of flexural stiffness supplied by the side primary supporting members to the deck beams is to be simulated by springs, applied at their connections, having rotational stiffness, in the plane of the deck beam webs, obtained, in kN.m/rad, from the following formulae:

- for intermediate decks:

$$R_F = \frac{3E(J_1 + J_2)(\ell_1 + \ell_2)}{\ell_1^2 + \ell_2^2 - \ell_1 \ell_2} 10^{-5}$$

- for the uppermost deck:

$$R_F = \frac{6EJ_1}{\ell_1} 10^{-5}$$

where:

ℓ_1, ℓ_2 : Heights, in m, of the 'tweendecks, respectively below and above the deck under examination (see Fig 3)

J_1, J_2 : Net moments of inertia, in cm^4, of side primary supporting members with attached shell plating, relevant to the 'tweendecks, respectively below and above the deck under examination.

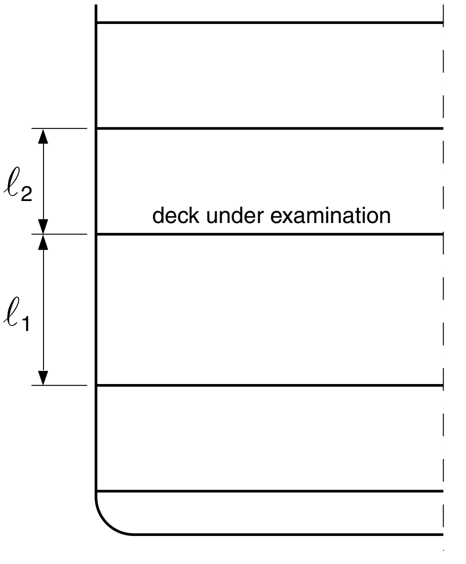
6.4 Load model

6.4.1 Hull girder and local loads are to be calculated and applied to the model according to [4].

6.5 Stress calculation

6.5.1 Stress components are to be calculated according to [5.1] and [5.3].

Figure 3 : Heights of tween-decks for grillage analysis of deck primary supporting members



APPENDIX 3 TORSION OF CATAMARANS

Symbols

Refer to Fig 1.

- G : Centre of the stiffnesses r_i, of the m deck beams
- O : Origin of abscissae, arbitrarily chosen
- m : Number of deck transverses
- x_i : Abscissa, in m, of deck beam i with respect to origin O
- S_i : Span of deck beam i, in m, between the inner faces of the hulls
- I_i : Bending inertia of deck beam i, in m^4
- E_i : Young's modulus of deck beam i, in N/mm^2, to be taken equal to
  - for steels in general:

    $E_i = 2{,}06 \cdot 10^5$ N/mm^2
  - for stainless steels:

    $E_i = 1{,}95 \cdot 10^5$ N/mm^2
  - for aluminium alloys:

    $E_i = 7{,}00 \cdot 10^4$ N/mm^2
- r_i : Stiffness of deck beam i, in N/m, equal to:

$$r_i = \frac{12 \cdot E_i \cdot I_i}{S^3{}_i} \cdot 10^6$$

- a : Abscissa, in m, of the centre G with respect to the origin O

$$a = \frac{\sum r_i \cdot x_i}{\sum r_i}$$

- n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

If F_i, in N, is the force taken over by the deck beam i, the deflection y_i, in m, of the hull in way of the beam i, is:

$$y_i = \frac{F_i S^3{}_i \cdot 10^{-6}}{12 E_i I_i} = \frac{F_i}{r_i} = d_i \omega$$

where:

- d_i : Abscissa, in m, of the deck beam i with respect to the origin G:

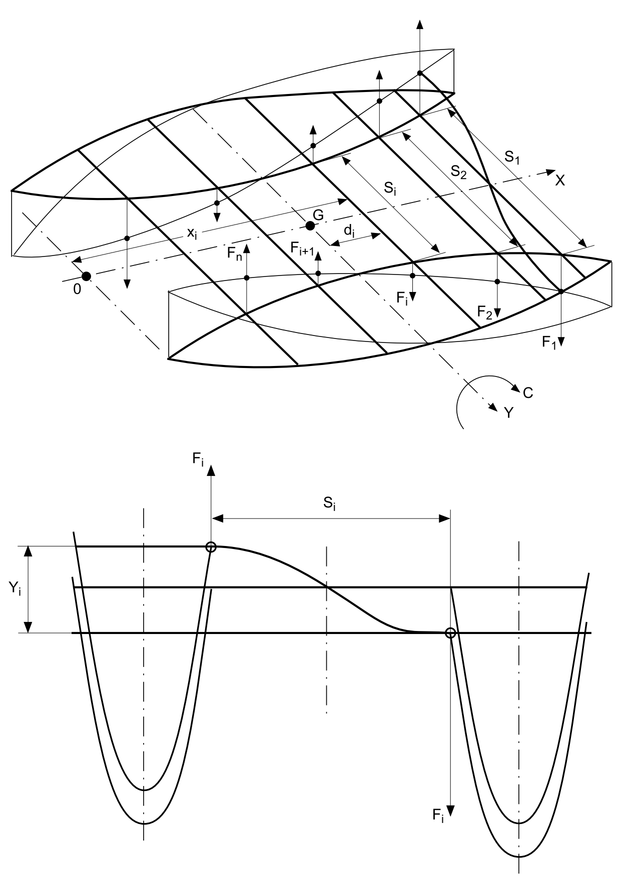
  $d_i = x_i - a$
- ω : Rotation angle, in rad, of one hull in relation to the other around a transverse axis passing through G.

1 General

1.1

1.1.1 In the special case of catamaran, when the structure connecting both hulls is formed by a deck with single plating stiffened by m reinforced beams, the normal and shear stresses in the beams can be calculated as indicated in [2].

Figure 1 : Transverse strength of catamaran



2 Transverse strength in special case of catamaran

2.1 General

2.1.1 Deck beams are assumed to be fixed into each hull. Consequently, deck beams are to be extended throughout the breadth of each hull, with the same scantlings all over their span, inside and outside the hulls.

2.2 Transverse torsional connecting moment

2.2.1 The catamaran transverse torsional connecting moment, in kN.m, about a transverse axis is given by:

$M_{tt} = 1{,}23\ \Delta\ L\ a_{CG}$

where:

Δ : Vessel displacement, in tons

a_{CG} : Design vertical acceleration at LCG, in m/s², to be taken not less than:

$$a_{CG} = 0{,}36\,Soc\,\frac{v}{\sqrt{L}}$$

v : Vessel speed, in km/h

Soc : Coefficient depending on the navigation coefficient n, defined as:

$Soc = 0{,}1\ (5{,}15n + 1{,}1)$

Moreover, the transverse torsional moment may be expressed as:

$$M_{tt} = \sum F_i \cdot d_i \cdot 10^{-3}$$

2.3 Calculation of rotation angle

2.3.1 The rotation angle may be derived from [2.2] and is given by the formula:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3$$

2.4 Determination of stresses in deck beams

2.4.1 As M_{tt}, r_i and d_i are known, ω is thus deduced. Then F_i, in N, the bending moment M_i, in N.m, and the corresponding normal and shear stresses can be evaluated in each beam:

$F_i = \omega\ r_i\ d_i$

$M_i = F_i\ S_i / 2$

2.5 Checking criteria

2.5.1 It is to be checked that the normal stress σ and the shear stress are in compliance with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0{,}5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

where:

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 5, Sec 2, [1.3]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 5, Sec 2, [1.3]

k : Material factor defined in Ch 2, Sec 3, [2.3], for steel and Ch 2, Sec 3, [3.5], for aluminium alloys.

Part B
Hull Design and Construction

Chapter 3
DESIGN LOADS

SECTION 1 GENERAL

SECTION 2 HULL GIRDER LOADS

SECTION 3 VESSEL MOTIONS AND ACCELERATIONS

SECTION 4 LOCAL LOADS

SECTION 1 GENERAL

Symbols

D : Depth, in m, defined in Ch 1, Sec 2, [2.3]

H_S : Significant wave height, in m, defined in Pt A, Ch 1, Sec 1, [1.2.10]

h_2 : Reference value of the relative motion, in m, defined in Ch 3, Sec 3, [2.2.1]

h_1 : Reference value of the relative motion, in m, defined in Ch 3, Sec 3, [2.2.1]

M_{WV} : Vertical wave bending moment, in kN.m

M_{WH} : Horizontal wave bending moment, in kN.m

Q_W : Vertical wave shear force, in kN.m

T : Scantling draught, in m, defined in Ch 1, Sec 2, [2.4].

1 Definitions

1.1 Still water loads

1.1.1 Still water loads are those acting on the vessel at rest in calm water.

1.2 Wave loads

1.2.1 Wave loads are those due to wave pressures and vessel motions, which can be assumed to have the same wave encounter period.

1.3 Dynamic loads

1.3.1 Dynamic loads are those that have a duration much shorter than the period of the wave loads.

1.4 Local loads

1.4.1 Local loads are pressures and forces which are directly applied to the individual structural members: plating panels, ordinary stiffeners and primary supporting members.

- still water local loads are constituted by the hydrostatic external river pressures and the static pressures and forces induced by the weights carried in the vessel spaces.
- wave local loads are constituted by the external river pressures due to waves and the inertial pressures and forces induced by the vessel accelerations applied to the weights carried in the vessel spaces.

1.5 Hull girder loads

1.5.1 Hull girder loads are still water and wave forces and moments which result as effects of local loads acting on the vessel as a whole and considered as a beam.

1.6 Loading condition

1.6.1 A loading condition is a distribution of weights carried in the vessel spaces arranged for their storage.

1.7 Load case

1.7.1 A load case is a state of the vessel structures subjected to a combination of hull girder and local loads.

1.8 Service conditions

1.8.1 Service conditions correspond to intact vessel in operating conditions.

2 Application criteria

2.1 Application

2.1.1 Requirements applicable to all types of vessels

The still water and wave induced loads defined in this Chapter are to be used for the determination of the hull girder strength and structural scantlings in any hull tranverse section.

2.1.2 Requirements applicable to specific vessel types

The design loads applicable to specific vessel types are to be determined in accordance with the requirements in Part D.

2.1.3 Load direct calculation

As an alternative to the formulae given in Ch 3, Sec 2, [3] and Ch 3, Sec 3, the Society may accept the values of wave induced loads derived from direct calculations, when justified on the basis of the vessel's characteristics and intended service. The calculations are to be submitted to the Society for review.

2.2 Hull girder loads

2.2.1 The hull girder loads to be used for the determination of:

- the hull girder strength, according to the requirements of Ch 4, Sec 2
- the structural scantling of plating, ordinary stiffeners and primary supporting members contributing to the hull girder strength, in combination with the local loads given in Ch 3, Sec 4, according to the requirements in Part B, Chapter 5 and Part B, Chapter 6,

are specified in Ch 3, Sec 2.

2.3 Local loads

2.3.1 Load cases

The local loads defined in [1.4] are to be calculated in each of the mutually exclusive load cases described in [4].

2.3.2 Vessel motions and accelerations

The wave local loads are to be calculated on the basis of the reference values of vessel motions and accelerations specified in Ch 3, Sec 3.

2.3.3 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 vessel motions and accelerations,

are specified in Ch 3, Sec 4, [2] for river pressures and in Ch 3, Sec 4, [3] for internal pressures and forces.

2.4 Load definition criteria to be adopted in structural analyses based on plate or isolated beam structural models

2.4.1 Application

The requirements of this sub-article apply for the definition of local loads to be used in the scantling checks of:

- plating
- ordinary stiffeners
- primary supporting members for which a three dimensional structural model is not required, according to Ch 2, Sec 8, [2.3].

2.4.2 Cargo and ballast distribution

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

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

- the external pressures considered as acting alone without any counteraction from the vessel interior
- the differential pressures (internal pressure minus external pressure) considering the compartment adjacent to the outer shell as being loaded.

2.4.3 Draught T_1 associated with each cargo and ballast distribution

Local loads are to be calculated on the basis of the vessel draught T_1 corresponding to the cargo or lightship distribution considered according to the criteria [2.4.2]. The vessel draught is to be taken as the distance measured vertically on the hull transverse section at the middle of the length L from the base line to the waterline in:

a) full load condition, when:
   - one or more cargo compartments are considered as being loaded and the ballast tanks are considered as being empty
   - the external pressures are considered as acting alone without any counteraction from the vessel's interior.

b) lightship condition, when one or more ballast tanks are considered as being loaded and the cargo compartments are considered as being empty.

Where the value of T_1 is not provided, it may be taken as follows:

- for cargo carriers which include:
  - cargo vessels, see Pt A, Ch 1, Sec 3, [2]
  - tankers, see Pt A, Ch 1, Sec 3, [3]
  - vessels for dredging activities, see Pt A, Ch 1, Sec 3, [5]

  T_1 as defined in Tab 1.
- for non-cargo carriers

  T_1 as defined in Tab 2.

Table 1 : T_1 for cargo carriers

<table>
<tr><th></th><th>Loading condition</th><th>External counter pressure</th><th>External design pressure</th></tr>
<tr><td rowspan="2">Harbour</td><td>1R and Nonhomload</td><td>0,20D</td><td>T</td></tr>
<tr><td>2R</td><td>0,575T</td><td>0,575T</td></tr>
<tr><td rowspan="2">Navigation</td><td>Full load</td><td>T</td><td>T</td></tr>
<tr><td>Lightship</td><td>0,20D</td><td>0,20D</td></tr>
</table>

Table 2 : T_1 for non-cargo carriers

<table>
<tr><th colspan="2">Loading condition</th><th>External counter pressure</th><th>External design pressure</th></tr>
<tr><td colspan="2">Full load condition (Navigation)</td><td>T</td><td>T</td></tr>
<tr><td rowspan="3">Lightship condition (Navigation)</td><td>Pontoon</td><td>0,20D</td><td>0,20D</td></tr>
<tr><td>Tug/Pusher</td><td>0,28D</td><td>0,28D</td></tr>
<tr><td>Others (1)</td><td>0,41D</td><td>0,41D</td></tr>
<tr><td colspan="4">(1) Passenger vessel / Launch / Pleasure vessel</td></tr>
</table>

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

2.5.1 Application

The requirements of this sub-article apply to the definition of local loads to be used in the scantling checks of primary supporting members for which a three dimensional structural model is required, according to Ch 2, Sec 8, [2.4].

2.5.2 Loading conditions

For all vessel types for which analyses based on three dimensional models are required according to Ch 2, Sec 8, [2.4], the most severe loading conditions for the structural elements under investigation are to be considered. These loading conditions are to be selected among those envisaged for the vessel operation.

Further criteria applicable to specific vessel types are specified in Part D.

2.5.3 Draught associated with each loading condition

Local loads are to be calculated on the basis of the vessel's draught T_1 corresponding to the loading condition considered according to the criteria in [2.5.2].

3 Standard loading conditions

3.1 Cargo vessels and tank vessels

3.1.1 Lightship

For non-propelled cargo vessels (see Pt A, Ch 1, Sec 3, [2]) and tank vessels (see Pt A, Ch 1, Sec 3, [3]), the vessel is assumed empty, without supplies nor ballast.

For self-propelled cargo vessels and tank vessels, the light standard loading conditions are:

- supplies: 100%
- ballast: 50%.

3.1.2 Full load condition

For non-propelled cargo vessels (see Pt A, Ch 1, Sec 3, [2]) and tank vessels (see Pt A, Ch 1, Sec 3, [3]), the vessel is considered to be homogeneously loaded at its maximum draught, without supplies nor ballast.

For self-propelled cargo vessels and tank vessels, the vessel is considered to be homogeneously loaded at its maximum draught with 10% of supplies (without ballast).

3.1.3 Transitory conditions

Transitory standard conditions are defined in [3.1.4] to [3.1.6].

For non-propelled cargo vessels (see Pt A, Ch 1, Sec 3, [2]) and tank vessels (see Pt A, Ch 1, Sec 3, [3]), the vessel is assumed without supplies nor ballast.

For self-propelled cargo vessels and tank vessels, the vessel without ballast, is assumed to carry following amount of supplies:

- in hogging condition: 100% of supplies
- in sagging condition: 10% of supplies.

3.1.4 Loading / unloading in two runs (2R)

Loading and unloading are performed uniformly in two runs of almost equal masses, starting from one end of the cargo space, progressing towards the opposite end.

3.1.5 Loading / unloading in one run (1R)

Loading and unloading are performed uniformly in one run, starting from one end of the cargo space, progressing towards the opposite end.

3.1.6 Loading / unloading for liquid cargoes

Loading and unloading for liquid cargoes are assumed to be performed in two runs (see [3.1.4]), unless otherwise specified.

3.2 Vessels for dredging activities

3.2.1 Application

The requirements under [3.2.2] to [3.2.4] apply to the following vessels for dredging activities:

- **Hopper dredger**
- **Hopper barge**
- **Split hopper barge**
- **Split hopper dredger**.

3.2.2 Lightship

For hopper barges, the vessel is assumed empty, without supplies nor ballast.

For hopper dredgers, the light standard loading conditions are:

- supplies: 100%
- ballast: 50%.

3.2.3 Full load condition

For hopper barges, the vessel is considered to be homogeneously loaded at its maximum draught, without supplies nor ballast.

For hopper dredgers, the vessel is considered to be homogeneously loaded at its maximum draught with:

- supplies: 10%
- ballast: empty.

3.2.4 Working condition

The standard loading conditions are defined in a) and b) below.

For hopper barges, the vessel is assumed without supplies nor ballast.

For hopper dredgers, the vessel without ballast, is assumed to carry the following amount of supplies:

- in hogging condition: 100% of supplies
- in sagging condition: 10% of supplies.

a) Loading / unloading in two runs (**2R**)

   Loading and unloading are performed uniformly in two runs of almost equal masses, starting from one end of the hopper space, progressing towards the opposite end.

b) Loading / unloading in one run (**1R**)

   Loading and unloading are performed uniformly in one run, starting from one end of the hopper space, progressing towards the opposite end.

3.3 Tugs and pushers

3.3.1 The vessel is considered to be homogeneously loaded as follows:

- at minimum draught with 10% supplies
- at maximum draught with 100% supplies.

3.4 Other vessels

3.4.1 The standard loading conditions to be considered for passenger vessels, launches and pleasure vessels are defined in [3.4.2] and [3.4.3].

3.4.2 Lightship

The light standard loading conditions are:

- supplies: 100%
- ballast: 50%.

3.4.3 Full load condition

The vessel is considered to be homogeneously loaded at its maximum draught with:

- all passengers and crew onboard
- supplies: 100%
- ballast: empty.

4 Load cases

4.1 General

4.1.1 The mutually exclusive load cases described in [4.2] to [4.5] are those to be used for the structural element analyses of:

- plating
- ordinary stiffeners
- primary supporting members analysed through isolated beam structural models or three dimensional structural models.

4.2 Upright vessel condition during loading/ unloading in harbour (load case ″a″)

4.2.1 Vessel condition

The vessel is considered in upright condition at rest in still water.

4.2.2 Local loads

The external pressure is the hydrostatic river pressure.

The internal loads are the still water loads induced by the weights carried, including those carried on decks.

4.2.3 Hull girder loads

The hull girder loads are the vertical still water bending moment and shear force.

4.3 Upright vessel condition during navigation (load case ″b″)

4.3.1 Vessel condition

The vessel is considered to encounter a wave which produces a relative motion of the water stretch (both positive and negative) symmetric on the vessel sides and induces wave vertical bending moment and shear force in the hull girder. The wave is also considered to induce heave and pitch motions.

4.3.2 Local loads

The external pressure is obtained by adding to or subtracting from the hydrostatic river pressure a wave pressure corresponding to the relative motion.

The internal loads are obtained by adding the still water loads induced by the weights carried, including those carried on decks, to the loads induced by the accelerations.

4.3.3 Hull girder loads

The hull girder loads are:

- the vertical still water bending moment and shear force
- the vertical wave bending moment and the shear force.

4.4 Upright vessel condition during working (load case ″b″)

4.4.1 This load case applies to vessels for dredging activities. Refer to [4.3] for vessel condition and encountered loads.

4.5 Inclined vessel condition during navigation (load cases ″c″ and ″d″)

4.5.1 Application

The inclined vessel condition is to be taken into account for **IN**(1,**2 < x ≤ 2**).

Regardless of the range of navigation, the inclined vessel condition is also to be taken into account for racking analysis and strength check of vessel specific components such as:

- container supports
- movable decks and ramps
- movable wheelhouses.

4.5.2 Vessel condition

The vessel is considered to encounter a condition which produces:

- sway, roll and yaw motions
- a relative motion of the waterline anti-symmetric on the vessel sides

and induces:

- vertical wave bending moment and shear force in the hull girder
- horizontal wave bending moment in the hull girder.

4.5.3 Local loads

The external pressure is obtained by adding or subtracting from the still water head a wave head linearly variable from positive values on one side of the vessel to negative values on the other.

The internal loads are the still water loads induced by the weights carried, including those carried on decks, and the wave loads induced by the accelerations.

4.5.4 Hull girder loads

The hull girder loads are:

- the still water bending moment and shear force
- the vertical wave bending moment and shear force
- the horizontal wave bending moment.

Table 3 : Wave local loads in each load case

Vessel condition	Load case	Relative motions		Accelerations a_X, a_Y, a_Z	
		Reference value	Combination factor	Reference value **(3)**	Combination factor
Upright	"a"	h_1	0,0	a_{X1}; 0; a_{Z1}	0,0
	"b" **(1)**	h_1	1,0	a_{X1}; 0; a_{Z1}	1,0
Inclined	"c" **(2)**	h_2	1,0	0; a_{Y2}; a_{Z2}	0,7
	"d" **(2)**	h_2	0,5	0; a_{Y2}; a_{Z2}	1,0

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

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

(3) Accelerations a_X, a_Y and a_Z are to be considered in both directions when assessing on-board equipment foundations and supports.

Table 4 : Wave hull girder loads in each load case

Vessel condition	Load case	Vertical bending moment		Horizontal bending moment	
		Reference value	Combination factor	Reference value	Combination factor
Upright	"a"	M_{WV}	0,0	M_{WH}	0,0
	"b"	M_{WV}	1,0	M_{WH}	0,0
Inclined	"c"	M_{WV}	0,4	M_{WH}	1,0
	"d"	M_{WV}	0,4	M_{WH}	1,0

4.6 Inclined vessel condition during working (load cases "c" and "d")

4.6.1 This load case applies to vessels for dredging activities. Refer to [4.5] for vessel condition and encountered loads.

4.7 Summary of load cases

4.7.1 The wave local and hull girder loads to be considered in each load case are summarized in Tab 3 and Tab 4, respectively.

5 Range of navigation

5.1 General

5.1.1 The ranges of navigation considered in these Rules are defined in Pt A, Ch 2, Sec 3, [10].

5.2 Navigation coefficient n

5.2.1 The navigation coefficient to be used for the determination of vessel scantlings is to be obtain according to the following formula:

$n = 0{,}165\ H_S$

SECTION 2 HULL GIRDER LOADS

Symbols

C : Wave parameter, taken equal to:

$$C = n(10,7 - 0,023L)$$

d_{AV} : Distance of foremost cargo area bulkhead from fore end (FE), in m

d_{AR} : Distance of aftmost cargo area bulkhead from aft end (AE), in m

F : Loading factor equal to: $F = P / P_T$

$0,8 \le F \le 1,0$

k_i : Coefficients defined in Tab 1

L_{AR} : Distance of cargo from aft end, in m, taken equal to:

$L_{AR} = d_{AR} + X_{AR}$

L_{AV} : Distance of cargo from fore end, in m, taken equal to:

$L_{AV} = d_{AV} + X_{AV}$

L_i : Coefficients taken equal to:

$L_1 = 0,5\ L - \ell_1 - L_{AV}$

$L_2 = 0,5\ L - \ell_2 - L_{AR}$

$L_3 = 0,5\ L - 0,5\ L_1 - L_{AV}$

ℓ_i : Coefficients taken equal to:

$$l_1 = \frac{-k_3}{k_2}L$$

$$l_2 = \frac{-k_3}{k_4}L$$

M_H : Design still water bending moment in hogging condition, in kN.m

M_L : Bending moment, in kN·m, taken equal to:

$M_L = P_L\ (k_2\ L_3 + k_3\ L)$

M_S : Design still water bending moment in sagging condition, in kN.m

M_{WH} : Horizontal wave bending moment, in kN.m, defined in [3]

M_{WV} : Vertical wave bending moment, in kN.m, defined in [3]

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

P : Actual cargo weight, in t

P_L : Coefficient taken equal to:

$$P_L = \frac{0,77L_1}{L - L_{AR} - L_{AV}}FLBTC_B$$

P_T : Cargo weight, in t, corresponding to the vessel scantling draught T

R : Coefficient taken equal to:

$$R = \frac{L - L_{AV} - L_{AR}}{L}$$

R_{ij} : Coefficients taken equal to:

$$R_{11} = \frac{0,5L - L_{AV} - L_1}{L - L_{AV} - L_{AR}}$$

$$R_{12} = \frac{L_1}{0,5L - L_{AV} - L_1}$$

$$R_{21} = \frac{0,5L - L_{AR} - L_2}{L - L_{AV} - L_{AR}}$$

$$R_{22} = \frac{L_2}{0,5L - L_{AR} - L_2}$$

T : Scantling draught, in m, defined in Ch 1, Sec 2, [2.4]

X_{AV} : Distance of foremost cargo edge to foremost cargo area bulkhead

X_{AR} : Distance of aftmost cargo edge to aftmost cargo area bulkhead.

1 General

1.1 Design still water bending moments

1.1.1 The design still water bending moments, M_H and M_S, are to be provided by the designer, for all loading conditions considered.

All calculation documents are to be submitted to the Society.

1.1.2 If the design still water bending moments are not provided by the designer, their absolute values are not to be taken less than those derived from [2].

Table 1 : Coefficients k_i

Vessels	Conditions	k_2	k_3	k_4
Non-propelled	-	4,90	− 1,213	4,80
Self-propelled	Hogging	3,45	− 0,70	-
	Sagging	4,40	− 0,865	3,55

2 Estimated still water bending moments

2.1 General

2.1.1 The absolute values of the estimated still water bending moments are given by type of vessels in [2.2] to [2.6].

2.2 Non-propelled cargo carriers

2.2.1 The requirements of this Subarticle apply to non-propelled cargo carriers of characteristics listed hereafter:

- $0,80 \leq R \leq 0,92$
- $C_B \geq 0,92$
- $L \geq 35$ m

2.2.2 The hogging and sagging bending moments (amidships) in still water conditions are to be obtained, in kN.m, from formulae given in Tab 2.

2.3 Self-propelled cargo carriers

2.3.1 The requirements of this Subarticle apply to self-propelled cargo carriers with machinery aft, of characteristics listed hereafter:

- $0,60 \leq R \leq 0,82$
- $0,79 \leq C_B < 0,95$
- $L \geq 35$ m

2.3.2 The hogging and sagging bending moments (amidships) in still water conditions are to be obtained, in kN.m, from formulae given in Tab 3.

2.4 Hopper barges, split hopper barges, hopper dredgers and split hopper dredgers

2.4.1 The still water bending moments are to be as required in:

- [2.2.2] for hopper barges
- [2.3.2] for hopper dredgers,

considering the load case "Working" instead of "Harbour" (see Ch 3, Sec 1, [4]).

2.5 Tugs and pushers

2.5.1 This requirement applies to tugs and pushers whose engines are located amidships and whose bunkers are inside the engine room or adjoin it.

The still water bending moments (amidships), in kN.m, are to be determined using the following formulae:

- still water hogging bending moment:

$$M_H = 1,96\ L^{1,5}\ B\ D\ (1 - 0,9\ C_B)$$

- still water sagging bending moment:

$$M_S = 0,01\ L^2\ B\ T\ (\varphi_1 + \varphi_2)$$

where:

$$\varphi_1 = 5,5\left(0,6(1 + C_B) - \frac{X}{L}\right)$$

$$\varphi_2 = \frac{10\Phi}{L^2 B}$$

X : Length, in m, of the machinery space increased by the length of adjacent bunkers

Φ : Total brake power of the propelling installation, in kW.

2.6 Other vessels

2.6.1 The still water bending moments (amidships), in kN.m, for passenger vessels, launches and pleasure vessels with machinery aft are to be determined using the following formulae:

- still water hogging bending moment

$$M_H = 0,2\ L^2\ B^{1,48}\ D^{0,172}\ (1,265 - C_B)$$

- still water sagging bending moment

$$M_S = 0$$

Table 2 : Estimated still water bending moments of non-propelled cargo carriers

		Hogging	Sagging
Navigation		$M_H = 1,4\ L^{1,98}\ B^{0,8}\ D^{0,2}\ (1,01 - C_B)$	$M_S = F\ (M_{H0} + M_{0S}) - M_{H0}$
Harbour	**2R**	$M_H = M_{H0} + (M_S - M_{S0})$	$M_S = 0,65\ L\ B\ T^2\ C_B\ [R_{11}\ (0,52\ L - 1,84\ \ell_1)\ (1 - R_{12}) + F\ R_{21}\ (0,5\ L - 1,23\ \ell_2)]$
	1R	$M_H = M_{H0} + (M_S - M_{S0})$	$M_S = 0,65\ L\ B\ T^2\ C_B\ [R_{11}\ (0,52\ L - 1,84\ \ell_1)\ (1 - R_{12}) + 1,15\ F\ R_{21}\ (0,5\ L - 1,23\ \ell_2)]$

Note 1:
$M_{0S} = 1,4\ L\ B\ T^2\ C_B\ [R_{11}\ (0,52\ L - 1,84\ \ell_1)\ (1 - R_{12}) + R_{21}\ (0,5\ L - 1,23\ \ell_2)\ (1 - R_{22})]$
M_{H0} : Still water bending moment in hogging condition during navigation
M_{S0} : Still water bending moment in sagging condition during navigation

Table 3 : Estimated still water bending moments of self-propelled cargo carriers

		Hogging	Sagging
Navigation		$M_H = 0,2\ L^2\ B^{1,48}\ D^{0,172}\ (1,265 - C_B)$	$M_S = M_{S0}$
Harbour	**2R**	$M_H = M_{HH} + 0,5\ M_L$	$M_S = 0,9\ M_{S0} + 0,5\ M_L$
	1R	$M_H = M_{HH} + M_L$	$M_S = 0,9\ M_{S0} + M_L$
Note 1: $M_{HH} = 0,4\ L^2\ B^{1,2}\ D^{0,2}\ (1,198 - C_B)$ $M_{HS} = 0,4\ L^{1,9}\ B^{1,46}\ (0,712 - 0,622\ C_B)$ $M_{S0} = F\ M_{CS} - M_{HS}$ $M_{CS} = 0,4\ L^{1,86}\ B^{0,8}\ T^{0,48}\ (C_B - 0,47)\ [3,1 + R_{11}\ (10,68\ L - 53,22\ \ell_1)\ (1 - R_{12}) + R_{21}\ (0,17\ L - 0,15\ \ell_2)\ (1 - R_{22})]$			

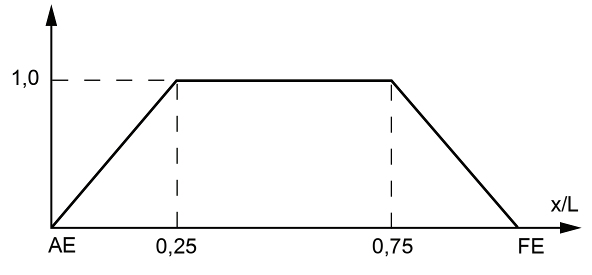
2.7 Distribution factor

2.7.1 Where estimated values of still water bending moments are used, their distribution factor F_{MT} along the hull girder is to be taken as defined in Tab 4 (see also Fig 1).

Table 4 : Distribution factor F_{MT}

Hull transverse section location	Distribution factor F_{MT}
$0 \le x < 0,25\ L$	$4\dfrac{x}{L}$
$0,25\ L \le x \le 0,75\ L$	1
$0,75\ L < x \le L$	$4\left(1 - \dfrac{x}{L}\right)$

Figure 1 : Distribution factor F_{MT}



3 Wave bending moments

3.1 General

3.1.1 As an alternative to the requirements in [3.2] and [3.3], the Society may accept the wave bending moment values obtained by direct calculations, when justified on the basis of the vessel's characteristics and intended service. The calculations are to be submitted to the Society for approval.

3.2 Vertical wave bending moment

3.2.1 An additional bending moment/wave bending moment taking into account the stream and water conditions in the navigation zone is to be considered.

- for range of navigation **IN**, the absolute value of the additional bending moment amidships is to be obtained, in kN.m, from the following formula:

  $M_{WV} = 0,045\ L^2\ B\ C_B$

- for range of navigation **IN(x ≤ 2)**, the absolute value of the vertical wave-induced bending moment amidships is to be obtained, in kN.m, from the following formula:

  $M_{WV} = 0,11\ C\ L^2\ B\ (C_B + 0,7)$

3.3 Horizontal wave bending moment

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

$$M_{WH} = C_{WH} F_{MT} \frac{n}{0,33} L^2 T C_B$$

where

C_{WH} : Horizontal wave coefficient

$C_{WH} = 0,895$

F_{MT} : Distribution factor defined in [3.4.1].

3.4 Distribution factor

3.4.1 The distribution factor F_{MT} of the wave bending moments along the hull girder is to be taken as defined in Tab 4 (see also Fig 1).

4 Vertical shear forces

4.1 General

4.1.1 The vertical still water and wave shear forces are to be provided by the designer.

4.2 Estimated value of the vertical shear force

4.2.1 If the values of the vertical shear forces are not provided by the designer, they are not to be taken less than, in kN:

$$T_s = \frac{\pi M}{L}$$

where:

M : Maximum vertical bending moment calculated according to:

- [2], for still water shear force
- [3.2], for wave shear force.

SECTION 3 VESSEL MOTIONS AND ACCELERATIONS

Symbols

A_P : Pitch amplitude, in rad, defined in [2.1.5]

A_R : Roll amplitude, in rad, defined in [2.1.4]

a_H : Heave acceleration, in m/s^2, defined in [2.1.3]

a_{SU} : Surge acceleration, in m/s^2, defined in [2.1.1]

a_{SW} : Sway acceleration, in m/s^2, defined in [2.1.2]

D : Depth, in m, defined in Ch 1, Sec 2, [2.3]

H_W : Wave parameter:

$$H_W = \frac{n}{0,33}\left(\frac{L}{L_{ref}}\right)^{-3}$$

L_{ref} : Reference length, in m

$$L_{ref} = 33,7$$

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

T_P : Pitch period, in s, defined in [2.1.5]

T_{SW} : Sway period, in s, defined in [2.1.2]

T_R : Roll period, in s, defined in [2.1.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Ch 3, Sec 1, [2.4.3]

V : Maximum ahead service speed, in km/h

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 2, [3.1]

α_P : Pitch acceleration, in rad/s^2, defined in [2.1.5]

α_Y : Yaw acceleration, in rad/s^2, defined in [2.1.6]

α_R : Roll acceleration, in rad/s^2, defined in [2.1.4]

Δ : Vessel's displacement, in ton.

1 General

1.1 General considerations

1.1.1 Vessel motions and accelerations are defined, with their signs, according to the reference co-ordinate system in Ch 1, Sec 2, [3.1].

1.1.2 Vessel motions and accelerations are assumed to be periodic. The motion amplitudes, defined by the formulae in this Section, are half of the crest to through amplitudes.

1.1.3 As an alternative to the formulae in this Section, the Society may accept the values of vessel motions and accelerations derived from direct calculations or obtained from model tests, when justified on the basis of the vessel's characteristics and intended service. In general, the values of vessel motions and accelerations to be determined are those which can be reached with a probability level of 10^{-5}. In any case, the model tests or the calculations, including the assumed sea scatter diagrams and spectra, are to be submitted to the Society for approval.

2 Vessel motions and accelerations

2.1 Vessel absolute motions and accelerations

2.1.1 Surge

The surge acceleration a_{SU} is obtained, in m/s^2, from the formula in Tab 3.

2.1.2 Sway

The sway acceleration a_{SW} is obtained, in m/s^2, from the formula in Tab 3. The sway period T_{SW} is obtained from the following formula:

$$T_{SW} = \frac{0,8\sqrt{L}}{0,1\frac{V}{\sqrt{L}} + 1}$$

2.1.3 Heave

The heave acceleration a_H is obtained, in m/s^2, from the formula in Tab 3.

2.1.4 Roll

The roll amplitude A_R, period T_R and acceleration α_R are obtained from the formulae in Tab 1.

2.1.5 Pitch

The pitch acceleration α_P is obtained, in rad/s^2, from the formula in Tab 3.

The pitch period T_P is obtained, in s, from the following formula:

$$T_P = 0,575\sqrt{L}$$

The pitch amplitude A_P is obtained, in rad, from the following formula:

$$A_P = \alpha_P\left(\frac{T_P}{2\pi}\right)^2$$

2.1.6 Yaw

The yaw acceleration α_Y is obtained, in rad/s^2, from the formula in Tab 3.

2.2 Vessel relative motions

2.2.1 The reference value of the relative motion in the upright condition h_1, in m, is obtained at any hull transverse section, from the following formulae:

a) **IN**

$h_1 = 0,3$ m

b) **IN(x ≤ 2)**

$$h_1 = h_2 - A_R \frac{B_W}{2}$$

h_2 : Reference value, in m, of the relative motion in the inclined vessel condition, calculated according to Tab 4

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

2.2.2 For **IN**, the reference value of the relative motion in the inclined vessel condition at any hull transverse section, is $h_2 = 0,3$ m.

For **IN(x ≤ 2)**, the reference value of the relative motion in the inclined vessel condition is obtained at any hull transverse section, from the formulae in Tab 4.

Table 1 : Roll amplitude, period and acceleration

Amplitude A_R in rad	Period T_R in s	Acceleration α_R in rad/s^2
$A_R = \frac{n}{0,33}\left(\sqrt{\frac{GM}{\delta}} + 0,9\right)\frac{T_1}{B}\frac{6,3}{\sqrt[3]{\Delta}}$	$2C_a\frac{\delta}{\sqrt{GM}}$	$A_R\left(\frac{2\pi}{T_R}\right)^2$

C_a : Added mass coefficient

$$C_a = 1,066 + 0,066\frac{B}{T_1} - 0,123\frac{L}{100}$$

δ : Roll radius of gyration, in m, for the loading condition considered, when δ is not known, the following value may be assumed:
- full load: $\delta = 0,35B$
- lightship: $\delta = 0,40B$

GM : Distance, in m, from the vessel's centre of gravity to the transverse metacentre, for the loading considered; when GM is not known, the following value may be assumed:

$$GM = \frac{C_{GM}B^2}{12T_1C_B} + 0,5T_1 - KG$$

C_{GM} : GM coefficient to be taken equal to:
- full load: $C_{GM} = 0,95$
- lightship: $C_{GM} = 0,82$

KG : Height, in m, of the vessel's centre of gravity above keel. When KG is unknown, it may be assumed according to Tab 2

T_1 : Draught associated with each cargo and ballast distribution, defined in Ch 3, Sec 1, [2.4.3].

Table 2 : Height of the vessel's centre of gravity above keel KG

Vessel type	KG	
	Full load	Lightship
Tanker	0,64 D	0,57 D
Container vessel	0,71 D	0,54 D
Pontoon	1,20 D	0,59 D
Passenger vessel	1,10 D	1,10 D
Tug/Pusher	0,73 D	0,73 D
Others	0,64 D	0,54 D

Table 3 : Vessel accelerations

$$X = \frac{1}{\mu}H_w L^{(k-1)}\Gamma$$

X	μ	k	Γ
a_{SU}	1471	3	$1,90\left(\frac{1}{B}\right)^{0,30}\left(\frac{1}{T_1}\right)^{0.10}$
a_{SW}	911	3	$0,30\left(\frac{L}{B}\right)^{0,50}\left(\frac{L}{T_1}\right)^{0,15}$
a_H	261	3	$1,50\left(\frac{1}{B}\right)^{0,25}T_1^{0,05}$
α_P	64	2	$7\left(\frac{1}{B}\right)\left(\frac{1}{T_1}\right)^{0,05}$
α_Y	368	2	$0,18\left(\frac{L}{B}\right)T_1^{0,25}$

Table 4 : Reference value of the relative motion h_2 in the inclined vessel condition

Location	Reference value of the relative motion h_2 in the inclined vessel condition, in m
$0 \le x \le 0,75L$	$\frac{n}{0,33}\left[\left(0,63 - \frac{2,5L}{1000}\right) + (BT_1)^{0,14}\right]$
$0,75L < x < L$	$h_{2,FC} + \frac{h_{2,FE} - h_{2,FC}}{0,25}\left(\frac{x}{L} - 0,75\right)$
$x = L$	$\frac{n}{0,33}\frac{12}{\sqrt[3]{L}}$

$h_{2,FC}$: Reference value h_2 calculated for x = 0,75 L

$h_{2,FE}$: Reference value h_2 calculated for x = L

2.3 Vessel relative accelerations

2.3.1 Definition

At any point, the accelerations in X, Y and Z direction are the acceleration components which result from the vessel motions defined from [2.1.1] to [2.1.6].

2.3.2 Vessel conditions

Vessel relative motions and accelerations are to be calculated considering the vessel in the following conditions:

- Upright vessel condition

in this condition, the vessel encounters waves which produce vessel motions in the X-Z plane, i.e. surge, heave and pitch

- Inclined vessel condition

in this condition, the vessel encounters waves which produce vessel motions in the X-Y and Y-Z planes, i.e. sway, heave, roll and yaw.

2.3.3 Accelerations

For **IN**, the reference values of the accelerations at any hull transverse section are to be taken equal to:

$a_X = a_Y = a_Z = 0$

For **IN(x ≤ 2)**, the reference values of the longitudinal, transverse and vertical accelerations at any point are obtained from the formulae in Tab 5 for upright and inclined vessel conditions.

Table 5 : Reference value of the accelerations a_X, a_Y and a_Z

Direction	Upright vessel condition	Inclined vessel condition
X - Longitudinal a_{x1} and a_{x2} in m/s²	$a_{X1} = \sqrt{a_{SU}^2 + [9,81 A_P + \alpha_P(z - T_1)]^2}$	$a_{X2} = 0$
Y - Transverse a_{y1} and a_{y2} in m/s²	$a_{Y1} = 0$	$a_{Y2} = \sqrt{a_{SW}^2 + [9,81 A_R + \alpha_R(z - T_1)]^2 + \alpha_Y^2 K_X L^2}$
Z - Vertical a_{z1} and a_{z2} in m/s²	$a_{Z1} = \sqrt{a_H^2 + \alpha_P^2 K_X L^2}$	$a_{Z2} = \sqrt{0,25 a_H^2 + \alpha_R^2 y^2}$

Note 1:

K_X : Coefficient defined as:

$$K_X = 1,2\left(\frac{x}{L}\right)^2 - 1,1\frac{x}{L} + 0,2 \geq 0,018$$

T_1 : Draught, in m, defined in Ch 3, Sec 1, [2.4.3].

SECTION 4 LOCAL LOADS

Symbols

a_{X1}, a_{Y1}, a_{Z1} : Reference values of the accelerations in the upright vessel condition, defined in Ch 3, Sec 3, [2.3], calculated in way of the centre of gravity:
- of the compartment, in general
- of any dry unit cargo, in the case of this type of cargo

a_{X2}, a_{Y2}, a_{Z2} : Reference values of the accelerations in the inclined vessel condition, defined in Ch 3, Sec 3, [2.3], calculated in way of the center of gravity:
- of the compartment, in general
- of any dry unit cargo, in the case of this type of cargo

C_{FA} : Combination factor, to be taken equal to
- C_{FA} = 0,7 for load case "c"
- C_{FA} = 1,0 for load case "d"

d_{AP} : Distance from the top of the air pipe to the top of the tank, in m, see Fig 1

g : Gravitational acceleration:

$$g = 9,81 \text{ m/s}^2$$

h_1 : Reference value of the relative motion defined in Ch 3, Sec 3, [2.2.1]

h_2 : Reference value of the relative motion defined in Ch 3, Sec 3, [2.2.1]

L_H : Length, in m, of the hold, to be taken as the longitudinal distance between the transverse bulkheads which form boundaries of the hold considered

m_B : Mass of dry bulk cargo, in t, in the hold considered

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design pressure, in kN/m²

p_{pv} : Setting pressure, in kN/m², of safety valves or maximum pressure, in kN/m², in the tank during loading/unloading, whichever is the greater

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Ch 3, Sec 1, [2.4.3]

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 2, [3.1]

z_{AP} : Z co-ordinate, in m, of the top of air pipe, (see Fig 1): $z_{AP} = z_{TOP} + d_{AP}$

z_H : Z co-ordinate, in m, of the bottom or inner bottom

z_L : z co-ordinate, in m, of the highest point of the liquid: $z_L = z_{TOP} + 0,5\ (z_{AP} - z_{TOP})$

z_{TOP} : Z co-ordinate, in m, of the highest point of the tank or compartment, see Fig 1

γ_{WB} : Factor taken as:
- γ_{WB} = 1, in general
- γ_{WB} = 1,6 for buckling and ultimate strength check according to Ch 2, Sec 7, when **IN(x ≤ 2)** is assigned

γ_{W2} : Partial safety factor covering uncertainties on wave local loads defined in Ch 5, Sec 1, [1.3]

φ_B : Dry bulk cargo angle of repose

ρ : River/sea water density, in t/m³

ρ_L : Density, in t/m³, of the liquid carried

ρ_B : Dry bulk cargo density, in t/m³.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the definition of local loads to be used for the scantling checks of:
- platings
- ordinary stiffeners
- primary supporting members.

2 External pressure

2.1 Pressure on sides and bottom

2.1.1 External still water pressure

The external still water pressure p_{SE} at any point of the hull, in kN/m², is given by the formula:

$$p_{SE} = \rho g\ (T_1 - z)$$

2.1.2 External wave pressure

The wave pressure p_{WE} at any point of the hull, in kN/m², is to be obtained from the formulae given in:
- Tab 1 (see Fig 3) for the upright vessel condition (load case "b").
- Tab 2 (see Fig 4 and Fig 5) for the inclined vessel condition (load cases "c" and "d").

Figure 1 : Definitions

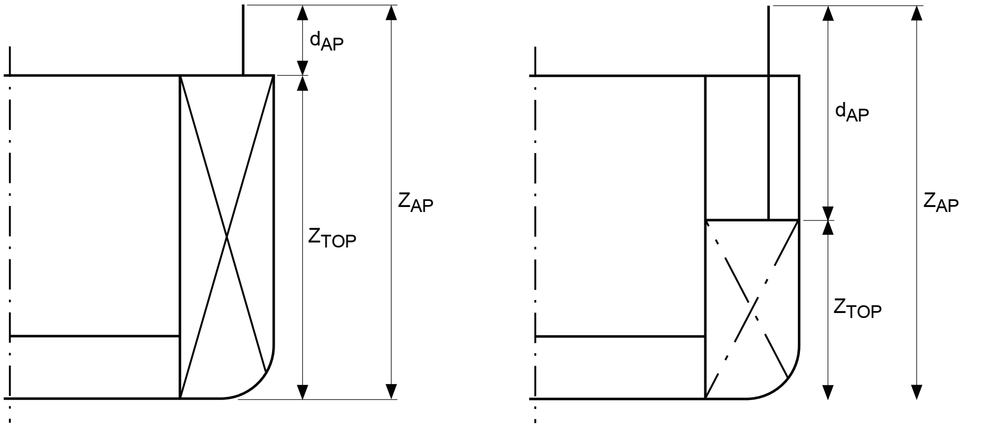


Table 1 : Wave pressure on sides and bottom in upright vessel conditions (load case "b")

Location	Wave pressure p_{WE}, in kN/m²	
	Crest (positive h_1)	Trough (negative h_1)
Bottom and sides below the waterline ($z \le T_1$)	$\rho g h_1 e^{\frac{-2\pi(T_1 - z)}{L}}$	$-\rho g h_1 e^{\frac{-2\pi(T_1 - z)}{L}}$ without being taken less than $\rho\ g\ (z - T_1)$
Sides above the waterline ($z > T_1$)	$\rho g\left(\frac{(T_1 - z)}{\gamma_{WB}} + h_1\right)$ without being taken less than: $(2 + p_{WD})/\gamma_{W2}$	0

Note 1: Wave pressure in way of wave trough is to be used only for the calculation of the external counter pressure p_{Em}

P_{WD} : Wind pressure defined in [2.1.3]

Table 2 : Wave pressure on sides, bottom in inclined vessel conditions (load cases "c" and "d")

Location	Wave pressure p_{WE}, in kN/m² (negative roll angle) **(1)**	
	$y \ge 0$	$y < 0$
Bottom and sides below the waterline ($z \le T_1$)	$C_{F2}\rho g\frac{2y}{B_W}h_2 e^{\frac{-2\pi(T_1 - z)}{L}}$	$C_{F2}\rho g\frac{2y}{B_W}h_2 e^{\frac{-2\pi(T_1 - z)}{L}}$ without being taken less than $\rho\ g\ (z - T_1)$
Sides above the waterline ($z > T_1$)	$\rho g\left[\frac{(T_1 - z)}{\gamma_{WB}} + C_{F2}\frac{2y}{B_W}h_2\right]$ without being taken less than $(2 + p_{WD})/\gamma_{W2}$	0

(1) In the formulae giving the wave pressure p_W, the ratio (y / B_W) is not to be taken greater than 0,5.

C_{F2} : Combination factor, to be taken equal to:

- C_{F2} = 1,0 for load case "c"
- C_{F2} = 0,5 for load case "d"

P_{WD} : Wind pressure defined in [2.1.3]

Figure 2 : External still water pressure

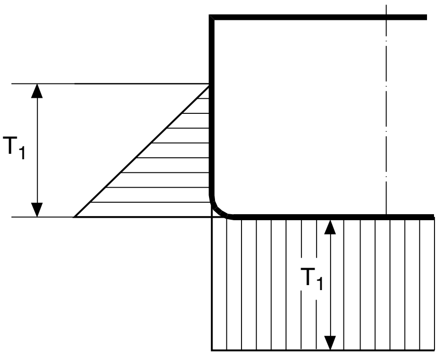


Figure 3 : Wave pressure in load case "b"

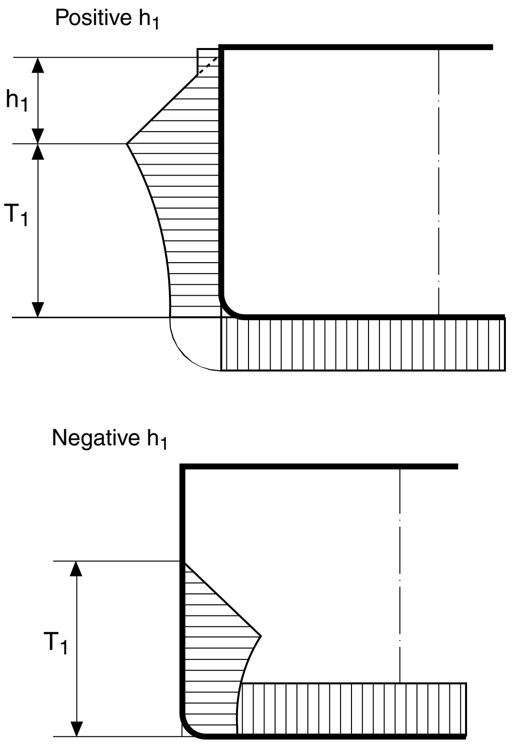


Figure 4 : Wave pressure in load case "c"

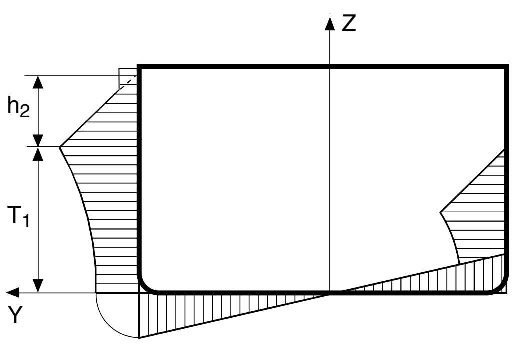
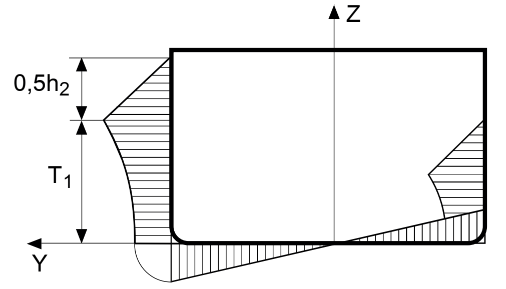


Table 3 : Wind pressure p_{WD}

Range of navigation	p_{WD} , in kN/m²
IN(x ≤ 2)	0,25(1+ n)
IN	0,25

Figure 5 : Wave pressure in load case "d"



2.1.3 Wind pressure

The wind pressure p_{WD}, in kN/m² is to be determined according to Tab 3.

2.2 Pressure on exposed decks

2.2.1 External pressure on the weather deck

The weather pressure p_E, in kN/m², transmitted to the hull structure is given by the formula:

$$p_E = 3,75\ (5,15\ y + 0,8)$$

where:

y : Coefficient to be taken as:

- Range of navigation **IN**:
  $y = 0,099$
- Range of navigation **IN(x ≤ 2)**:
  $y = n$

2.2.2 Pressure due to load carried

The pressure p_D, in kN/m², transmitted to the hull structure is the combination of the still water pressure p_S and the wave pressure p_W.

The still water pressure p_S is to be provided by the designer. Otherwise, it is not to be taken less than the values defined in Tab 4. The wave pressure p_W is defined in Tab 5.

Table 4 : Still water pressure on exposed decks

Deck location/type	p_S, in kN/m²
Weather deck, trunk	3,0
First tier (non public)	2,0
Upper tiers (non public)	1,5
Public	4,0

Table 5 : Inertial pressure on exposed decks

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright (positive heave motion)	"a"	No inertial pressure
	"b"	$p_W = p_S \dfrac{a_{Z1}}{g}$
Inclined	"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the inertial pressure transmitted to the deck structures in inclined condition may generally be disregarded. See also Ch 3, Sec 1, [4.5.1]
	"d"	

3 Internal loads

3.1 Liquids

3.1.1 Still water pressure

The still water pressure p_S is to be obtained, in kN/m², from the following formulae:

- liquid cargo:

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

  $p_S = \rho_L\, g\, (z_{TOP} - z) + 1{,}15\, p_{pv}$

- ballast:

  $p_S = \rho g\, (z_{TOP} - z + d_{AP})$

3.1.2 Inertial pressure

The inertial pressure p_W is to be obtained, in kN/m², from the formulae in Tab 6.

In addition, p_W should be taken such that $p_S + p_W \geq 0$

Table 6 : Watertight bulkheads of liquid compartments - Inertial pressure

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright	"a"	No inertial pressure
	"b"	$\rho_L[0,5\, a_{X1}\, \ell_B + a_{Z1}(z_{TOP} - z)]$
Inclined (negative roll angle)	"c"	$\rho_L\left[a_{TY}(y - y_H) + a_{TZ}(z - z_H) + \dfrac{g}{\gamma_{WB}}(z - z_{TOP})\right]$
	"d"	

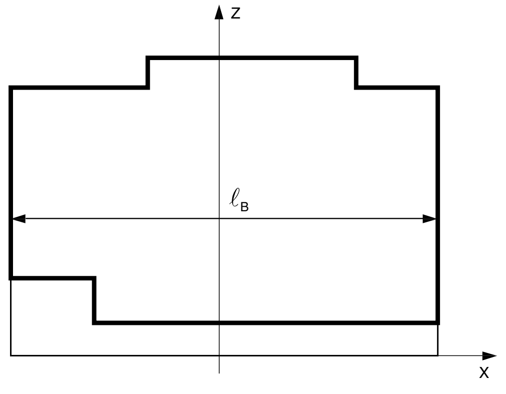
Note 1:

ℓ_B : Longitudinal distance, in m, between the transverse tank boundaries, without taking into account small recesses in the lower part of the tank (see Fig 6)

a_{TY}, a_{TZ} : Y and Z components, in m/s², of the total acceleration vector defined in [3.1.3] for load case "c" and load case "d"

y_H, z_H : Y and Z co-ordinates, in m, of the highest point of the tank in the direction of the total acceleration vector, defined in [3.1.4] for load case "c" and load case "d".

Figure 6 : Distance ℓ_B



3.1.3 Total acceleration vector

The total acceleration vector is the vector obtained from the following formula:

$$\vec{A_T} = \vec{A} + \vec{G}$$

where:

A : Acceleration vector whose absolute values of X, Y and Z components are the longitudinal, transverse and vertical accelerations defined in Ch 3, Sec 3, [2.3.3]

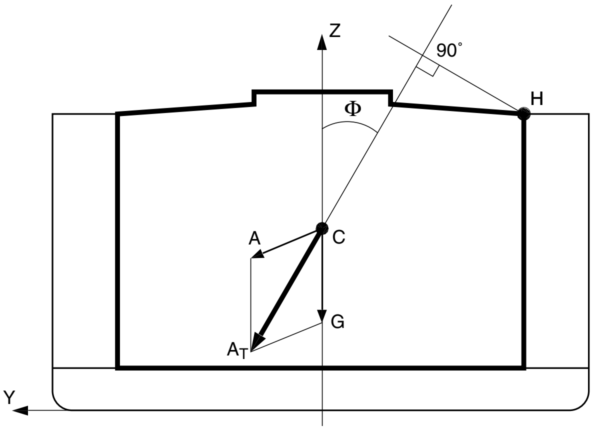
G : Gravity acceleration vector.

The Y and Z components of the total acceleration vector and the angle it forms with the z direction are defined in Tab 7.

Table 7 : Inclined vessel conditions Y and Z components of the total acceleration vector and angle Φ it forms with the z direction

Components (negative roll angle)		Angle Φ, in rad
a_{TY}, in m/s²	a_{TZ}, in m/s²	
$0{,}7\, C_{FA}\, a_{Y2}$	$-0{,}7\, C_{FA}\, a_{Z2} - g$	$\operatorname{atan}\dfrac{a_{TY}}{a_{TZ}}$

Figure 7 : Inclined vessel conditions Highest point H of the tank in the direction of the total acceleration vector



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

The highest point of the tank in the direction of the total acceleration vector A_T, defined in [3.1.3], is the point of the tank boundary whose projection on the direction forming the angle Φ with the vertical direction is located at the greatest distance from the tank's centre of gravity. It is to be determined for the inclined vessel condition, as indicated in Fig 7, where A and G are the vectors defined in [3.1.3] and C is the tank's centre of gravity.

3.2 Dry bulk cargoes

3.2.1 Pressure on side (or inner side) and bulkhead structures

The pressure p_C, in kN/m² transmitted to side (or inner side) and bulkhead structures is to be obtained using the formula:

$$p_C = \left(\frac{D - z}{D - z_H}\right) p_0$$

where:

p_0 : Mean total pressure on bottom or inner bottom, in kN/m²: $p_0 = p_S + p_W \geq 0$

p_S : Mean still water pressure on bottom or inner bottom, in kN/m²:

$$p_S = \frac{g\, m_B}{L_H B_1}$$

p_W : Mean inertial pressure on bottom or inner bottom is obtained, in kN/m², as specified in Tab 8.

Table 8 : Dry bulk cargoes Inertial pressure for side and inner side

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright	"a"	No inertial pressure
	"b"	$p_W = \frac{a_{Z1} m_B}{L_H B_1}$
Inclined	"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the inertial pressure transmitted to the hull structures in inclined condition may generally be disregarded. See also Ch 3, Sec 1, [4.5.1]
	"d"	
Note 1: B_1 : Breadth, in m, of the hold		

Table 9 : Dry bulk cargoes Inertial pressure for bottom and inner bottom

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright	"a"	No inertial pressure
	"b"	$p_W = a_{Z1}\sqrt{\rho_B \tan\varphi_B \frac{m_B}{L_H}}$
Inclined	"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the inertial pressure transmitted to the hull structures in inclined condition may generally be disregarded. See also Ch 3, Sec 1, [4.5.1]
	"d"	

3.2.2 Bottom or inner bottom still water design pressure

The bottom or inner bottom still water design pressure p_S is obtained, in kN/m², from the following formula:

$$p_S = g\sqrt{\rho_B \tan\varphi_B \frac{m_B}{L_H}}$$

3.2.3 Bottom or inner bottom inertial design pressure

The bottom or inner bottom inertial design pressure p_W is obtained, in kN/m², as specified in Tab 9:

3.3 Dry uniform cargoes

3.3.1 Design pressure

The design pressure p_C, in kN/m², is the combination of the still water pressure p_S, to be defined by the Designer and the inertial pressure p_W, defined in Tab 10.

3.4 Dry unit cargoes

3.4.1 The force F, in kN, transmitted to the hull structure is the combination of the still water force, F_S and the inertial force, F_W defined in [3.4.2] and [3.4.3], respectively.

Account is to be taken of the elastic characteristics of the lashing arrangement and/or the structure which contains the cargo.

Table 10 : Dry uniform cargoes - Inertial pressure

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright (positive heave motion)	"a"	No inertial pressure
	"b"	$p_{W,Z} = p_S \frac{a_{Z1}}{g}$ in z direction
Inclined (negative roll angle)	"c"	$p_{W,Y} = p_S \frac{C_{FA} a_{Y2}}{g}$ in y direction
	"d"	$p_{W,Z} = p_S \frac{C_{FA} a_{Z2}}{g}$ in z direction

Table 11 : Dry unit cargoes Inertial forces

Vessel condition	Load case	Inertial force F_W, in kN
Upright (positive heave motion)	"a"	No inertial force
	"b"	$F_{W,X} = m_C\, a_{X1}$ in x direction $F_{W,Z} = m_C\, a_{Z1}$ in z direction
Inclined (negative roll angle)	"c"	$F_{W,Y} = m_C\, C_{FA}\, a_{Y2}$ in y direction
	"d"	$F_{W,Z} = m_C\, C_{FA}\, a_{Z2}$ in z direction
Note 1: m_C : Mass, in t, as defined in [3.4.2].		

3.4.2 Still water force

The still water force F_S transmitted to the hull structure is to be determined on the basis of the force obtained, in kN, from the following formula:

$F_S = g\, m_C$

where m_C is the mass, in t, of the dry unit cargo.

3.4.3 Inertial forces

The inertial forces F_W are to be obtained, in kN, from Tab 11.

3.5 Wheeled cargoes

3.5.1 Tyred vehicles

The forces transmitted through the tyres are considered as pressure uniformly distributed on the tyre print, whose dimensions are to be indicated by the designer together with information concerning the arrangement of wheels on axles, the load per axle and the tyre pressures.

With the exception of dimensioning of plating, such forces may be considered as concentrated in the tyre print centre.

3.5.2 Non-tyred vehicles

The requirements of [3.5.4] also apply to tracked vehicles; in this case the print to be considered is that below each wheel or wheelwork.

For vehicles on rails, all the forces transmitted are to be considered as concentrated at the contact area centre.

3.5.3 The force F, in kN, transmitted to the hull structure is the combination of the still water force, F_S and the inertial force, F_W defined in [3.5.4] and [3.5.5], respectively.

3.5.4 Still water force

The still water force F_S transmitted to the hull structure by one wheel is to be determined on the basis of the force obtained, in kN, from the formula:

$F_s = g\ m_C$

where:

$m_C = Q_A / n_w$

Q_A : Axle load, in t. For fork-lift trucks, the value of Q_A is to be taken equal to the total mass of the vehicle, including that of the cargo handled, applied to one axle only

n_w : Number of wheels for the axle considered.

3.5.5 Inertial forces

The inertial forces F_W are to be obtained, in kN, from Tab 12.

3.6 Accommodation

3.6.1 The pressure, p_D, in kN/m², is the combination of the still water pressure p_S and the inertial pressure p_W, defined in [3.6.2] and [3.6.3], respectively.

3.6.2 Still water pressure

The still water pressure p_S, in kN/m², transmitted to the deck structure is to be defined by the designer and, in general, is not to be taken less than values given in Tab 13.

3.6.3 Inertial pressure

The deck inertial pressure p_W is to be obtained, in kN/m², from Tab 14.

Table 12 : Wheeled cargoes - Inertial forces F_W

Vessel condition	Load case	Inertial force F_W, in kN
Upright (positive heave motion)	"a"	No inertial force
	"b"	$F_{W,X} = m_C\ a_{X1}$ in x direction $F_{W,Z} = m_C\ a_{Z1}$ in z direction
Inclined (negative roll angle)	"c"	$F_{W,Y} = m_C\ C_{FA}\ a_{Y2}$ in y direction
	"d"	$F_{W,Z} = m_C\ C_{FA}\ a_{Z2}$ in z direction
Note 1: m_C : Mass, in t, as defined in [3.5.4].		

Table 13 : Minimum deck still water pressure p_S in accommodation compartments

Type of accommodation compartment	p_S, in kN/m²
Large spaces (such as: restaurants, halls, cinemas, lounges, kitchen, service spaces, games and hobbies rooms, hospitals)	4,0
Cabins	3,0
Other compartments	2,5

Table 14 : Accommodation - Inertial pressure

Vessel condition	Load case	Inertial pressure p_W, in kN/m²
Upright (positive heave motion)	"a"	No inertial pressure
	"b"	$p_W = p_S \dfrac{a_{Z1}}{g}$
Inclined	"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the inertial pressure transmitted to the hull structures in inclined condition may generally be disregarded. See also Ch 3, Sec 1, [4.5.1]
	"d"	

4 Flooding pressure

4.1 Still water pressure

4.1.1 On vessels required to comply with damage stability, the still water pressure p_{FL} to be considered as acting on platings and stiffeners of watertight bulkheads of compartments not intended to carry liquids is obtained, in kN/m², from the following formula:

$p_{FL} = \rho g\ d_F$

where:

d_F : Distance, in m, from the calculation point to the deepest waterline to be provided by the designer. Where the location of the deepest waterline is not known, d_F will be taken as:

$d_F = D - z$

5 Testing pressures

5.1 Still water pressures

5.1.1 The still water pressures p_{ST} to be considered as acting on plates and stiffeners subject to tank testing are specified in Tab 15.

Table 15 : Testing - Still water pressure p_{ST}

Compartment or structure to be tested	Still water pressure p_{ST}, in kN/m²
Double bottom tanks Double side tanks Fore peaks used as tank After peaks used as tank	$p_{ST} = g\ [(z_{TOP} - z) + d_{AP}]$ $p_{ST} = g\ [(z_{TOP} - z) + 1]$ whichever is the greater
Cargo tank bulkheads Deep tanks Independent cargo tanks Fuel oil tanks	$p_{ST} = g\ [(z_{TOP} - z) + d_{AP}]$ $p_{ST} = g\ [(z_{TOP} - z) + 1]$ $p_{ST} = g\ (z_{TOP} - z) + 1{,}3\ p_{pv}$ whichever is the greater
Ballast compartments Cofferdams	$p_{ST} = g\ [(z_{TOP} - z) + d_{AP}]$ $p_{ST} = g\ [(z_{TOP} - z) + 1]$ whichever is the greater
Double bottom Fore peaks not used as tank After peaks not used as tank	$p_{ST} = g\ (z_{AP} - z)$
Other independent tanks	$p_{ST} = g\ [(z_{TOP} - z) + d_{AP}]$

Part B
Hull Design and Construction

Chapter 4
GLOBAL STRENGTH ANALYSIS - METALLIC HULLS

SECTION 1 LONGITUDINAL HULL GIRDER STRENGTH ANALYSIS

SECTION 2 TRANSVERSE STRENGTH ANALYSIS FOR MULTIHULLS

SECTION 1 LONGITUDINAL HULL GIRDER STRENGTH ANALYSIS

Symbols

k : Material factor defined in Ch 2, Sec 3, [2.3], for steel hulls and Ch 2, Sec 3, [3.5]. for aluminium hulls

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

Z : Hull girder section modulus, in cm^3.

1 General

1.1 Application

1.1.1 This Section specifies:

- the criteria for calculating the hull girder strength characteristics to be used for the checks, in association with the hull girder loads
- the yielding strength check criteria.

1.2 Length-to-depth ratio - Steel hulls

1.2.1 In principle, the length-to-depth ratio is not to exceed the following values:

- for **IN(1,2 ≤ x ≤ 2)**: L / D = 25
- for **IN(x < 1,2)**: L / D = 38(1-1,7n)
- for **IN**: L / D = 35.

Vessels having a different ratio will be considered by the Society on a case by case basis.

1.3 Length-to-depth ratio - Aluminium alloy hulls

1.3.1 For vessels with a rule length equal to or greater than 40 m, the length-to-depth ratio will be specially considered by the Society.

2 Characteristics of the hull girder transverse sections

2.1 Hull girder transverse sections

2.1.1 General

The hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder longitudinal strength, i.e. all continuous longitudinal members below the strength deck defined in [2.2], taking into account the requirements of [2.1.2] to [2.1.8].

2.1.2 Continuous trunks and continuous longitudinal hatch coamings

Continuous trunks and continuous longitudinal hatch commons may be included in the hull girder transverse sections, provided they are effectively supported by longitudinal bulkheads or primary supporting members.

2.1.3 Longitudinal ordinary stiffeners or girders welded above the decks

Longitudinal ordinary stiffeners or girders welded above the decks (including the deck of any trunk fitted as specified in [2.1.2]) may be included in the hull girder transverse sections.

2.1.4 Longitudinal bulkheads with vertical corrugations

Longitudinal bulkheads with vertical corrugations may not be included in the hull girder transverse sections.

2.1.5 Members in materials other than steel

Where a member contributing to the longitudinal strength is made in material other than steel with a Young's modulus E equal to 2,06 10^5 N/mm², the steel equivalent sectional area that may be included in the hull girder transverse sections is obtained, in m², from the following formula:

$$A_{SE} = \frac{E}{2{,}06.10^5} A_M$$

where:

A_M : Sectional area, in m², of the member under consideration.

2.1.6 Large openings and scallops

Large openings are:

- in the side shell plating: openings having a diameter greater than or equal to 300 mm
- in the strength deck: openings having a diameter greater than or equal to 350 mm.

Large openings and scallops, where scallop welding is applied, are always to be deducted from the sectional areas included in the hull girder transverse sections.

2.1.7 Small openings

Individual small openings which do not comply with the arrangement requirements given in Ch 5, Sec 4, [3.4], are to be deducted from the sectional areas included in the hull girder transverse sections.

2.1.8 Lightening holes, draining holes and single scallops

Lightening holes, draining holes and single scallops in longitudinals or girders need not be deducted if their height is less than 0,25 h_W, without being greater than 75 mm, where h_W is the web height, in mm.

Otherwise, the excess is to be deducted from the sectional area or compensated.

2.2 Strength deck

2.2.1 The strength deck is, in general, the uppermost continuous deck.

In the case of a superstructure or deckhouses contributing to the longitudinal strength, the strength deck is the deck of the superstructure or the deck of the uppermost deckhouse.

Superstructures and deckhouses are deck erections defined in Ch 1, Sec 2, [2.8] and Ch 1, Sec 2, [2.9].

2.2.2 A superstructure extending at least 0,15 L within 0,4 L amidships may generally be considered as contributing to the longitudinal strength. For other superstructures and for deckhouses, their contribution to the longitudinal strength is to be assessed on a case by case basis, through a finite element analysis of the whole ship, which takes into account the general arrangement of the longitudinal elements (side, decks, bulkheads).

The presence of openings in the side shell and longitudinal bulkheads is to be taken into account in the analysis. This may be done in two ways:

- by including these openings in the finite element model
- by assigning to the plate panel between the side frames beside each opening an equivalent thickness, in mm, obtained from the following formula:

$$t_{EQ} = 10^3\left[\ell_P\left(\frac{Gh^2}{12EI_J}+\frac{1}{A_J}\right)\right]^{-1}$$

where (see Fig 1):

ℓ_P : Longitudinal distance, in m, between the frames beside the opening

h : Height, in m, of openings

I_J : Moment of inertia, in m^4, of the opening jamb about the transverse axis y-y (jamb stiffeners included)

A_J : Shear area, in m^2, of the opening jamb in the direction of the longitudinal axis x-x (jamb stiffeners not included)

G : Coulomb's modulus, in N/mm^2, of the material used for the opening jamb, to be taken equal to:

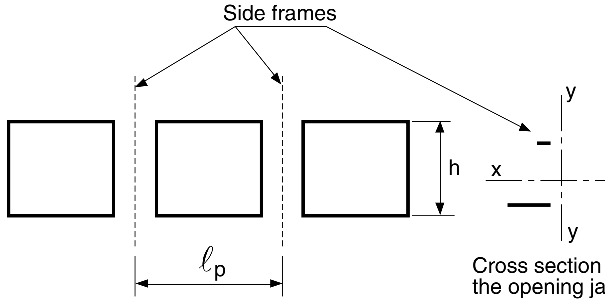
- for steels:

  $G = 8{,}0.10^4$ N/mm^2

- for aluminium alloys:

  $G = 2{,}7.10^4$ N/mm^2.

Figure 1 : Side openings



2.3 Hull girder section modulus

2.3.1 The section modulus at any point of a hull transverse section is obtained, in cm^3, from the following formula:

$$Z = \frac{I_Y}{100|z-N|}$$

where:

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in [2.1], about its horizontal neutral axis

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

z : Z co-ordinate, in m, of the calculation point of a structural element.

2.3.2 The section moduli at bottom and at deck are obtained, in m^3, from the following formulae:

- at bottom:

$$Z = \frac{I_Y}{N}$$

- at deck:

$$Z = \frac{I_Y}{V_D}$$

where:

I_Y, N : Defined in [2.3.1]

V_D : Vertical distance, in m:

- in general:

  $V_D = z_D - N$

- if continuous trunks or hatch coamings are taken into account in the calculation of I_Y:

$$V_D = (z_T - N)\left(0{,}9 + 0{,}2\frac{y_T}{B}\right) \geq z_D - N$$

- if longitudinal ordinary stiffeners or girders welded above the strength deck are taken into account in the calculation of I_Y, V_D is to be obtained from the formula given above for continuous trunks and hatch coamings. In this case, y_T and z_T are the Y and Z co-ordinates, in m, of the top of the longitudinal stiffeners or girders with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [3].

z_D : Z co-ordinate, in m, of strength deck with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [3]

y_T, z_T : Y and Z co-ordinates, in m, of the top of continuous trunk or hatch coaming with respect to the reference co-ordinate system defined in Ch 1, Sec 2, [3]; y_T and z_T are to be measured for the point which maximises the value of V_D

3 Characteristics of the hull girder transverse sections for multihulls

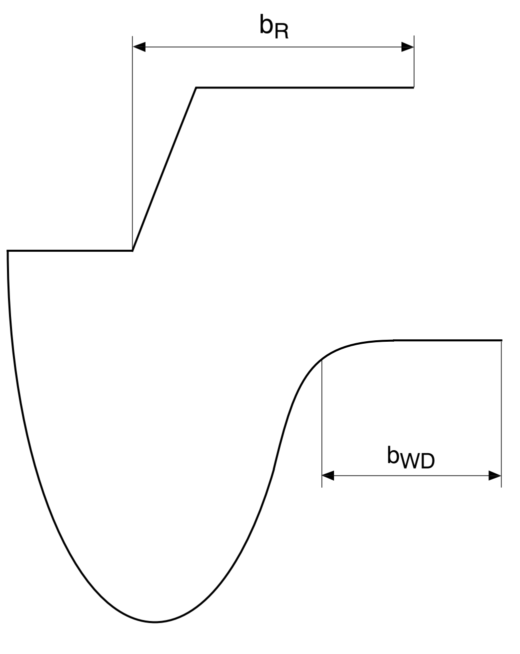
3.1 General

3.1.1 The longitudinal hull girder strength of a multihull having more than two floats will be considered on a case-by-case basis.

3.1.2 The characteristics of the hull girder transverse sections are to be determined as specified in [2].

The moment of inertia I_Y is to be calculated for only one float. A platform extending in length over at least 0,4 L_{WL} is to be considered for the calculation of the inertia of the float with breadths b_R and b_{WD} as defined in Fig 2, limited to 10% of the platform longitudinal length.

Figure 2 : Hull girder strength areas to be taken into account for continuous structural members



4 Yielding strength check

4.1 Stress calculation

4.1.1 The hull girder normal stresses σ_1 induced by vertical bending moments are obtained, in N/mm², from the following formulae:

- in sagging conditions

$$\sigma_1 = \frac{M_S + M_{WV}}{Z} 10^3$$

- in hogging conditions

$$\sigma_1 = \frac{M_H + M_{WV}}{Z} 10^3$$

4.2 Checking criterion

4.2.1 It is to be checked that the hull girder normal stresses, in N/mm², at any point of the net hull girder transverse section, calculated according to [2] are in compliance with the following condition:

$\sigma_1 \leq \sigma_{1,All}$

where

$\sigma_{1,All}$: Allowable hull girder normal stress, in N/mm²

- $\sigma_{1,All}$ = 190/k, for steel hulls
- $\sigma_{1,All}$ = 60/k, for aluminium alloy hulls.

4.2.2 The requirement [4.2.1] does not apply to vessels with rule length less than 40 m complying with the alternative requirements of Ch 5, Sec 6.

SECTION 2 TRANSVERSE STRENGTH ANALYSIS FOR MULTIHULLS

Symbols

Refer to Fig 1.

G : Centre of the stiffnesses r_i, of the m deck beams

O : Origin of abscissae, arbitrarily chosen

m : Number of deck transverses

x_i : Abscissa, in m, of deck beam i with respect to origin O

S_i : Span of deck beam i, in m, between the inner faces of the hulls

I_i : Bending inertia of deck beam i, in m^4

E_i : Young's modulus of deck beam i, in N/mm^2, to be taken equal to

- for steels in general:

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

- for stainless steels:

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

- for aluminium alloys:

  $E_i = 7{,}00 \cdot 10^4$ N/mm^2

r_i : Stiffness of deck beam i, in N/m, equal to:

$$r_i = \frac{12 \cdot E_i \cdot I_i}{S^3_i} \cdot 10^6$$

a : Abscissa, in m, of the centre G with respect to the origin O

$$a = \frac{\sum r_i \cdot x_i}{\sum r_i}$$

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

If F_i, in N, is the force taken over by the deck beam i, the deflection y_i, in m, of the hull in way of the beam i, is:

$$y_i = \frac{F_i S^3_i \cdot 10^{-6}}{12 E_i I_i} = \frac{F_i}{r_i} = d_i \omega$$

where:

d_i : Abscissa, in m, of the deck beam i with respect to the origin G:

$d_i = x_i - a$

ω : Rotation angle, in rad, of one hull in relation to the other around a transverse axis passing through G.

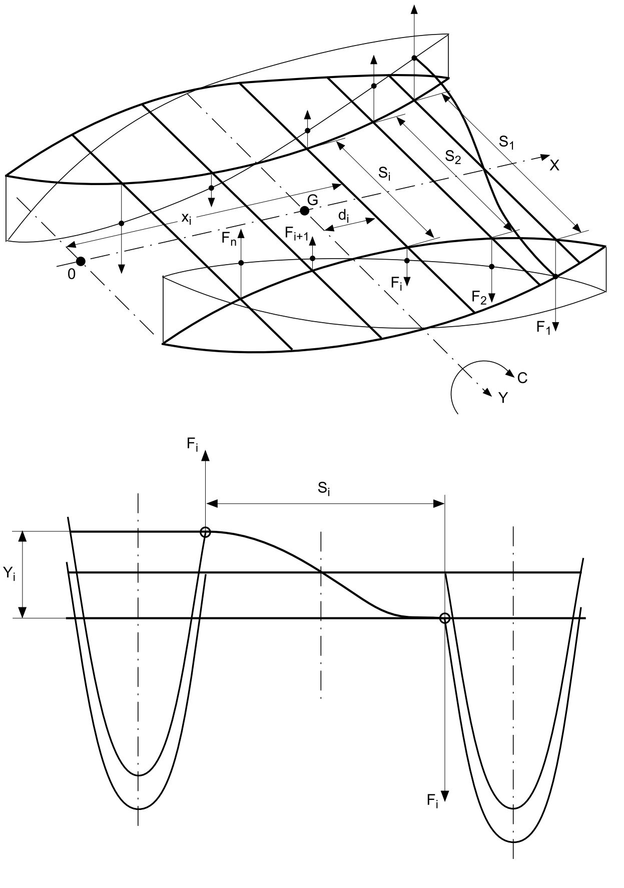
1 General

1.1

1.1.1 The transverse strength of a multihull having more than two floats will be considered on a case-by-case basis.

1.1.2 In the special case of catamaran, when the structure connecting both hulls is formed by a deck with single plating stiffened by m reinforced beams, the normal and shear stresses in the beams can be calculated as indicated in [2].

Figure 1 : Transverse strength of catamaran



2 Transverse strength in special case of catamaran

2.1 General

2.1.1 Deck beams are assumed to be fixed into each hull. Consequently, deck beams are to be extended throughout the breadth of each hull, with the same scantlings all over their span, inside and outside the hulls.

2.2 Transverse torsional connecting moment

2.2.1 The catamaran transverse torsional connecting moment, in kN.m, about a transverse axis is given by:

$M_{tt} = 1,23\ \Delta\ L\ a_{CG}$

where:

- Δ : Vessel displacement, in tons
- a_{CG} : Design vertical acceleration at LCG, in m/s^2, to be taken not less than:

$$a_{CG} = 0,36 Soc \frac{v}{\sqrt{L}}$$

- v : Vessel speed, in km/h
- Soc : Coefficient depending on the navigation coefficient n, defined as:

  Soc = 0,1 (5,15y + 1,1)

  y : Coefficient to be taken as:
  - y = 0.099 for **IN**
  - y = n for **IN(x** $\leq$ 2)

Moreover, the transverse torsional moment may be expressed as:

$$M_{tt} = \sum F_i \cdot d_i \cdot 10^{-3}$$

2.3 Calculation of rotation angle

2.3.1 The rotation angle may be derived from Ch 2, App 3, [2.2] and is given by the formula:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3$$

2.4 Determination of stresses in deck beams

2.4.1 As M_{tt} , r_i and d_i are known, ω is thus deduced. Then F_i , in N, the bending moment M_i , in N.m, and the corresponding normal and shear stresses can be evaluated in each beam:

$F_i = \omega\ r_i\ d_i$

$M_i = F_i\ S_i / 2$

2.5 Checking criteria

2.5.1 It is to be checked that the normal stress, the shear stress and the Von Mises equivalent stress are in compliance with the following conditions:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0,5 \frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma_{VM}$$

where:

- σ : Normal stress, in N/mm^2, in the direction of the deck beam axis
- τ : Shear stress, in N/mm^2, in the direction of the force F_i applied to the deck beam.
- σ_{VM} : Von Mises equivalent stress, in N/mm^2

$$\sigma_{VM} = \sqrt{\sigma^2 + 3\tau^2}$$

- R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:
  - R_y= 235/k N/mm^2 for steel
  - R_y= 100/k N/mm^2 for aluminium alloys

  unless otherwise specified
- γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 8, [2.1.2]
- γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 8, [2.1.2]
- k : Material factor defined in Ch 2, Sec 3, [2.3], for steel and Ch 2, Sec 3, [3.5], for aluminium alloys.

Part B
Hull Design and Construction

Chapter 5
HULL SCANTLINGS

SECTION 1 GENERAL

SECTION 2 BOTTOM SCANTLINGS

SECTION 3 SIDE SCANTLINGS

SECTION 4 DECK SCANTLINGS

SECTION 5 BULKHEAD SCANTLINGS

SECTION 6 ALTERNATIVE REQUIREMENTS APPLICABLE TO VESSELS WITH LENGTH L < 40 M - METALLIC HULLS

SECTION 1 GENERAL

Symbols

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

p_B : Ballast design pressure, in kN/m^2

$p_B = p_S + \gamma_{W2}\ p_W$

p_C : Cargo design pressure, in kN/m^2

$p_C = p_S + \gamma_{W2}\ p_W$

p_D : External design pressure, in kN/m^2

$p_D = p_S + \gamma_{W2}\ p_W$

p_E : External design pressure, in kN/m^2

$p_E = p_{SE} + \gamma_{W2}\ p_{WE}$

p_S : Still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{SE} : External still water pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.1]

p_{ST} : Test pressure, in kN/m^2, defined in Ch 3, Sec 4, [5.1.1]

p_W : Inertial pressure, in kN/m^2, defined in Ch 3, Sec 4, [3]

p_{WD} : Wind pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.3]

p_{WE} : External wave pressure, in kN/m^2, defined in Ch 3, Sec 4, [2.1.2]

z : Z co-ordinate, in m, of the calculation point of a structural element.

1 General

1.1 Application

1.1.1 This Chapter contains the requirements for the arrangement and the determination of the hull scantlings applicable to the central part (see Ch 1, Sec 1, [2.1.3]) of all types of vessels covered by these Rules, made of metallic material. For the structures of other parts, see Part B, Chapter 6.

These requirements are to be integrated with those specified under applicable Chapters of Part D, depending on the vessel notations.

1.1.2 The scantling determination is to be carried out independently for all applicable load cases defined in Ch 3, Sec 1, [4].

1.1.3 The scantling determination is to be carried out considering the vessel in service conditions (see Ch 3, Sec 1, [1.8], for definition) and, as applicable, in flooding and testing conditions.

1.2 Net scantlings

1.2.1 All scantlings referred to in this Chapter are net, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Ch 2, Sec 5, [2].

1.3 Partial safety factors

1.3.1 Plating

The partial safety factors covering uncertainties regarding wave hull girder loads (γ_{W1}), wave local loads (γ_{W2}), material (γ_m) and resistance (γ_R) to be considered for the checking of the plating are specified in Tab 1.

1.3.2 Ordinary stiffeners

The partial safety factors covering uncertainties regarding wave hull girder loads (γ_{W1}), wave local loads (γ_{W2}), material (γm) and resistance (γ_R) to be considered for the checking of ordinary stiffeners are specified in Tab 2.

1.3.3 Primary supporting members

The partial safety factors covering uncertainties regarding wave hull girder loads (γ_{W1}), wave local loads (γ_{W2}), material (γm) and resistance (γ_R) to be considered for checking primary structural members are specified in Tab 3 for analyses based on isolated beam models.

Table 1 : Plating - Partial safety factors

Limit state	Condition	γ_{W1} **(2)**	γ_{W2} **(2)**	γ_R	γ_m
Strength check of plating subjected to lateral pressure	General	1,15	1,20	1,20	1,02
	Flooding	1,15	1,20	1,05 **(1)**	1,02
	Testing	NA	NA	1,05	1,02

(1) For plating of the collision bulkhead, γ_R =1,25.
(2) For range of navigation **IN**, $\gamma_{W1} = \gamma_{W2} = 1,00$
Note 1: NA = not applicable.

Table 2 : Ordinary stiffeners - Partial safety factors

Limit state	Condition	γ_{W1} **(2)**	γ_{W2} **(2)**	γ_R	γ_m
Yielding check	General	1,15	1,20	1,02	1,02
	Flooding	1,15	1,20	1,02 **(1)**	1,02
	Testing	NA	NA	1,02	1,02

(1) For ordinary stiffeners of the collision bulkhead, γ_R =1,25.
(2) For range of navigation **IN**, $\gamma_{W1} = \gamma_{W2} = 1,00$
Note 1: NA = not applicable.

Table 3 : Primary supporting members analysed through isolated beam models - Partial safety factors

Limit state	Condition	γ_{W1} **(2)**	γ_{W2} **(2)**	γ_R	γ_m
Yielding check	General	1,15	1,20	1,02	1,02
	Bottom and side girders **(3)**	1,15	1,20	1,15	1,02
	Flooding	1,15	1,20	1,02 **(1)**	1,02
	Testing	NA	NA	1,02	1,02

(1) For primary supporting members of the collision bulkhead, γ_R =1,25.
(2) For range of navigation **IN**, $\gamma_{W1} = \gamma_{W2} = 1,00$
(3) Includes bottom girders, bottom transverses, reinforced floors, side stringers, side transverses and web frames.
Note 1: NA = not applicable.

2 Load model

2.1 Design lateral pressure

2.1.1 The design lateral pressure, p, to be used for hull scantling is defined in Tab 4.

Table 4 : Design lateral pressure, p, in kN/m²

Structure	In service conditions	In testing conditions	In flooding conditions
Shell structure	p_E $p_C - p_{Em}$ $p_B - p_{Em}$	p_{ST} $p_{ST} - p_{SE}$ **(1)**	–
Deck structure	p_E **(2)** p_C p_B p_D	p_{ST}	–
Hatch coaming	$2+p_{WD}$	–	–
Internal structure	p_C p_B	p_{ST}	p_{FL}

(1) Testing afloat
(2) External deck pressure defined in Ch 3, Sec 4, [2.2.1].

2.2 Forces induced by wheeled and dry unit cargoes

2.2.1 The force transmitted to the hull structure by dry unit cargoes and wheeled cargoes are given by the formula:

$$F = F_S + \gamma_{W2} F_W$$

where:

F_S, F_W : Still water and wave forces defined in Ch 3, Sec 4, [3.3], for dry unit cargoes, and Ch 3, Sec 4, [3.5], for wheeled cargoes.

2.3 Hull girder normal stresses

2.3.1 The requirements in Pt D, Ch 2, Sec 12, [4.2] apply in addition to vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**.

Table 5 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c" "d"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
Flooding	0,6

Table 6 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} \geq 1$	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} < 1$	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.
Note 1:
- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

Table 7 : Hull girder normal stresses - Ordinary stiffeners and primary supporting members subjected to lateral pressure

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:		
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
Lateral pressure applied on the same side as the ordinary stiffener:		
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.
Note 1:
- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

Table 8 : Hull girder normal stresses - Ordinary stiffeners and primary supporting members subjected to wheeled loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
Hogging	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
Sagging **(1)**	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.
Note 1:
- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

2.3.2 The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm2, from the following formulae:

- in general $\sigma_{X1} = \sigma_{S1} + \gamma_{W1} C_{FV}\, \sigma_{WV1}$
- for structural members not contributing to the hull girder longitudinal strength: $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV1} : Hull girder normal stresses, in N/mm^2, defined in:
- Tab 6, for plating subjected to lateral loads
- Tab 7, for ordinary stiffeners and primary supporting members subjected to lateral pressure
- Tab 8, for ordinary stiffeners and primary supporting members subjected to wheeled loads

C_{FV} : Combination factors defined in Tab 5.

3 Direct calculation

3.1 General

3.1.1 Direct calculation may be adopted instead of the Rule scantling requirements in the following cases:

- as an alternative to the Rule scantling formulae
- for the analysis of structural members not covered by the Rules
- for the analysis of structural members with configurations not covered by the Rules.

The direct calculation guidance for the yielding and buckling strength checks of structural members is given in Ch 2, Sec 8, [2].

SECTION 2 BOTTOM SCANTLINGS

Symbols

A_{sh} : Net shear sectional area, in cm^2

B_1 : Breadth, in m, of the hold or tank:
- if no longitudinal bulkhead is fitted: $B_1 = B - 2\ B_2$
- if a longitudinal bulkhead is fitted: $B_1 = (B - 2\ B_2) / 2$

B_2 : Breadth, in m, of the side tank

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1 + 0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \leq 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \geq 0,5$$

where:

r : Radius of curvature, in m

c : Dry bulk coefficient to be taken equal to:

$$c = \frac{p_C}{9,81\rho_B B_1 \tan\varphi_B}$$

with $0,55 \leq c \leq 1$

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design lateral pressure, in kN/m^2, defined in Ch 5, Sec 1, [2.1]

p_C : Cargo design pressure, in kN/m^2, defined in Ch 5, Sec 1, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:
- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

β_b , β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 5, [2]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 5, [2]

η : Coefficient taken equal to:

$\eta = 1 - s / (2\ \ell)$

φ_B : Dry bulk cargo angle of repose, in degree

ℓ : Span, in m, of ordinary stiffeners or primary supporting members defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2]

ρ_B : Dry bulk cargo density, in t/m^3

σ_{X1} : Hull girder normal stress, in N/mm^2, defined in Ch 5, Sec 1, [2.3]

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and arrangement of longitudinally or transversely framed single and double bottom structures made of steel or aluminium alloys, fitted in the vessel central part.

The requirements applicable to specific vessel notations are defined in Part D.

1.1.2 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.2 General arrangement

1.2.1 The bottom structure is to be checked by the designer to make sure that it withstands the loads resulting from the dry-docking of the vessel.

1.2.2 The bottom is to be locally stiffened where concentrated loads are envisaged.

1.2.3 Girders or floors are to be fitted under each line of pillars, when deemed necessary by the Society on the basis of the loads carried by the pillars.

1.2.4 Adequate tapering is to be provided between double bottom and adjacent single bottom structures. Similarly, adequate continuity is to be provided in the case of height variation in the double bottom. Where such a height variation occurs within 0,6 L amidships, the inner bottom is generally to be maintained continuous by means of inclined plating.

1.2.5 Provision is to be made for the free passage of water from all parts of the bottom to the suctions.

1.2.6 When solid ballast is fitted, it is to be securely positioned. If necessary, intermediate floors may be required for this purpose.

1.3 Keel

1.3.1 Vessels having a rise of floor are to be fitted with a keel plate of about 0,1 B in width, with a thickness equal to 1,15 times the bottom plating thickness.

In the case there is no rise of floor, the keel plate thickness is to be not less than the bottom plating thickness.

1.4 Bilge

1.4.1 Radius

Where the bilge plating is rounded, the radius of curvature is not to be less than 20 times the thickness of the plating.

1.4.2 Extension of rounded bilge

The bilge is to extend at least 100 mm on either side of the rounded part.

1.4.3 On tank vessels for oil and/or chemicals, wear plates in form of doubling plates are not permitted to be attached to the bilge plating within the cargo area, i.e. between the aftmost and the foremost cofferdam bulkhead.

1.5 Drainage and openings for air passage

1.5.1 Holes are to be cut into floors and girders to ensure the free passage of air and liquids from all parts of the double bottom.

2 Plating scantling

2.1 Plating net thicknesses

2.1.1 In the central part, the bottom and inner bottom plating net thicknesses, in mm, are not to be less than the values t_1 and t_2 given in Tab 1.

2.2 Bilge plating

2.2.1 Rounded bilge plating

The bilge plating net thickness, in mm, is to be not less than the following values:

- in the case of a bilge radius of curvature practically equal to the floor depth or bottom transverse depth:

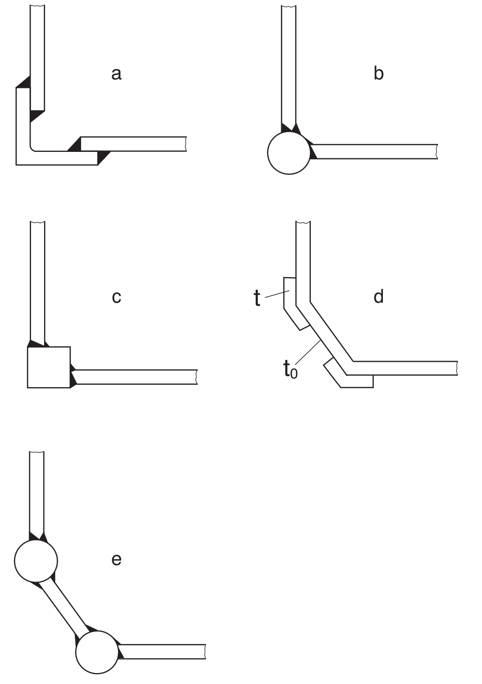
  $t = 1,15\ t_0$

- in the case of a bilge radius of curvature less than the floor depth or bottom transverse depth but greater than 20 times the bottom plating thickness:

  $t = 1,15\ t_0 + 1$

where $t_0 = \max (t_1; t_2)$ for adjacent bottom plating.

Figure 1 : Square bilge



2.2.2 Square bilge plating

In the case of a square bilge with chine bars (sketches a, b, c and e of Fig 1), the net scantling of the chine bar is to be determined as follows:

- angle bars

  The net thickness of the bars plating, in mm, is to be not less than the following formulas, where t_0 is the rule bottom plating net thickness:

  - angle bars inside the hull: $t = t_0 + 2$
  - other cases: $t = t_0 + 3$

- round bars and square bars

  The diameter of the round bars or the side of the square bars is to be not less than 30 mm.

In the case of a double chine without chine bars (sketch d of Fig 1), the thickness of the doublers, in mm, is to be not less than: $t = t_0 + 3$

where t_0 is the adjacent bottom plating thickness, in mm.

3 Structural member scantlings

3.1 Minimum web net thicknesses

3.1.1 Ordinary stiffeners

The net thickness, in mm, of the web of ordinary stiffeners is to be not less than:

- for $L < 120$ m: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
- for $L \geq 120$ m: $t = 3,9\ (k_0 k)^{0,5} + s$

3.1.2 Primary supporting members

The net thickness, in mm, of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

Table 1 : Bottom and inner bottom plating net thicknesses, in mm

Plating	Transverse framing	Longitudinal framing
Bottom	$t_1 = 1,85 + 0,03\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 17,2C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	$t_1 = 1,1 + 0,03\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 14,9C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_L R_y}}$
Inner bottom	$t_1 = 1,5 + 0,016\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 17,2C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	$t_1 = 1,5 + 0,016\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 14,9C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_L R_y}}$

Note 1:

$$\lambda_L = \sqrt{1-0,95\left(\gamma_m\frac{\sigma_{x1}}{R_y}\right)^2} - 0,225\gamma_m\frac{\sigma_{x1}}{R_y}$$

$$\lambda_T = 1-0,89\gamma_m\frac{\sigma_{x1}}{R_y}$$

Note 2: In testing conditions

$$t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{R_y}}$$

Table 2 : Net scantlings of single bottom structure

Item	w, in cm³	A_{Sh}, in cm²
Bottom longitudinals	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y-\gamma_R\gamma_m\sigma_{X1})}s\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}\eta s\ell$
Floors **(1) (2)**	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{mR_y}s\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}\eta s\ell$
Bottom transverses / reinforced floors **(2)**	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{mR_y}S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}S\ell$
Bottom centre and side girders **(3)**	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y-\gamma_R\gamma_m\sigma_{X1})}S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}S\ell$

(1) In way of side ordinary frames: $\beta_b = \beta_S = 1$
(2) Scantlings of floors and bottom transverses are to be at least the same as those of web frames or side transverses connected to them.
(3) The span ℓ is to be taken equal to the web frames / side transverses spacing.
Note 1: The value of σ_{X1} is to be taken in relation with the pressure p considered.
Note 2:
m : Boundary coefficient, to be taken equal to:
- for bottom longitudinals: m = 12
- for other bottom structural members: m = 8

3.2 Net section modulus and net shear sectional area of structural members

3.2.1 The net scantlings of single and double bottom structural members are not to be less than the values obtained from:

- Tab 2 for single bottom structure
- Tab 3 for double bottom structure,

taking into account the following for double bottom floors and transverses:

- in way of side plate web frames or where the inner side plating extends down to the bottom plating:
  $\ell = B_1$ and $B_3 = 0$
- elsewhere:
  if no longitudinal bulkhead is fitted: $\ell = B$ and $B_3 = B_2$
  if a longitudinal bulkhead is fitted: $\ell = 0,5B$ and $B_3 = 0,5B_2$

4 Transversely framed single bottom

4.1 Floors

4.1.1 Floors are to be fitted at every frame.

4.1.2 Minimum shear sectional area of floors

The minimum shear sectional area A_{sh} of floors, in cm², is to be not less than the value given in Tab 2, however, the Society may waive this rule subject to direct calculation of the shearing stresses.

Table 3 : Net scantlings of double bottom structure

Item	w, in cm³	A_{Sh}, in cm²
Bottom longitudinals Inner bottom longitudinals	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})} s\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}\eta s\ell$
Floors in the way of hold / cargo tank **(1)**	$w = \max(w_1\,;\,w_2)$ $w_1 = \dfrac{\gamma_R\gamma_m\beta_b p_E}{mR_y} s\ell^2 10^3$ $w_2 = \dfrac{\gamma_R\gamma_m\beta_b(p_{\gamma I} - p_{Em})}{mR_y} s(\ell^2 - 4B_3^2)10^3$	$A_{Sh} = \max(A_1\,;\,A_2)$ $A_1 = 10\gamma_R\gamma_m\beta_s\dfrac{p_E}{R_y}\eta s\ell$ $A_2 = 10\gamma_R\gamma_m\beta_s\dfrac{(p_{\gamma I} - p_{Em})}{R_y}\eta s(\ell - 2B_3)$
Floors in the way of side tank **(1)**	$w = \max(w_1\,;\,w_2)$ $w_1 = 4,2\dfrac{\gamma_R\gamma_m\beta_b p_E}{mR_y} sB_2(\ell - B_2)10^3$ $w_2 = 4,2\dfrac{\gamma_R\gamma_m\beta_b(p_{\gamma I} - p_{Em})}{mR_y} sB_2(\ell - 2B_3)10^3$	
Bottom transverses/reinforced floors in the hold / cargo tank	$w = \max(w_1\,;\,w_2)$ $w_1 = \dfrac{\gamma_R\gamma_m\beta_b p_E}{mR_y} S\ell^2 10^3$ $w_2 = \dfrac{\gamma_R\gamma_m\beta_b(p_{\gamma I} - p_{Em})}{mR_y} S(\ell^2 - 4B_3^2)10^3$	$A_{Sh} = \max(A_1\,;\,A_2)$ $A_1 = 10\gamma_R\gamma_m\beta_s\dfrac{p_E}{R_y}S\ell$ $A_2 = 10\gamma_R\gamma_m\beta_s\dfrac{(p_{\gamma I} - p_{Em})}{R_y}S(\ell - 2B_3)$
Bottom transverses/reinforced floors in the side tank	$w = \max(w_1\,;\,w_2)$ $w_1 = 4,2\dfrac{\gamma_R\gamma_m\beta_b p_E}{mR_y} SB_2(\ell - B_2)10^3$ $w_2 = 4,2\dfrac{\gamma_R\gamma_m\beta_b(p_{\gamma I} - p_{Em})}{mR_y} SB_2(\ell - 2B_3)10^3$	
Bottom centre and side girders **(2)**	$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})} S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}S\ell$

(1) In way of side ordinary frames: $\beta_b = \beta_S = 1$

(2) The span ℓ is to be taken equal to the web frames or side transverses spacing.

Note 1: The value of σ_{X1} is to be taken in relation with the pressure p considered.

Note 2:

m : Boundary coefficient, to be taken equal to:
- m = 12 for bottom and inner bottom longitudinals
- m = 8 for other double bottom structural members.

4.1.3 Floor height

Where the ratio of the floor web height to its net thickness exceeds 100, the floor web is to be provided with stiffeners in compliance with Ch 2, Sec 4, [5.8.1].

In the case of vessels with rise of floor, the floor height may be required to be increased so as to assure a satisfactory connection to the side frames.

4.2 Girders

4.2.1 Centre girder

All single bottom vessels are to have a centre girder. The Society may waive this rule for vessels with B_F less than 6 m, when the floor is a rolled section or when the floor stability is covered otherwise, where B_F is the breadth of the vessel, in m, measured on the top of floor.

The web depth of the centre girder has to extend to the floor plate upper edge. The web thickness is not to be less than that of the floor plates.

Centre girder is to be fitted with a face plate or a flange, the net sectional area of which, in cm², is not to be less than:

$A_f = 0,6\ L + 2,7$

4.2.2 Side girders

Depending on the breadth B_F defined in [4.2.1], side girders are to be fitted in compliance with the following:
- $B_F \le 6$ m: no side girder
- 6 m < $B_F \le 9$ m: one side girder at each side
- $B_F > 9$ m: two side girders at each side.

Side girders are to be fitted with a face plate or a flange, the net sectional area of which is not to be less than that of the floor plate.

4.2.3 Centre and side girders are to be extended as far aft and forward as practicable.

Intercostal web plates of centre and side girders are to be aligned and welded to floors.

4.2.4 Where two girders are slightly offset, they are to be shifted over a length at least equal to two frame spacings.

4.2.5 Towards the ends, the thickness of the web plate as well as the sectional area of the top plate may be reduced by 10%. Lightening holes are to be avoided.

4.2.6 Where side girders are fitted in lieu of the centre girder, the scarfing is to be adequately extended and additional stiffening of the centre bottom may be required.

5 Longitudinally framed single bottom

5.1 Bottom longitudinals

5.1.1 General

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

5.1.2 Strengthening

The section modulus of longitudinals located in way of the web frames of transverse bulkheads is to be increased by 10%.

The Society may call for strengthening of the longitudinal located in the centreline of the vessel.

5.2 Bottom transverses

5.2.1 Spacing

In general, the transverse spacing is to be not greater than 8 frame spacings, nor than 4 m, which is the lesser.

5.2.2 Minimum shear sectional area of bottom transverses

Taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area A_{sh} of bottom transverses, in cm², is to be not less than the value given in Tab 2, however, the Society may waive this rule subject to direct calculation of the shearing stresses.

5.2.3 Bottom transverse height

Where the ratio of the bottom transverse web height to its net thickness exceeds 100, the bottom transverse web is to be provided with stiffeners in way of longitudinals in compliance with Ch 2, Sec 4, [5.8.1] to Ch 2, Sec 4, [5.8.3], as applicable. The stiffeners are to extend between the longitudinals and the upper faceplate of the transverse, without any connection with that faceplate.

In the case of vessels with rise of floor, the bottom transverse height may be required to be increased so as to assure a satisfactory connection to the side transverses.

5.3 Girders

5.3.1 The requirements in [4.2] apply also to longitudinally framed single bottoms, with transverses instead of floors.

Where the ratio of the girder web height to its net thickness exceeds 100, the girder web is to be provided with stiffeners in compliance with Ch 2, Sec 4, [5.8.1].

6 Transversely framed double bottom

6.1 Double bottom arrangement

6.1.1 Where the height of the double bottom varies in the longitudinal direction, the variation is to be made gradually over an adequate length.

The knuckles of inner bottom plating are to be located in way of plate floors. Where this is impossible, suitable longitudinal structures such as partial girders, longitudinal brackets etc., fitted across the knuckle are to be arranged.

6.1.2 For vessels without a flat bottom, the height of double bottom specified in [6.1.1] may be required to be adequately increased such as to ensure sufficient access to the areas towards the sides.

6.1.3 Strength continuity

Adequate strength continuity of floors is to be ensured in way of the side tank by means of brackets.

6.2 Floors

6.2.1 Spacing

Floors are to be fitted at every frame.

Watertight floors are to be fitted:

- in way of transverse watertight bulkheads
- in way of double bottom steps.

6.2.2 In general, floors are to be continuous.

6.2.3 Minimum shear sectional area of floors

The minimum shear sectional area A_{sh} of floors, in cm², is to be not less than the value given in Tab 3, however, the Society may waive this rule subject to direct calculation of the shearing stresses.

6.2.4 Where the double bottom height does not enable to connect the floors and girders to the inner bottom by fillet welding, slot welding may be used. In that case, the floors and girders are to be fitted with a face plate or a flange.

6.3 Bilge wells

6.3.1 Bilge wells arranged in the double bottom are to be limited in depth and formed by steel plates having a thickness not less than the greater of that required for watertight floors and that required for the inner bottom.

6.3.2 In vessels subject to stability requirements, such bilge wells are to be fitted so that the distance of their bottom from the shell plating is not less than 400 mm.

6.4 Girders

6.4.1 A centre girder is to be fitted on all vessels exceeding 6 m in breadth.

This centre girder is to be formed by a vertical intercostal plate connected to the bottom plating and to double bottom top.

The intercostal centre girder is to extend over the full length of the vessel or over the greatest length consistent with the lines. It is to have the same thickness as the floors. No manholes are to be provided into the centre girder.

6.4.2 For vessels with a range of navigation **IN(1,2 ≤ x ≤ 2)**, continuous or intercostal girders are to be fitted in the extension of the inner sides. These girders are to have a net thickness equal to that of the inner sides.

For vessels with a range of navigation **IN(x < 1,2)** built in the transverse system and without web frames, partial intercostal girders are to be fitted in way of the transverse bulkheads of the side tanks, in extension of the inner sides. These girders are to be extended at each end by brackets having a length equal to one frame spacing. They are to have a net thickness equal to that of the inner sides.

7 Longitudinally framed double bottom

7.1 General

7.1.1 The requirements in [6.1], [6.3] and [6.4] are applicable to longitudinally framed double bottoms.

7.2 Transverses

7.2.1 The spacing of transverses, in m, is generally to be not greater than 8 frame spacings nor 4 m, whichever is the lesser.

Additional transverses are to be fitted in way of transverse watertight bulkheads.

Where the ratio of the double bottom transverse web height to its net thickness exceeds 100, the double bottom transverse web is to be provided with stiffeners in way of longitudinals in compliance with Ch 2, Sec 4, [5.8.1] to Ch 2, Sec 4, [5.8.3], as applicable. The stiffeners are to extend between the longitudinals and the upper faceplate of the transverse, without any connection with that faceplate.

7.3 Bottom and inner bottom longitudinal ordinary stiffeners

7.3.1 Bottom and inner bottom longitudinal ordinary stiffeners are generally to be continuous through the transverses.

In the case the longitudinals are interrupted in way of a transverse, brackets on both sides of the transverse are to be fitted in perfect alignment.

7.4 Brackets to centreline girder

7.4.1 In general, intermediate brackets are to be fitted connecting the centre girder to the nearest bottom and inner bottom ordinary stiffeners.

7.4.2 Such brackets are to be stiffened at the edge with a flange having a width not less than 1/10 of the local double bottom height.

If necessary, the Society may require a welded flat bar to be arranged in lieu of the flange.

SECTION 3 SIDE SCANTLINGS

Symbols

A_{sh} : Net shear sectional area, in cm^2

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

where:

r : Radius of curvature, in m

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design lateral pressure, in kN/m^2, defined in Ch 5, Sec 1, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:
- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

z : Z co-ordinate, in m, of the calculation point

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 5, [2]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 5, [2]

η : Coefficient taken equal to:

$\eta = 1 - s / (2\ \ell)$

ℓ : Span, in m, of ordinary stiffeners or primary supporting members, defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2]

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

σ_{X1} : Hull girder normal stress, in N/mm^2, defined in Ch 5, Sec 1, [2.3].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and arrangement of longitudinally or transversely framed single and double side structures made of steel or aluminium alloys, fitted in the vessel central part.

The requirements applicable to specific vessel notations are defined in Part D.

1.1.2 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.2 General arrangement

1.2.1 The transversely framed side structures are built with transverse frames possibly supported by struts, side stringers and web frames.

1.2.2 The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by side vertical primary supporting members.

2 Plating scantling

2.1 Plating net thicknesses

2.1.1 In the central part, the side and inner side plating net thicknesses, in mm, are not to be less than the values t_1 and t_2 given in Tab 1.

3 Structural member scantlings

3.1 Minimum web net thicknesses

3.1.1 Ordinary stiffeners

The net thickness, in mm, of the web of ordinary stiffeners is to be not less than:
- for L < 120 m: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
- for L ≥ 120 m: $t = 3,9\ (k_0k)^{0,5} + s$

3.1.2 Primary supporting members

The net thickness, in mm, of plating which forms the web of side and inner side primary supporting members is to be not less than the value obtained from the following formula:

$t = 3,8 + 0,016\ L\ (k_0k)^{0,5}$

Table 1 : Side and inner side plating net thicknesses, in mm

Plating	Transverse framing	Longitudinal framing
Side	$t_1 = 1,68 + 0,025\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 1,25 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Inner side	$t_1 = 2 + 0,003\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 2 + 0,003\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$

Note 1:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{x1}}{R_y}$$

$$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{x1}}{R_y}$$

Note 2: In testing conditions

$$t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{R_y}}$$

Table 2 : Net scantlings of single side structure

Item		w, in cm³	A_{sh} , in cm²
Side frames	• if $\ell_0 \le \ell$:	$w = \frac{\gamma_R \gamma_m \beta_b s}{m R_y}(6 \ell \ell_0^2 + 1,45 \lambda_W p_F \ell_F^2) 10^3$	$A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} \eta s \ell_0$
	• if $\ell_0 > \ell$:	$w = \frac{\gamma_R \gamma_m \beta_b s}{m R_y}(\lambda_b p \ell^2 + 1,45 \lambda_W p_F \ell_F^2) 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \frac{p}{R_y} \eta s \ell$
Side longitudinals		$w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$
Side web frames and side transverses **(1)**	• if $\ell_0 \le \ell$:	$w = k_1 \frac{\gamma_R \gamma_m \beta_b \ell}{m R_y} S \ell_0^2 10^3$	$A_{sh} = 68 \gamma_R \gamma_m \beta_S \frac{\ell}{R_y} S \ell_0$
	• if $\ell_0 > \ell$:	$w = k_2 \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \frac{p}{R_y} S \ell$
Side stringers **(2)**		$w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$

(1) Scantlings of web frames and side transverses at the lower end are to be the same as those of floors or bottom transverses connected to them.

(2) The span of side stringers is to be taken equal to the side transverses spacing or web frames spacing.

Note 1: The value of σ_{X1} is to be taken in relation with the pressure p considered.

Note 2:

m : Boundary coefficient, to be taken, in general, equal to:
- m = 12 for side ordinary stiffeners
- m = 8 for side primary supporting members

ℓ_F : Floor span, in m

ℓ_0 : Span parameter, in m, equal to:

$\ell_0 = p_d / g$

p_d : Total pressure, in kN/m², at the lower end of the stiffener

p_F : Floor design lateral pressure, in kN/m²

λ_W : Coefficient to be taken equal to:
- in transverse framing: $\lambda_W = 0,08$
- in combination framing: $\lambda_W = 0$

k_1, k_2 :
- For open deck vessels:
  $k_1 = 26$
  $k_2 = 4,4$
- For other vessels:
  $k_1 = 6$
  $k_2 = 1$

Table 3 : Net scantlings of double side hull structure

Item		w, in cm^3	A_{sh}, in cm^2
Side frames Inner side frames	• if $\ell_0 \le \ell$:	$w = 6\dfrac{\gamma_R\gamma_m\beta_b\ell}{mR_y}s\ell_0^2 10^3$	$A_{sh} = 68\gamma_R\gamma_m\beta_S\dfrac{\ell}{R_y}\eta s\ell_0$
	• if $\ell_0 > \ell$:	$w = \dfrac{\gamma_R\gamma_m\lambda_b\beta_b p}{mR_y}s\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_S\dfrac{p}{R_y}\eta s\ell$
Side and inner side longitudinals		$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}s\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_S\dfrac{p}{R_y}\eta s\ell$
Side and inner side web frames and transverses	• if $\ell_0 \le \ell$:	$w = 6\dfrac{\gamma_R\gamma_m\beta_b\ell}{mR_y}S\ell_0^2 10^3$	$A_{sh} = 68\gamma_R\gamma_m\beta_S\dfrac{\ell}{R_y}S\ell_0$
	• if $\ell_0 > \ell$:	$w = \dfrac{\gamma_R\gamma_m\lambda_b\beta_b p}{mR_y}S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_S\dfrac{p}{R_y}S\ell$
Plate web frames	• if $\ell_0 \le \ell$:	$w = k_1\dfrac{\gamma_R\gamma_m\beta_b\ell}{mR_y}S\ell_0^2 10^3$	$A_{sh} = 68\gamma_R\gamma_m\beta_S\dfrac{\ell}{R_y}S\ell_0$
	• if $\ell_0 > \ell$:	$w = k_2\dfrac{\gamma_R\gamma_m\lambda_b\beta_b p}{mR_y}S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_S\dfrac{p}{R_y}S\ell$
Side and inner side stringers **(1)**		$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}S\ell^2 10^3$	$A_{sh} = 10\gamma_R\gamma_m\beta_S\dfrac{p}{R_y}S\ell$

(1) The span of side and inner side stringers is to be taken equal to the side transverses spacing or web frames spacing.
Note 1: The value of σ_{X1} is to be taken in relation with the pressure p considered.
Note 2:

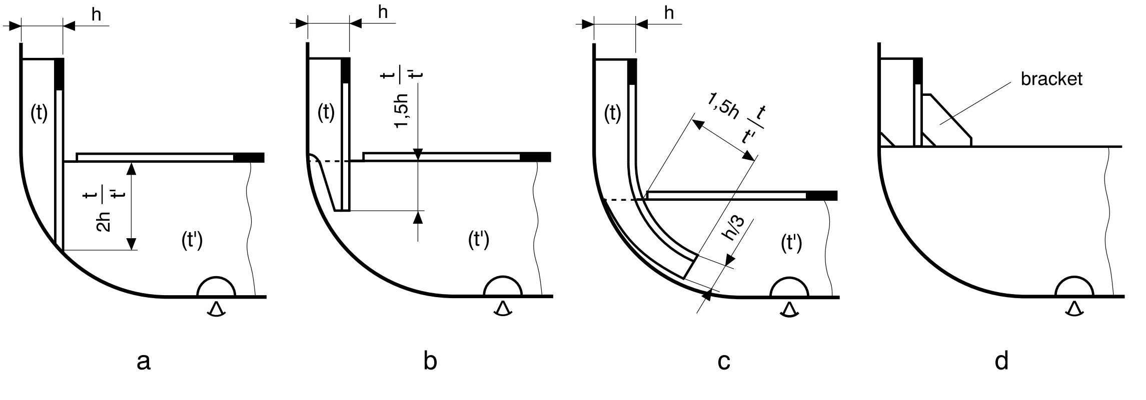
m : Boundary coefficient, to be taken, in general, equal to:
- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members

ℓ_0 : Span parameter, in m
$\ell_0 = p_d / g$

p_d : Total pressure, in kN/m^2, at the lower end of the stiffener

k_1, k_2 :
- For open deck vessels:
  $k_1 = 26$
  $k_2 = 4,4$
- For other vessels:
  $k_1 = 6$
  $k_2 = 1$

Figure 1 : Connection with floors



3.2 Net section modulus and net shear sectional area of structural members

3.2.1 The net scantlings of single and double side structural members are not to be less than the values obtained from:

- Tab 2 for single side structure
- Tab 3 for double side structure.

4 Transversely framed single side

4.1 Side frames

4.1.1 Transverse frames are to be fitted at every frame.

4.1.2 Continuity

Frames are generally to be continuous when crossing primary supporting members.

Otherwise, the detail of the connection is to be examined by the Society on a case by case basis.

4.1.3 Connection with floors

The frames are to be connected to the floors in accordance with Fig 1, or in an equivalent way.

For overlapping connection as to Fig 1 sketches b and c, a fillet weld run all around has to be provided.

4.1.4 Connection with deck structure

At the upper end of frames, connecting brackets are to be provided in compliance with [8].

On single hull open deck vessels, such brackets are to extend to the hatch coaming.

In the case of longitudinally framed deck, connecting brackets are to extend up to the deck longitudinal most at side and even to:

- the side trunk bulkhead, in the case of a trunk vessel
- the hatch coaming, in other cases.

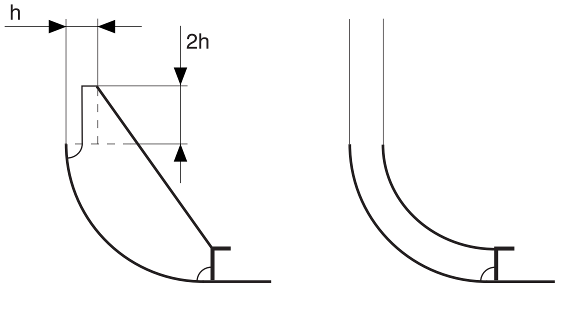
4.1.5 Reduction on section modulus

When a side stringer is fitted at about mid-span of the frame, the required section modulus of the frame may be reduced by 20%.

4.1.6 Single bottom: connection of frames to bottom longitudinals

In the case of a longitudinally framed single bottom, the side frames are to be connected to the bottom longitudinal most at side, either directly or by means of a bracket, in accordance with Fig 2.

Figure 2 : Connection of frames to bottom longitudinals



4.2 Side stringers

4.2.1 Arrangement

Side stringers, if fitted, are to be flanged or stiffened by a welded face plate.

The side stringers are to be connected to the frames by welds, either directly or by means of collar plates.

4.3 Web frames

4.3.1 Spacing

Web frames are to be fitted with a spacing, in m, not greater than 5 m.

For a construction on the combination system, side web frames are to be provided in way of bottom transverses.

4.3.2 End connections

Where the web frames are connected to the floors or the strong beams, web frame strength continuity is to be ensured according to Ch 2, Sec 4, [5.6].

4.3.3 End connection in the case of a trunk deck

For vessels fitted with a trunk having a breadth greater than 0,8 B, the web frames determined as laid down before are to extend up to the level of the trunk deck where, as a rule, they are to be connected to strong beams.

5 Longitudinally framed single side

5.1 Side transverses

5.1.1 Spacing

Side transverses are to be fitted:

- in general, with a spacing not greater than 8 frame spacings, nor than 4m
- in way of hatch end beams.

5.1.2 The side transverses are generally directly welded to the shell plating.

In the case of a double bottom, the side transverses are to be bracketed to the bottom transverses.

5.1.3 Minimum shear sectional area

Taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area of a side transverse, in cm², is to be not less than the value given in Tab 2.

The Society may waive this rule subject to direct calculation of the shearing stresses.

5.2 Side longitudinals

5.2.1 Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

In the case the longitudinals are interrupted by a primary supporting member, brackets on both sides of the primary supporting member are to be fitted in perfect alignment.

The section modulus of side longitudinals located in way of the stringers of transverse bulkheads is to be increased by 20%.

6 Transversely framed double side

6.1 General

6.1.1 Adequate continuity of strength is to be ensured in way of breaks or changes in width of the double side.

In particular, scarfing of the inner side is to be ensured beyond the cargo hold region.

6.2 Side and inner side frames

6.2.1 Struts

Side frames may be connected to the inner side frames by means of struts having a sectional area not less than those of the connected frames.

Struts are generally to be connected to side and inner side frames by means of vertical brackets or by appropriate weld sections.

Where struts are fitted between side and inner side frames at mid-span, the section modulus of side frames and inner side frames may be reduced by 30%.

6.3 Side and inner side web frames

6.3.1 It is recommended to provide web frames, fitted every 3 m and in general not more than 6 frame spacings apart.

In any case, web frames are to be fitted in way of strong deck beams.

6.3.2 At their upper end, side and inner side web frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to that of the web frames.

At mid-span, the web frames are to be connected by means of struts, the cross sectional area of which is not to be less than those of the connected web frames.

At their lower end, the web frames are to be adequately connected to the floors.

7 Longitudinally framed double side

7.1 General

7.1.1 The requirements in [6.1.1] also apply to longitudinally framed double side.

7.2 Side and inner side longitudinal

7.2.1 Struts

Side longitudinal may be connected to the inner side longitudinal by means of struts having a sectional area not less than those of the connected longitudinal.

Struts are generally to be connected to side and inner side longitudinal by means of brackets or by appropriate weld sections.

Where struts are fitted between side and inner side longitudinal at mid-span, the section modulus of side longitudinal and inner side longitudinal may be reduced by 30%.

7.3 Side transverses

7.3.1 The requirements in [6.3] also apply to longitudinally framed double side, with side transverses instead of side web frames.

8 Frame connections

8.1 General

8.1.1 End connections

At their lower end, frames are to be connected to floors, by means of lap weld or by means of brackets.

At the upper end of frames, connecting brackets are to be provided, in compliance with [8.2]. In the case of open deck vessels, such brackets are to extend to the hatch coaming.

Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

8.1.2 Brackets

The same minimum value d is required for both arm lengths of straight brackets. Straight brackets may therefore have equal sides.

A curved bracket is to be considered as the largest equal-sided bracket contained in the curved bracket.

8.2 Upper and lower brackets of frames

8.2.1 Arm length

The arm length of upper brackets, connecting frames to deck beams, and the lower brackets, connecting frames to the inner bottom or to the face plate of floors is to be not less than the value obtained, in mm, from the following formula:

$$d = \varphi\sqrt{\frac{w+30}{t}}$$

where:

- t : Bracket net thickness, in mm, to be taken not less than the stiffener thickness.
- w : Required net section modulus of the stiffener, in cm^3, given in [8.2.2] and depending on the type of connection
- φ : Coefficient equal to:
  - for unflanged brackets:

    $\varphi = 50$
  - for flanged brackets:

    $\varphi = 45$

Figure 3 : Connections of perpendicular stiffeners in the same plane

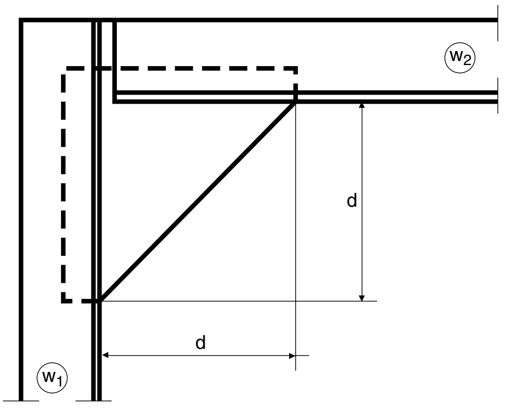
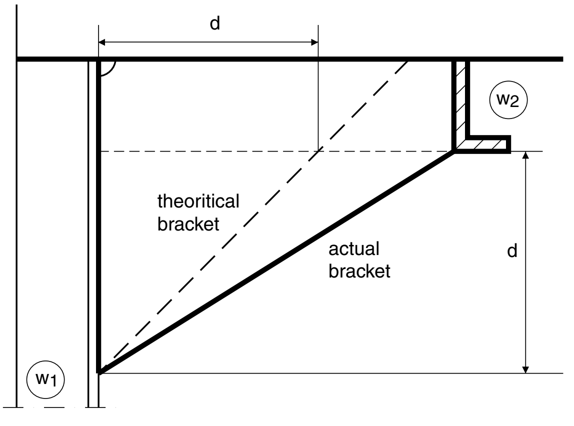


Figure 4 : Connections of stiffeners located in perpendicular planes



8.2.2 Section modulus of connections

For connections of perpendicular stiffeners located in the same plane (see Fig 3) or connections of stiffeners located in perpendicular planes (see Fig 4), the required section modulus is to be taken equal to:

$w = w_2$ if $w_2 \leq w_1$

$w = w_1$ if $w_2 > w_1$

where w_1 and w_2 are the required net section moduli of stiffeners, as shown in Fig 3 and Fig 4.

8.2.3 All brackets for which:

$$\frac{\ell_b}{t} > 60$$

where:

t : Bracket net thickness, in mm,

ℓ_b : Length, in mm, of the free edge of the bracket

are to be flanged or stiffened by a welded face plate.

The sectional area, in cm², of the flange or the face plate is to be not less than $0{,}01\ \ell_b$.

The width of the face plate, in mm, is to be not less than 10 t.

9 Side shell openings

9.1 General

9.1.1 Openings in the vessel's sides, e.g. for cargo ports, are to be well rounded at the corners and located well clear of superstructure ends or any openings in the deck areas at sides of hatchways.

9.2 Local strengthening

9.2.1 Openings are to be compensated if their edge is less than 0,25 D from the bottom or from the deck and if all these openings are located over 0,25L from either end perpendicular.

Compensation is not required for circular openings having a diameter at most equal to 300 mm.

9.2.2 Openings for water intakes are to be well rounded at the corners and, within 0,6L amidships, located outside the bilge strakes. Where arrangements are such that water intakes are unavoidably located in the curved zone of the bilge strakes, such openings are to be elliptical with the major axis in the longitudinal direction.

9.2.3 Openings in [9.2.1] and [9.2.2] and, when deemed necessary by the Society, other openings of considerable size, are to be compensated by means of insert plates or doublers sufficiently extended in length. Such compensation is to be partial or total depending on the stresses occurring in the area of the openings.

9.2.4 Circular openings on the sheerstrake need not be compensated where their diameter does not exceed 20% of the sheerstrake minimum width, and where they are located away from openings on deck at the side of hatchways or superstructure ends.

SECTION 4 DECK SCANTLINGS

Symbols

A_{sh} : Net shear sectional area, in cm²

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1 + 0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

where:

r : Radius of curvature, in m

D_1 : Unsupported stringer plate length, in m

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design lateral pressure, in kN/m², defined in Ch 5, Sec 1, [2.1]

R_{eH} : Minimum yield stress, in N/mm², of the material, defined in Ch 2, Sec 3, [2]

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Net thickness, in mm, of plating

w : Net section modulus, in cm³, of ordinary stiffeners or primary supporting members

z_{hc} : Z co-ordinate, in m, of the top of hatch coaming

β_b , β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 5, [2]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 5, [2]

η : Coefficient taken equal to: $\eta = 1 - s / (2\ \ell)$

λ_b , λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members, defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2]

σ_{X1} : Hull girder normal stress, in N/mm², defined in Ch 5, Sec 1, [2.3].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and arrangement of deck structures made of steel or aluminium alloys, fitted in the vessel central part.

The requirements applicable to specific vessel notations are defined in Part D.

The vessels covered by these Rules may be fitted with:

- open decks, consisting of a stringer plate and a longitudinal hatch coaming (Fig 1)
- flush decks, consisting of a deck continuous over the breadth of the vessel (Fig 2 and Fig 3)
- trunk decks, differing from flush decks solely by the presence of a trunk.

Figure 1 : Open deck

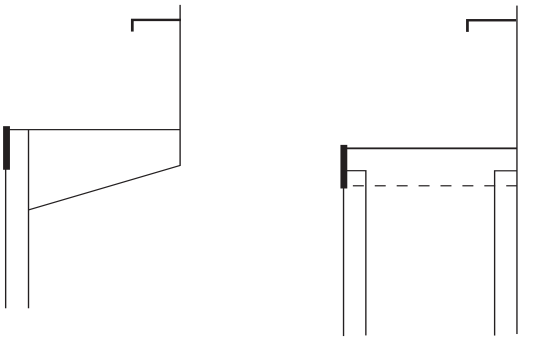


Figure 2 : Transversely framed flush deck

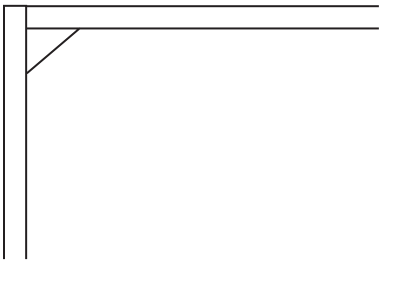
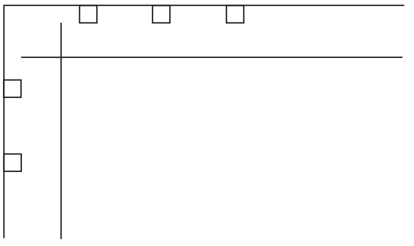


Figure 3 : Longitudinally framed flush deck



1.1.2 The decks can be longitudinally or transversely framed and may be sustained by pillars, bulkheads or strong beams.

1.1.3 The requirements applicable to specific vessel notations are defined in Part D.

1.1.4 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.2 General arrangement

1.2.1 Breaks in the deck of the cargo zone are to be avoided. In any case, the continuity of longitudinal strength is to be ensured at such places.

To ensure continuity in the case of a break, the stringer plate of the lower deck is to:

- extend beyond the break, over a length at least equal to three times its width
- stop at a web frame of sufficient scantlings.

Decks which are interrupted are to be tapered on the side by means of horizontal brackets.

1.2.2 Adequate continuity of strength is also to be ensured in way of changes in the framing system.

Details of structural arrangements are to be submitted to the Society for review / approval.

1.2.3 Deck supporting structures under deck machinery, cranes and king posts are to be adequately stiffened.

1.2.4 Where devices for vehicle lashing arrangements and/or corner fittings for containers are directly attached to deck plating, provision is to be made for the fitting of suitable additional reinforcements of the scantlings required by the load carried.

1.2.5 Stiffeners are to be fitted in way of the ends and corners of deckhouses and partial superstructures.

1.2.6 Manholes and flush deck plugs

Manholes and flush deck plugs exposed to the weather are to be fitted with steel covers of efficient construction capable of ensuring tightness. These covers are to be fitted with permanent securing device, unless they are secured with closed spaced bolts.

1.2.7 Freeing ports

Arrangements are to be made to ensure rapid evacuation of water on the decks; in particular, where the bulwarks constitute wells on the weather deck, freeing ports of adequate sectional area are to be provided.

1.2.8 Scuppers

Scuppers on the weather deck and terminating outside the hull are to be made of pipes the thickness of which, as a rule, is not to be less than that of the side plating under the sheerstrake but, however needs not exceed 8 mm.

See also Ch 6, Sec 7, [4].

1.2.9 Stringer plate openings

The openings made in the stringer plate other than scupper openings are to be wholly compensated to the satisfaction of the Society.

2 Open deck

2.1 Stringer plate

2.1.1 Width

The stringer plate is to extend between the side shell plating and the hatch coaming. In principle its width, in m, is to be not less than:

- $b = 0,1\ B$ for single hull vessels
- $b = 0,6$ m for double hull vessels unless otherwise specified.

The stringer plate width and arrangements are to be so that safe circulation of people is possible.

2.1.2 Stringer plate net thickness

The net thickness of the stringer plate, in mm, is not to be less than the values t_1 and t_2 obtained from Tab 1.

2.1.3 Stringer plate longitudinal stiffeners

The scantling of stringer plate longitudinal stiffeners are to be obtained from Tab 5.

Table 1 : Stringer plate net thickness, in mm

Transverse framing	Longitudinal framing
$t_1 = 2 + 0,02\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 2 + 0,02\ L\ (k_0k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_L R_y}}$

Note 1:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225\gamma_m \frac{\sigma_{x1}}{R_y}$$

$$\lambda_T = 1 - 0,89\gamma_m \frac{\sigma_{x1}}{R_y}$$

Note 2: In testing conditions

$$t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{R_y}}$$

2.1.4 Stringer angle

If a stringer angle is provided, its thickness is to be at least equal to that of the side shell plating plus 1 mm, being not less than that of the stringer plate. This stringer angle is to be continuous on all the hold length.

2.1.5 In vessels having range of navigation **IN(x ≤ 2)**, the Society may require transverse deck plating strips efficiently strengthened and joining the stringer plates of both sides to be fitted.

2.2 Sheerstrake

2.2.1 General

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

2.2.2 Net thickness

The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

In addition, this thickness is not to be less than the minimum value, in mm, obtained from following formulae:

$t_1 = 3{,}6 + 0{,}11\ L\ (k_0k)^{0{,}5} + 3{,}6\ s$

Where a doubling plate is provided instead of an inserted side strake, its thickness, in mm, is not to be less than:

$t_1 = 2{,}6 + 0{,}076\ L\ (k_0k)^{0{,}5} + 3{,}6\ s$

2.2.3 Width

Where the sheerstrake thickness is greater than that of the adjacent side shell plating, the sheerstrake is to extend over a height b, measured from the deckline, in compliance with the following:

$0{,}08\ D \leq b \leq 0{,}15\ D$

2.3 Hatch coaming

2.3.1 Height

The height of the hatch coaming above the deck, in m, is not to be less than the value obtained from the following formula, where b is the stringer plate width defined in [2.1.1]:

$h_C = 0{,}75\ b$

Furthermore, the height of the hatch coaming above the deck is to comply with the following:

$z_{hc} \geq T + h_2 + 0{,}15$

2.3.2 Expanded depth

The expanded depth of the underdeck portion of the hatch coaming is to be not less than:

- 0,15 m for single hull vessels
- 0,25 b for double hull vessels, where b_2 is the stringer plate width, in m.

2.3.3 Stiffening arrangements

The hatch coaming is to be fitted with a longitudinal stiffening member close to the coaming upper edge. Intermediate longitudinals may be required, depending upon the hatch coaming height, to withstand the hull girder loads.

The hatch coaming longitudinal stiffeners are to be protected against tripping and buckling by means of stays fitted above web frames and transverse bulkheads.

The spacing of the stays is not to be greater than that required for web frames or side transverses in accordance with Ch 5, Sec 3, [4.3] or Ch 5, Sec 3, [5.1].

Strength continuity of the stays is to be ensured below the deck, as far as practicable, in way of web frames and bulkheads. Stiffeners are to be provided under the deck where necessary, in way of the intermediate stays and of the transverse boundary stays.

The net moment of inertia (I_{eS}) in way of the lower end of the stays with attached plating, in cm⁴, shall be in compliance with the following formula:

$$I_{eS} = 13\left(\frac{h_C}{\ell}\right)^3 I_e$$

where:

- ℓ : Span of hatch coaming longitudinal stiffener, in m
- I_e : Net moment of inertia, in cm⁴, of the upper hatch coaming longitudinal stiffener with attached plating.

2.3.4 Plating scantling

The net thickness of the hatch coaming plating is to be maintained over the length of the hold and is not to be less than t_1 and t_2 given in Tab 2.

When the height of the upper most strake (above the hatch coaming upper most longitudinal stiffener) exceeds 8 times the hatch coaming net thickness, the buckling strength is to be checked in compliance with Ch 2, Sec 7.

Table 2 : Hatch coaming plate net thickness, in mm

Transverse framing	Longitudinal framing
$t_1 = 1{,}6 + 0{,}04\ L\ (k_0k)^{0{,}5} + 3{,}6\ s$ $t_2 = 17{,}2 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 1{,}6 + 0{,}04\ L\ (k_0k)^{0{,}5} + 3{,}6\ s$ $t_2 = 14{,}9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Note 1: $\lambda_L = \sqrt{1 - 0{,}95\left(\gamma_m \dfrac{\sigma_{x1}}{R_y}\right)^2} - 0{,}225 \gamma_m \dfrac{\sigma_{x1}}{R_y}$ $\lambda_T = 1 - 0{,}89 \gamma_m \dfrac{\sigma_{x1}}{R_y}$ p : Lateral pressure to be taken equal to 3 kN/m².	

2.4 Transverse strength of topside structure for single hull vessels

2.4.1 General

The topside structure is to be considered as a girder consisting of the stringer plate, the sheerstrake and the hatch coaming, with scantlings according to [2.1], [2.2] and [2.3].

The distributed transverse load, in kN/m, acting on the topside structure is to be taken not less than:

- if $\ell_0 \leq \ell$:

  $q = 0{,}25\ (6\ \ell\ \ell_0 + \lambda_W\ p_F\ \ell_F)$

- if $\ell_0 > \ell$:

  $q = 0,25\ (\lambda_b\ p\ \ell + \lambda_W\ p_F\ \ell_F)$

where:

ℓ_0 : Span parameter, in m, equal to:

$\ell_0 = p_d / g$

p_d : Total pressure, in kN/m², at the lower end of the stiffener

ℓ : Side frame span, in m

p : Side frame pressure, in kN/m², defined in Ch 2, Sec 5, [3.1]

p_F : Floor design lateral pressure, in kN/m², defined in Ch 5, Sec 2, Tab 2

ℓ_F : Span of floor connected to the side frame, in m

λ_W : $\lambda_W = 0,08$ in transverse framing system

$\lambda_W = 0$ in combination framing system.

The actual section modulus of the topside structure, in cm³, may be determined by means of the following formula:

$$w = Ab + \frac{tb^2}{60}\left(1 + \frac{A_a - A}{A_a + 0,05tb}\right)$$

where:

t : Thickness of stringer plate, in mm

b : Width of stringer plate in, cm

$A = \min (A_1 ; A_2)$

$A_a = \max (A_1 ; A_2)$

A_1 : Sheerstrake sectional area, in cm², including a part of the shell plating extending on 0,15 D

A_2 : Hatch coaming sectional area, in cm², including longitudinal stiffeners. The width, in m, of the hatch coaming to be considered is:

$h = h_S + \min (0,75\ h_C ; 1)$

h_S : Expanded depth of the underdeck portion of the hatch coaming, in m, defined in [2.3.2]

h_C : Hatch coaming height above deck, in m.

2.4.2 Unsupported stringer plate length

The unsupported stringer plate length D_1 , in m, is to be taken as the distance between transverse efficient supports (transverse bulkheads, transverse partial bulkheads, reinforced rings).

2.4.3 Topside structure strength check

The minimum required net section modulus, in cm³, of the topside structure is to be obtained using the formula:

$$Z_{TS} = \frac{q}{mk_1(200/k - \sigma_1)}D^2{}_1 10^3$$

where:

q : Distributed transverse load, in kN/m, defined in [2.4.1]

D_1 : Length not to be taken greater than 33,3 m

k_1 : Coefficient to be taken equal to:

$$k_1 = 1 + 0,25\left(\frac{D_1}{s} - 1\right)\frac{w}{100D}$$

w : Side frame net section modulus, in cm³

σ_1 : Maximum hull girder normal stress, in N/mm², in the stringer plate.

m : Boundary coefficient, to be taken, in general, equal to:

- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members

2.4.4 Strong deck box beams

Where the stringer plate is supported by reinforced rings, the net section modulus of the strong deck box beams is to be not less than:

$$w = \frac{\gamma_R \gamma_m p}{m(R_y - \gamma_R \gamma_m \sigma_A)} D_1 \ell^2 10^3$$

where:

p : Deck design load, in kN/m², to be defined by the Designer. In any case, p is not to be taken less than the value derived from formula given under [2.2]

σ_A : Deck box beam axial stress, in N/mm²:

$$\sigma_A = \frac{10qD_1}{A}$$

A : Deck box beam sectional area, in cm²

q : Distributed transverse load, in kN/m, defined in [2.4.1].

m : Boundary coefficient, defined in [2.4.3]

2.5 Cargo hatchways

2.5.1 Position of openings and local strengthening

Openings in the strength deck are to be kept to a minimum and spaced as far apart from one another and from breaks of effective superstructures as practicable. Openings are to be cut as far as practicable from hatchway corners.

Stringer plate cut-outs situated in the cargo hold space of open deck vessels are to be strengthened by means of plates having an increased thickness or by means of doubling plates. This is not applicable to scupper openings.

2.5.2 Corners of hatchways

The corners of hatchways are recommended to be rounded.

In any case, continuity is to be ensured by means of brackets and extended girders.

2.5.3 Deck strengthening

The deck plating where the hatchways form corners is to have:

- twice the thickness of the stringer plate over 0,5 L amidships
- the same thickness as the stringer plate over 0,15 L at the ends of the vessel.

As an alternative for small hatch openings, the deck plating may be strengthened by a doubling plate having the same thickness as the stringer plate.

The area of strengthened plating is to extend over twice the actual stringer plate width on either side of the hatch end and, if necessary, beyond the transverse bulkheads of passenger and crew accommodation if the floor of these cabins is not level with the upper deck.

The strengthenings referred to herebefore may be partly or wholly dispensed with if the hatch coamings blend with the longitudinal bulkheads of the accommodation located beyond the hatchway, thus ensuring longitudinal strength continuity in that region.

2.5.4 Hatch coamings arrangement

Where there are cut-outs in the coaming upper part to make way for the hatchway beams, the edges of the cut-outs are to be carefully rounded and a doubling plate or a plate with an increased thickness is to be provided to ensure adequate bearing capability of the hatchway beams.

Longitudinal coamings are to be extended under the deck. In the case of single hull vessels, the longitudinal coaming extension is to be bent under the brackets to which it is connected.

As far as practicable, it is recommended to extend the part of the hatch coaming which is located above the deck and to connect it to the side bulkheads of the accommodation spaces.

At the end of large-size hatchways, strength continuity of the top structure is to be ensured. This is to be arranged by extending the deck girders beyond the hatchways over two frame spacings or over a distance equal to the height of the hatch coaming.

Transverse coamings are to extend below the deck at least to the lower edge of the longitudinal coaming. Transverse coamings not in line with ordinary deck beams below are to extend below the deck up to the next deck girder.

3 Flush deck

3.1 Stringer plate

3.1.1 Net thickness

The stringer plate net thickness, in mm, is to be determined in accordance with Tab 3.

The stringer plate thickness is to be not less than that of the adjacent deck plating.

3.1.2 Width

Where the stringer plate has a thickness greater than that of the deck plating, its width is to be not less than 50 times its thickness.

3.1.3 Stringer angle

Where a stringer angle is fitted, its thickness is not to be less than that of the side shell plating increased by 1 mm nor, as a rule, when the vessel is built on the transverse system, than that of the stringer plate.

3.1.4 If the stringer plate is rounded at side, it is to extend on the side shell plating over a length at least equal to 25 times its thickness, for vessels built on the transverse system.

3.2 Deck plating

3.2.1 Plating net thickness

The deck plating net thickness, in mm, is not to be less than the values t_1 and t_2 given in Tab 3.

Table 3 : Deck plating and stringer plate net thicknesses, in mm

Transverse framing	Longitudinal framing
$t_1=0{,}9+0{,}034\ L\ (k_0k)^{0,5}+3{,}6\ s$	$t_1=0{,}57+0{,}031\ L\ (k_0k)^{0,5}+3{,}6\ s$
$t_2 = 17{,}2C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	$t_2 = 14{,}9C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{\lambda_L R_y}}$
Note 1: $\lambda_L = \sqrt{1-0{,}95\left(\gamma_m\dfrac{\sigma_{x1}}{R_y}\right)^2}-0{,}225\gamma_m\dfrac{\sigma_{x1}}{R_y}$; $\lambda_T = 1-0{,}89\gamma_m\dfrac{\sigma_{x1}}{R_y}$	
Note 2: In testing conditions $t_2 = 14{,}9C_aC_rs\sqrt{\dfrac{\gamma_R\gamma_m p}{R_y}}$	

3.3 Sheerstrake

3.3.1 General

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

See also Ch 2, Sec 4, [3.1.2].

3.3.2 Net thickness

The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

In addition, this thickness is not to be less than the minimum value, in mm, obtained from following formulae:

$t_1 = 3{,}6 + 0{,}11\ L\ (k_0k)^{0,5} + 3{,}6\ s$

Where a doubling plate is provided instead of an inserted side strake, its thickness, in mm, is not to be less than:

$t_1 = 2{,}6 + 0{,}076\ L\ (k_0k)^{0,5} + 3{,}6\ s$

3.3.3 Rounded sheerstrake

In the case of a rounded sheerstrake connecting the side shell to the deck, the radius of curvature of the strake, in mm, is not to be less than 5 times its thickness.

3.3.4 Width

Where the sheerstrake thickness is greater than that of the adjacent side shell plating, the sheerstrake is to extend over a height b, measured from the deckline, in compliance with the following relation:

$0{,}08\ D \le b \le 0{,}15\ D$

Where a sheerstrake does not rise above deck, a footguard angle or flat is to be fitted at about 100 mm from the side shell.

The height of the sheerstrake / footguard above the deck is to be at least 50 mm.

3.4 Cargo hatchways

3.4.1 Position of openings and local strengthening

Openings in the strength deck are to be kept to a minimum and spaced as far apart from one another and from breaks of effective superstructures as practicable. Openings are to be cut as far as practicable from hatchway corners.

No compensation is required where the openings are:

- circular of less than 350 mm in diameter and at a distance, sufficiently far, from any other opening
- elliptical with the major axis in the longitudinal direction and the ratio of the major to minor axis not less than 2.

If the openings arrangements do not comply with the requirements of the present Sub-Article, the hull girder longitudinal strength assessment is to be carried out by subtracting such opening areas.

3.4.2 Corners of hatchways

Hatchways are to be rounded at their corners. The radius of circular corners is to be not less than:

- 5% of the hatch width, where a continuous longitudinal deck girder is fitted below the hatch coaming
- 8% of the hatch width, where no continuous longitudinal deck girder is fitted below the hatch coaming.

Corner radiusing, in the case of the arrangement of two or more hatchways athwartship, is considered by the Society on a case by case basis.

Strengthening by insert plates in the cargo area are, in general, not required in way of corners where the plating cutout has an elliptical or parabolic profile and the half axis of elliptical openings, or the half lengths of the parabolic arch, are not less than:

- 1/20 of the hatchway width or 600 mm, whichever is the lesser, in the transverse direction
- twice the transverse dimension, in the fore and aft direction.

3.4.3 Deck strengthening

The deck plating where the hatchways form corners, is to be increased by 60% with respect to the adjacent plates. As an alternative, the deck plating may be strengthened by a doubling plate having the same thickness.

A lower thickness may be accepted by the Society on the basis of calculations showing that stresses at hatch corners are lower than permissible values.

3.4.4 Hatch coamings arrangement

The lower part of longitudinal coamings are to extend to the lower edge of the nearest beams to which they are to be efficiently secured.

In case of girders fitted under deck or under beams in the plane of the coaming longitudinal sides, strength continuity is to be ensured by means of suitable shifting. The same applies in case of strengthened beams in the plane of the coaming transverse boundaries.

Where necessary, the coaming boundaries are to be stiffened with stays.

3.4.5 Very small hatches

The following requirements apply to very small hatchways with a length and width of not more than 1,2 m.

In case of very small hatches, no brackets are required.

Small hatch covers are to have strength equivalent to that required for main hatchways. In any case, weathertightness is to be maintained.

Accesses to cofferdams and ballast tanks are to have manholes fitted with weathertight covers fixed with bolts which are sufficiently closely spaced. Other design configurations may be agreed by the Society case by case basis.

Hatchways of special design are considered by the Society on a case by case basis.

4 Trunk deck

4.1 General

4.1.1 The top structure of a trunk deck vessel is made of:

- sheerstrake
- stringer plate
- trunk, made of longitudinal vertical plating strips and the upper deck (trunk top) to which they are connected.

4.2 Sheerstrake

4.2.1 General

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

See also Ch 2, Sec 4, [3.1.2].

4.2.2 Net thickness

The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

Moreover, this thickness is not to be less than the minimum value, in mm, obtained from the following formula:

$t_1 = 3,6 + 0,11\ L\ (k_0 k)^{0,5} + 3,6\ s$

Where a doubling plate is provided instead of an inserted side strake, its thickness, in mm, is not to be less than:

$t_1 = 2,6 + 0,076\ L\ (k_0 k)^{0,5} + 3,6\ s$

4.2.3 Rounded sheerstrake

In the case of a rounded sheerstrake connecting the side shell to the deck, the radius of curvature of the strake, in mm, is not to be less than 5 times its thickness.

4.2.4 Width

Where the sheerstrake is thicker than the adjacent side shell plating, the sheerstrake is to extend over a height b_3, measured from the deckline, in compliance with the following relation:

$0,08\ D \le b_3 \le 0,15\ D$

Where a sheerstrake does not rise above deck, a footguard angle or flat is to be fitted at about 100 mm from the side shell.

The height of the sheerstrake/footguard above the deck is to be at least 50 mm.

4.3 Stringer plate

4.3.1 Net thickness

The stringer plate net thickness, in mm, is to be determined in accordance with Tab 4.

4.3.2 Width

The stringer plate is to extend between the side shell and the trunk. Its width and arrangements are to be so that safe circulation of people is possible.

4.3.3 Stringer angle

Where a stringer angle is fitted, its thickness is not to be less than that of the side shell plating increased by 1 mm nor, as a rule, when the vessel is built on the transverse system, than that of the stringer plate.

4.3.4 If the stringer plate is rounded at side, it is to extend on the side shell plating over a length at least equal to 25 times its thickness, for vessels built on the transverse system.

4.4 Trunk

4.4.1 Trunk plating net thickness

The plating net thicknesses of the trunk longitudinal bulkhead and trunk deck are not to be less than t_1 and t_2 given in Tab 4.

Table 4 : Plating net thickness, in mm

Transverse framing	Longitudinal framing
$t_1=0,9 + 0,034L(k_0k)^{0,5} + 3,6s$ $t_2 = 17,2C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	$t_1=0,57+0,031L(k_0k)^{0,5} + 3,6s$ $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_L R_y}}$
Note 1: $\lambda_L = \sqrt{1-0,95\left(\gamma_m\frac{\sigma_{x1}}{R_y}\right)^2} - 0,225\gamma_m\frac{\sigma_{x1}}{R_y}$ $\lambda_T = 1-0,89\gamma_m\frac{\sigma_{x1}}{R_y}$ **Note 2:** In testing conditions $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{R_y}}$	

5 Top structure supporting members

5.1 General

5.1.1 The top structure supporting members consist of ordinary stiffeners (beams or longitudinals), longitudinally or transversely arranged, supported by primary supporting members which may be sustained by pillars.

5.2 Minimum net thickness of web plating

5.2.1 Ordinary stiffeners

The net thickness, in mm, of the web of ordinary stiffeners is to be not less than:

- for L < 120 m: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
- for L ≥ 120 m: $t = 3,9\ (k_0k)^{0,5} + s$

5.2.2 Primary supporting members

The net thickness, in mm, of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$t = 3,8 + 0,016\ L\ (k_0k)^{0,5}$

5.3 Net scantlings of structural members

5.3.1 Net section modulus and net shear sectional area

The net section modulus w, in cm³, and the net shear sectional area A_{Sh}, in cm², of top structure structural members in service conditions are to be obtained from Tab 5.

5.4 Arrangement of hatch supporting structure

5.4.1 Hatch side girders and hatch end beams of reinforced scantlings are to be fitted in way of cargo hold openings.

In general, hatched end beams and deck transverses are to be in line with bottom and side transverse structures, so as to form a reinforced ring.

5.4.2 Clear of openings, adequate continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

5.4.3 The details of connection of deck transverses to longitudinal girders and web frames are to be submitted to the Society.

5.5 Coaming of separate hatchways

5.5.1 Height

The coaming upper edge is not to be less than 300 mm above the deck.

Furthermore, the height of the hatch coaming, h_C, above the deck is to comply with the following:

$z_C \geq T + h_2 + 0,15$

5.5.2 Net thickness

The net thickness of the coaming boundaries is not to be less than:

$t = 0,25\ a + 3 \leq 5$ mm,

a being the greater dimension of the hatchway, in m.

The Society reserves the right to increase the scantlings required here before where range of navigation **IN(1,2 ≤ x ≤ 2)** is assigned.

Table 5 : Net scantlings of top structure supporting members

Item	w, in cm³	A_{Sh}, in cm²
Deck beams	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m R_y} s \ell^2 10^3$	$A_{Sh} = 10 \gamma_R \gamma_m \beta_S \dfrac{p}{R_y} \eta s \ell$
Trunk vertical stiffeners **(1)**	$w = \dfrac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} s \ell^2 10^3$	$A_{Sh} = 10 \gamma_R \gamma_m \lambda_S \beta_S \dfrac{p}{R_y} \eta s \ell$
Deck longitudinals Stringer plate longitudinals Trunk longitudinals Hatch coaming longitudinals	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$	$A_{Sh} = 10 \gamma_R \gamma_m \beta_S \dfrac{p}{R_y} \eta s \ell$
Deck transverses Reinforced deck beams Trunk web frames **(2)**	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m R_y} S \ell^2 10^3$	$A_{Sh} = 10 \gamma_R \gamma_m \beta_S \dfrac{p}{R_y} S \ell$
Deck girders	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$	$A_{Sh} = 10 \gamma_R \gamma_m \beta_S \dfrac{p}{R_y} S \ell$

(1) Scantlings of trunk vertical stiffeners are not to be less than those of deck beams connected to them
(2) Scantlings of trunk web frames are not to be less than those of deck transverses connected to them.
Note 1:
m : Boundary coefficient, to be taken, in general, equal to:
- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members.

5.5.3 Stiffening

The coaming boundaries are to be stiffened with an horizontal stiffening member close to the coaming upper edge. In the case the coaming is higher than 750 mm, a second stiffener is to be fitted at about 0,75 times the hatch coaming height.

The coaming boundaries are to be stiffened with stays, the ends of which are to be connected to the deck and to the upper horizontal stiffeners.

Where necessary, stiffeners are to be provided under deck in way of the stays.

5.5.4 Strength continuity

Arrangements are to be made to ensure strength continuity of the top structure, at the end of large-size hatchways, mainly by extending the deck girders along the hatchway, beyond the hatchways, up to the end bulkhead or over two frame spacings, whichever is greater.

6 Transversely framed deck

6.1 Deck beams

6.1.1 General

In general, deck beams or deck half-beams are to be fitted at each frame.

6.1.2 Open deck vessels

In the hatchway region, it is recommended to replace the half-beams by brackets, extending to the hatch coaming, as shown on Fig 1.

6.2 Reinforced deck beams

6.2.1 Reinforced deck beams are to be fitted in way of side webs.

6.3 Deck girders

6.3.1 Where deck beams are fitted in a hatched deck, they are to be effectively supported by longitudinal girders located in way of hatch side girders to which they are to be connected by brackets and/or clips.

6.3.2 Deck girders subjected to concentrated loads are to be adequately strengthened.

6.3.3 Deck girders are to be fitted with tripping stiffeners or brackets:

- spaced not more than 20 times the girder faceplate width
- in way of concentrated loads and pillars.

6.3.4 Where a deck girder comprises several spans and its scantlings vary from one span to another, the connection of two different parts is to be effected gradually by strengthening the weaker part over a length which, as a rule, is to be equal to 25% of its length.

6.3.5 The connection of girders to the supports is to ensure correct stress transmission. In particular, connection to the bulkheads is to be obtained by means of flanged brackets having a depth equal to twice that of the deck girder and the thickness of the girder, or by any equivalent method.

7 Longitudinally framed deck

7.1 Deck longitudinals

7.1.1 Deck longitudinals are to be continuous, as far as practicable, in way of deck transverses and transverse bulkheads.

Other arrangements may be considered, provided adequate continuity of longitudinal strength is ensured.

The section modulus of deck longitudinals located in way of the web frames of transverse bulkheads is to be increased by 20%.

7.1.2 Frame brackets, in vessels with transversely framed sides, are generally to have their horizontal arm extended to the adjacent longitudinal ordinary stiffener.

7.2 Deck transverses

7.2.1 In general, the spacing of deck transverses is not to exceed 8 frame spacings or 4 m, whichever is the lesser.

7.2.2 Where applicable, deck transverses of reinforced scantlings are to be aligned with bottom transverses.

7.2.3 Deck and trunk deck transverses

The section modulus of transverse parts in way of the stringer plate and of the trunk sides is not to be less than the rule value obtained by determining them as deck transverses or as side shell transverses, whichever is greater.

8 Pillars

8.1 General

8.1.1 Pillars or other supporting structures are generally to be fitted under heavy concentrated loads.

8.1.2 Structural members at heads and heels of pillars as well as substructures are to be constructed according to the forces they are subjected to, taking into account the requirement of Ch 8, Sec 2, [3.7].

Where pillars are affected by tension loads doublings are not permitted.

8.1.3 Pillars in tanks are to be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

8.1.4 Pillars are to be fitted, as far as practicable, in the same vertical line.

8.2 Buckling check

8.2.1 The buckling strength check of pillars is to be carried out according to Ch 2, Sec 7, [6].

8.3 Connections

8.3.1 Pillars are to be attached at their heads and heels by continuous welding.

8.3.2 Pillars working under pressure may be fitted by welds only, in the case the thickness of the attached plating is at least equal to the thickness of the pillar.

Where the thickness of the attached plating is smaller than the thickness of the pillar, a doubling plate is to be fitted.

8.3.3 Heads and heels of pillars which may also work under tension (such as those in tanks) are to be attached to the surrounding structure by means of brackets or insert plates so that the loads are well distributed.

8.3.4 Pillars are to be connected to the inner bottom, where fitted, at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

8.3.5 Manholes and lightening holes may not be cut in the girders and floors below the heels of pillars.

8.3.6 Where side pillars are not fitted in way of hatch ends, vertical stiffeners of bulkheads supporting hatch side girders or hatch end beams are to be bracketed at their ends.

9 Hatch supporting structures

9.1 General

9.1.1 Hatch side girders and hatch end beams of reinforced scantlings are to be fitted in way of cargo hold openings.

In general, hatched end beams and deck transverses are to be in line with bottom and side transverse structures, so as to form a reinforced ring.

9.1.2 Clear of openings, adequate continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

9.1.3 The details of connection of deck transverses to longitudinal girders and web frames are to be submitted to the Society for approval.

SECTION 5 BULKHEAD SCANTLINGS

Symbols

A_{sh} : Net shear sectional area, in cm^2

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \leq 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \geq 0,5$$

where:

r : Radius of curvature, in m

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

- for steels in general: $E = 2,06 \cdot 10^5$ N/mm^2
- for stainless steels: $E = 1,95 \cdot 10^5$ N/mm^2
- for aluminium alloys: $E = 7,0 \cdot 10^4$ N/mm^2

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- $k_0 = 1$ for steel
- $k_0 = 2,35$ for aluminium alloys

l : Span, in m, of ordinary stiffeners or primary supporting members

p : Design lateral pressure, in kN/m^2, defined in Ch 5, Sec 1, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- $R_y = 235/k$ N/mm^2 for steel
- $R_y = 100/k$ N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 5, [2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 5, [2]

η : Coefficient taken equal to: $\eta = 1 - s / (2\ l)$

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

σ_{X1} : Hull girder normal stress, in N/mm^2, defined in Ch 5, Sec 1, [2.3].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and arrangement of transverse or longitudinal bulkhead structures made of steel or aluminium alloys. The bulkheads may be plane or corrugated.

The requirements applicable to specific vessel notations are defined in Part D.

1.1.2 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.2 General arrangement

1.2.1 Bulkheads may be horizontally or vertically stiffened.

Horizontally framed bulkheads consist of horizontal ordinary stiffeners supported by vertical primary supporting members.

Vertically framed bulkheads consist of vertical ordinary stiffeners which may be supported by horizontal girders.

2 Plating scantling

2.1 Plating net thicknesses

2.1.1 The bulkhead plating net thickness, in mm, is not to be less than the values t_1 and t_2 given in Tab 1.

3 Structural member scantlings

3.1 Minimum web net thicknesses

3.1.1 Ordinary stiffeners

The net thickness, in mm, of the web plating of ordinary stiffeners is to be not less than:

$$t = 1,1 + 0,0048\ L\ (k_0 k)^{0,5} + 4,8\ s$$

Table 1 : Bulkhead plating net thickness t

Bulkheads			t, in mm
Transverse	Collision bulkhead		$t_1 = 0{,}026\ L\ (k_0k)^{0,5} + 3{,}6\ s$ $t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p_T}{R_y}}$
	Watertight bulkhead and hold bulkhead		$t_1 = 0{,}026\ L\ (k_0k)^{0,5} + 3{,}6\ s$ $t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p_T}{R_y}}$
	Tank bulkhead		$t_1 = 2 + 0{,}003\ L\ (k_0k)^{0,5} + 3{,}6\ s$ with $t_1 \geq 4{,}4$ $t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p_T}{R_y}}$
	Wash bulkhead		$t_1 = 2 + 0{,}003\ L\ (k_0k)^{0,5} + 3{,}6\ s$ with $t_1 \geq 4{,}4$
Longitudinal	Watertight bulkhead		$t_1 = 2 + 0{,}003\ L\ (k_0k)^{0,5} + 3{,}6\ s$
		• vertical stiffening:	$t_2 = 17{,}2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$
		• longitudinal stiffening:	$t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
	Tank bulkhead		$t_1 = 2 + 0{,}003\ L\ (k_0k)^{0,5} + 3{,}6\ s$ with $t_1 \geq 4{,}4$
		• vertical stiffening:	$t_2 = 17{,}2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$
		• longitudinal stiffening:	$t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
	Wash bulkhead		$t_1 = 2 + 0{,}003\ L\ (k_0k)^{0,5} + 3{,}6\ s$ with $t_1 \geq 4{,}4$

Note 1:

$$\lambda_L = \sqrt{1 - 0{,}95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0{,}225\gamma_m \frac{\sigma_{x1}}{R_y}$$

$$\lambda_T = 1 - 0{,}89\gamma_m \frac{\sigma_{x1}}{R_y}$$

Note 2:

P_T : Lateral pressure, in kN/m², in testing conditions, defined in Ch 5, Sec 2, [3.2.1]

Note 3: In testing conditions

$$t_2 = 14{,}9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{R_y}}$$

3.1.2 Primary supporting members

The net thickness, in mm, of plating which forms the web of bulkhead primary supporting members is to be not less than the values obtained from the following formulae:

- for collision bulkhead:

  $t = 4{,}4 + 0{,}018\ L\ (k_0k)^{0,5}$
- otherwise:
  - $t = 3{,}8 + 0{,}016\ L\ (k_0k)^{0,5}$

3.2 Net section modulus and net sectional area of structural members

3.2.1 The net scantlings of bulkhead structural members are not to be less than the values obtained from Tab 2.

4 Bulkhead arrangements

4.1 General arrangement

4.1.1 Where an inner bottom terminates on a bulkhead, the lowest strake of the bulkhead forming the watertight floor of the double bottom is to extend at least 300 mm above the inner bottom.

4.1.2 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.

Table 2 : Net scantlings of bulkhead structure

Item		w, in cm^3	A_{sh}, in cm^2
Transverse bulkhead	Vertical stiffeners	$w = \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_s \beta_s \frac{p}{R_y} \eta s \ell$
	Transverse stiffeners	$w = \frac{\gamma_R \gamma_m \beta_b p}{m R_y} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$
	Web frames, transverses	$w = \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_s \beta_s \frac{p}{R_y} S \ell$
Longitudinal bulkhead	Vertical stiffeners	$w = \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_s \beta_s \frac{p}{R_y} \eta s \ell$
	Longitudinal stiffeners	$w = \beta_b \frac{\gamma_R \gamma_m \beta_b p}{m (R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$
	Web frames	$w = \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_s \beta_s \frac{p}{R_y} S \ell$
	Stringers	$w = \frac{\gamma_R \gamma_m \beta_b p}{m (R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$

Note 1:
m : Boundary coefficient, to be taken, in general, equal to:
- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members.
- m = 10.6 for the stiffeners which are fixed at one end and simply supported/sniped at the other end

Note 2: The value of σ_{X1} is to be taken in relation with the pressure p considered.

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

4.1.4 The height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck.

Requirements in Ch 5, Sec 3, [6.3] or Ch 5, Sec 3, [7.3] are to be complied with too.

5 Plane bulkheads

5.1 General

5.1.1 Where a bulkhead does not extend up to the uppermost continuous deck, such as the after peak bulkhead, suitable strengthening is to be provided in the extension of the bulkhead.

5.1.2 Bulkheads are to be stiffened in way of deck girders.

5.1.3 The stiffener webs of side tank watertight bulkheads are generally to be aligned with the webs of inner hull longitudinal stiffeners.

5.1.4 Floors are to be fitted in the double bottom in way of plane transverse bulkheads.

5.1.5 In way of the sterntube, the thickness of the after peak bulkhead plating is to be increased by 60%.

Instead of the thickness increase required herebefore, a doubling plate of the same thickness as the bulkhead plating may be fitted.

5.2 Bulkhead stiffeners

5.2.1 As a rule, stiffeners are to be fitted in way of structural components likely to exert concentrated loads, such as deck girders and pillars, and for engine room end bulkheads, at the ends of the engine seatings.

5.2.2 On vertically framed watertight bulkheads, where stiffeners are interrupted in way of the watertight doors, stanchions are to be fitted on either side of the door, carlings are to be fitted to support the interrupted stiffeners.

5.3 End connections

5.3.1 In general, end connections of ordinary stiffeners are to be welded directly to the plating or bracketed. However, stiffeners may be sniped, provided the scantlings of such stiffeners are modified accordingly.

Sniped ends may be accepted where the hull lines make it mandatory in the following cases:

- liquid compartment boundaries
- collision bulkhead.

5.3.2 Where sniped ordinary stiffeners are fitted, the snipe angle is to be not greater than 30° and their ends are to be extended, as far as practicable, to the boundary of the bulkhead.

Moreover, the thickness of the bulkhead plating supported by the stiffener is to be in compliance with Ch 2, Sec 4, [4.5.3].

5.4 Bracketed ordinary stiffeners

5.4.1 Where bracketed ordinary stiffeners are fitted, the arm lengths of end brackets of ordinary stiffeners, as shown in Fig 1 and Fig 2, are to be not less than the following values, in mm:

- for arm length a:
  - brackets of horizontal stiffeners and bottom bracket of vertical stiffeners:

    $a = 100\,\ell$

  - upper bracket of vertical stiffeners:

    $a = 80\,\ell$

- for arm length b, the greater of:

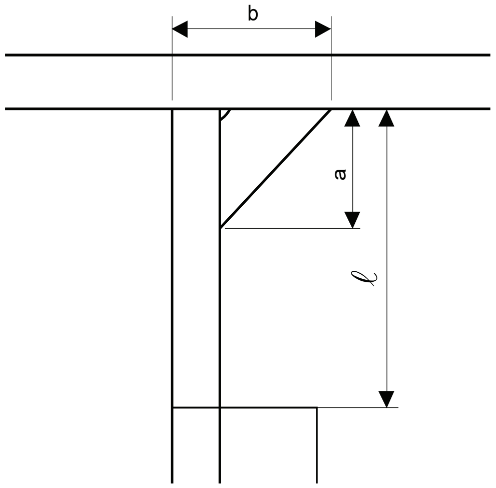
$$b = 80\sqrt{\frac{w+20}{t}}$$

$$b = \alpha\frac{ps\ell}{t}$$

where:

ℓ	:	Span, in m, of the stiffener measured between supports
w	:	Net section modulus, in cm^3, of the stiffener
t	:	Net thickness, in mm, of the bracket
p	:	Design pressure, in kN/m^2, calculated at mid-span
α	:	$\alpha = 4{,}9$ for tank bulkheads
		$\alpha = 3{,}6$ for watertight bulkheads.

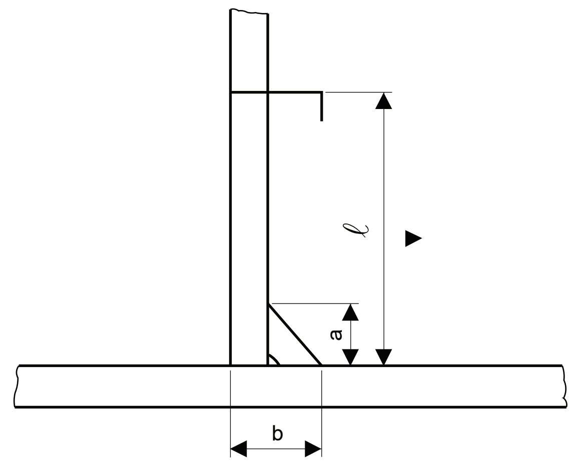
Figure 1 : Bracket at upper end of ordinary stiffener on plane bulkhead



5.4.2 The connection between the stiffener and the bracket is to be such that the section modulus of the connection is not less than that of the stiffener.

The brackets are to extend up to the next stiffener where the framing is transverse, or connect the stiffener to a longitudinal stiffener where the framing is longitudinal.

Figure 2 : Bracket at lower end of ordinary stiffener on plane bulkhead



6 Corrugated bulkheads

6.1 General

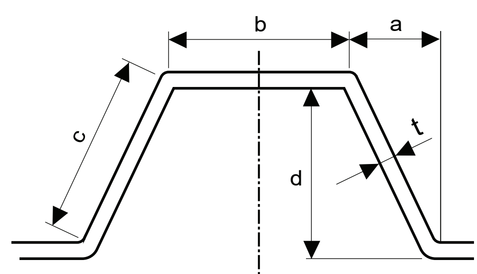
6.1.1 The main dimensions a, b, c and d of corrugated bulkheads are defined in Fig 3.

6.1.2 Unless otherwise specified, the following requirement is to be complied with:

$a \leq 1{,}2d$

Moreover, in some cases, the Society may prescribe an upper limit for the ratio b/t.

Figure 3 : Corrugated bulkhead



6.1.3 In general, the bending internal radius R_i is to be not less than the following values, in mm:

- for normal strength steel:

  $R_i = 2{,}5\ t$

- for high tensile steel:

  $R_i = 3{,}0\ t$

where t is the gross thickness, in mm, of the corrugated plate.

6.1.4 When butt welds in a direction parallel to the bend axis are provided in the zone of the bend, the welding procedures are to be submitted to the Society for approval, as a function of the importance of the structural element.

6.1.5 Transverse corrugated bulkheads having horizontal corrugations are to be fitted with vertical primary supporting members of number and size sufficient to ensure the required vertical stiffness of the bulkhead.

6.1.6 In general, where girders or vertical primary supporting members are fitted on corrugated bulkheads, they are to be arranged symmetrically.

6.2 Bulkhead scantlings

6.2.1 Bulkhead plating

The bulkhead plating net thickness is to be determined as specified in [3], substituting the stiffener spacing by the greater of the two values b and c, in m, as per [6.1.1].

6.2.2 Corrugations

The section modulus of a corrugation is to be not less than that of the equivalent stiffener having the same span as the corrugation and an attached plating width equal to (b + a).

The actual section modulus of a corrugation is to be obtained according to Ch 2, Sec 4, [4.4.2].

Moreover, where the ratio $b / t \geq 46$, the net section modulus required for a bulkhead is to be in accordance with the following formula:

$$w = 206 c_k \left(\frac{b+a}{E}\right) p \left(\frac{\ell b}{80t}\right)^2$$

where:

c_k : Coefficient defined in Tab 3

p : Bulkhead design pressure, in kN/m^2, calculated at mid-span.

Table 3 : Values of coefficient c_k

Boundary conditions	Collision bulkhead	Watertight bulkhead	Cargo hold bulkhead
simply supported	1,73	1,38	1,04
simply supported (at one end)	1,53	1,20	0,92
clamped	1,15	0,92	0,69

6.2.3 Stringers and web frames

It is recommended to fit stringers or web frames symmetrically with respect to the bulkhead. In all cases, their section modulus is to be determined in the same way as for a plane bulkhead stringer or web frame.

6.3 Structural arrangement

6.3.1 The strength continuity of corrugated bulkheads is to be ensured at ends of corrugations.

6.3.2 Where corrugated bulkheads are cut in way of primary members, attention is to be paid to ensure correct alignment of corrugations on each side of the primary member.

6.3.3 In general, where vertically corrugated transverse bulkheads are welded on the inner bottom, floors are to be fitted in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

6.3.4 Where stools are fitted at the lower part of transverse bulkheads, the thickness of adjacent plate floors is to be not less than that of the stool plating.

6.3.5 In general, where vertically corrugated longitudinal bulkheads are welded on the inner bottom, girders are to be fitted in double bottom in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

6.3.6 In general, the upper and lower parts of horizontally corrugated bulkheads are to be flat over a depth equal to 0,1 D.

6.4 Bulkhead stool

6.4.1 In general, plate diaphragms or web frames are to be fitted in bottom stools in way of the double bottom longitudinal girders or plate floors, as the case may be.

6.4.2 Brackets or deep webs are to be fitted to connect the upper stool to the deck transverses or hatch end beams, as the case may be.

6.4.3 The continuity of the corrugated bulkhead with the stool plating is to be adequately ensured. In particular, the upper strake of the lower stool is to be of the same thickness and yield stress as those of the lower strake of the bulkhead.

7 Hold bulkheads of open deck vessels

7.1 Special arrangements

7.1.1 The upper end of vertical stiffeners is to be connected either to a box beam or a stringer located at the stringer plate level or above.

7.1.2 As far as practicable, the bottom of the box beam or the bulkhead end stringer is to be located in the same plane as the stringer plate.

Where this is not the case, the bulkhead plating or the box beam sides are to be fitted with an efficient horizontal framing at that level.

7.1.3 The upper part of horizontally framed bulkheads are to be subject of a special review by the Society.

8 Non-tight bulkheads

8.1 General

8.1.1 Definition

A bulkhead is considered to be acting as a pillar when besides the lateral loads, axial loads are added.

8.2 Non-tight bulkheads not acting as pillars

8.2.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- for transverse bulkheads: 0,9 m
- for longitudinal bulkheads: 2-frame spacings with a maximum of 1,5 m.

8.3 Non-tight bulkheads acting as pillars

8.3.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 2-frame spacing, when the frame spacing does not exceed 0,75 m
- 1-frame spacing, when the frame spacing is greater than 0,75 m.

8.3.2 Each vertical stiffener, in association with a width of plating equal to 35 times the plating thickness, is to comply with the applicable requirements for pillars in Ch 5, Sec 4, [8], the load supported being determined in accordance with the same requirements.

8.3.3 In the case of non-tight bulkheads supporting longitudinally framed decks, web frames are to be provided in way of deck transverses.

9 Wash bulkheads

9.1 General

9.1.1 The requirements in [8.2] apply to transverse and longitudinal wash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

9.2 Openings

9.2.1 The total area of openings in a transverse wash bulkhead is generally to be less than 10% of the total bulkhead area.

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

9.2.2 In any case, the distribution of openings is to fulfill the strength requirements specified in [8.3].

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

Table 4 : Areas of openings in transverse wash bulkheads

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

SECTION 6 ALTERNATIVE REQUIREMENTS APPLICABLE TO VESSELS WITH LENGTH L < 40 M - METALLIC HULLS

Symbols

A_{sh} : Net web sectional area, in cm².

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature, equal to:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

E : Young's modulus, in N/mm², to be taken equal to:

- for steels in general:

  $E = 2,06.10^5$ N/mm²

- for stainless steels:

  $E = 1,95.10^5$ N/mm²

- for aluminium alloys:

  $E = 7,0.10^4$ N/mm²

k : Material factor defined in:

- for steel:

  Ch 2, Sec 3, [2.3]

- for aluminium alloys:

  Ch 2, Sec 3, [3.5]

k_0 : Coefficient to be taken equal to:

- for steel:

  $k_0 = 1$

- for aluminium alloys:

  $k_0 = 2,35$

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design lateral pressure, in kN/m², defined in Ch 5, Sec 1, [2.1]

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- for steel:

  $R_y = 235/k$ N/mm²

- for aluminium alloys

  $R_y = 100/k$ N/mm²

unless otherwise specified

R_{eH} :
- for hull structural steels:

  R_{eH} is the nominal yield point, in N/mm²

- for aluminium alloys:

  R_{eH} is 0,2% proof stress, in N/mm²

r : Radius of curvature, in m

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Net thickness, in mm, of plating

w : Net section modulus, in cm³, of ordinary stiffeners or primary supporting members

β_b , β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 2, Sec 5, [2]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Ch 2, Sec 5, [2]

η : Coefficient taken equal to:

$\eta = 1 - s / (2\ l)$

ℓ : Span, in m, of ordinary stiffeners or primary supporting members.

1 General

1.1 Application

1.1.1 As an alternative to the provisions of Ch 5, Sec 2 to Ch 5, Sec 5, this Section contains the requirements for the determination of the hull scantlings applicable to the central part of all types of vessels with length L < 40 m, of normal design and dimensions, made of steel or aluminium alloys.

Cargo carriers covered by these requirements have their machinery aft and are assumed to be loaded and unloaded in two runs.

1.1.2 Arrangement and scantlings not covered by this Section are to be as specified in Ch 5, Sec 2 to Ch 5, Sec 5.

Table 1 : Values of coefficient K_M

Range of navigation	Vessel type	Bottom and inner bottom plating	Top plating	Stiffeners
IN	Self-propelled cargo carriers and passenger vessels	1,08	1,056	1,08
	Non-propelled cargo carriers	1,0	1,0	1,0
	Other vessels	1,2	1,5	1,5
IN(x ≤ 2)	Self-propelled cargo carriers and passenger vessels	0,83 + 3,6 n	0,88 + 2,58 n	0,83 + 3,6 n
	Non-propelled cargo carriers	0,385 + 7,73 n	0,75 + 2,73 n	0,385 + 7,73 n
	Other vessels	1 + 3,6 n	1 + 7,73 n	1 + 7,73 n

2 Strength deck sectional area

2.1 Strength deck

2.1.1 The strength deck is the uppermost continuous deck.

2.1.2 The sectional area of the strength deck is the sum of the sectional area of members contributing to the longitudinal strength.

This sectional area includes:

- deck plating abreast hatchways
- stringer plates
- trunk structure
- deck longitudinal girders, provided their continuity is ensured
- where the deck is framed longitudinally, deck longitudinals, provided their continuity is ensured.

2.2 Gross sectional area of flush deck and trunk deck

2.2.1 Within the central part, the gross sectional area, in cm^2, of the deck structure in way of the hatchways is not to be less than:

$A = 6\ B\ s\ K_{MZ}\ (k_0 k\ L)^{0,5}$

where:

$$K_{MZ} = \sqrt{\frac{K_M}{K_Z}}$$

K_M : Coefficient defined in Tab 1

K_Z : Coefficient defined in Tab 2.

Table 2 : Values of coefficient K_Z

Range of navigation	K_Z
IN	1,0
IN(x ≤ 2)	1 + 0,814 n

3 Plating scantling

3.1 Plating net thicknesses

3.1.1 In the central part, the hull plating net thicknesses, in mm, are not to be less than the values t_1, t_2 and t_3 given in Tab 3.

4 Structural member scantlings

4.1 Net section modulus and net sectional area of structural members

4.1.1 The net scantlings of contributing hull structural members are not to be less than the values given in Tab 4.

In addition, hatch coaming stiffener scantlings are to comply with the following formulae:

- for longitudinal stiffeners:

$$i_e = 20\sqrt{\frac{R_{eH}}{E}}\ell$$

- for stays:

$$I_{eS} = 13\left(\frac{h_C}{\ell}\right)^3 I_e$$

where:

h_C : Actual hatch coaming height above the deck, in m

b_e : Width of attached plating of longitudinal stiffener:

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

i_e : Radius of gyration, in cm:

$$i_e = \sqrt{\frac{I_e}{A_e}}$$

I_e : Net moment of inertia, in cm^4, of the stiffener with attached plating

A_e : Net cross sectional area, in cm^2, of the stiffener with attached plating.

Table 3 : Hull plating net thicknesses, in mm

Item		Transverse framing	Longitudinal framing
Bottom		$t_1 = 1,85 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$ $t_3 = 44,4 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$	$t_1 = 1,1 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$ $t_3 = 25,5 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$
Inner bottom		$t_1 = 1,5 + 0,016\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$ $t_3 = 44,4 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$	$t_1 = 1,5 + 0,016\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$ $t_3 = 25,5 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$
Side		$t_1 = 1,68 + 0,025\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 1,25 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Inner side Longitudinal bulkhead		$t_1 = 2 + 0,003\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t_1 = 2 + 0,003\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Open deck	Stringer plate	$t_1 = 2 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$ $t_3 = 39,4 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$	$t_1 = 2 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$ $t_3 = 36,8 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$
	Hatch coaming	$t_1 = 1,6 + 0,04\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$ $t_3 = (1 + h_C / D)\ t_0$	$t_1 = 1,6 + 0,04\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$ $t_3 = (1 + h_C / D)\ t_0$
Flush deck and trunk deck		$t_1 = 0,9 + 0,034\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_T R_y}}$ $t_3 = 39,4 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$	$t_1 = 0,57 + 0,031\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda_L R_y}}$ $t_3 = 36,8 s K_{MZ} \sqrt{\frac{R_{eH} L}{E}}$
Sheerstrake		• for doubling strake: $t_1 = 2,6 + 0,076\ L\ (k_0 k)^{0,5} + 3,6\ s$ • for inserted strake: $t_1 = 3,6 + 0,11\ L\ (k_0 k)^{0,5} + 3,6\ s$	

Note 1:

t_0 : Rule stringer plate thickness, in mm

h_C : Actual hatch coaming height above the deck, in m

$$K_{MZ} = \sqrt{\frac{K_M}{K_Z}}$$

K_M : Coefficient defined in Tab 1

K_Z : Coefficient defined in Tab 2.

Note 2: In testing conditions

$$t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{R_y}}$$

Note 3:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{for}}{R_y}\right)^2} - 0,225\gamma_m \frac{\sigma_{for}}{R_y}$$

$$\lambda_T = 1 - 0,89\gamma_m \frac{\sigma_{for}}{R_y}$$

σ_{for} : Parameter, in N/mm^2, taken equal to

- $\sigma_{for} = 100\ N/mm^2$ for steel
- $\sigma_{for} = 45\ N/mm^2$ for aluminium alloys

Table 4 : Net scantlings of contributing structural members

Item	w (cm³)	A_{sh} (cm²)
Bottom, side, inner side and deck longitudinals	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m R_y (1-0,18\gamma_R \gamma_m K_{MZ})} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} \eta s \ell$
Side and inner side stringers, bottom and deck girders **(1)**	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m R_y (1-0,18\gamma_R \gamma_m K_{MZ})} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} S \ell$

(1) The span ℓ is to be taken equal to the side transverse spacing or web frame spacing.

Note 1:

m : Boundary coefficient to be taken, in general, equal to:
- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members

$K_{MZ} = \sqrt{\dfrac{K_M}{K_Z}}$

K_M : Coefficient defined in Tab 1

K_Z : Coefficient defined in Tab 2

Part B
Hull Design and Construction

Chapter 6
OTHER STRUCTURES

SECTION 1	FORE PART
SECTION 2	AFT PART
SECTION 3	MACHINERY SPACE
SECTION 4	SUPERSTRUCTURES AND DECKHOUSES
SECTION 5	HATCH COVERS
SECTION 6	MOVABLE DECKS AND RAMPS
SECTION 7	MISCELLANEOUS FITTINGS
SECTION 8	HELICOPTER DECKS AND PLATFORMS

SECTION 1 FORE PART

Symbols

A_{sh} : Net shear sectional area, in cm^2

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

where:

r : Radius of curvature, in m

f : Coefficient defined as follows:

f = 1,0 for **IN(1,2 < x ≤ 2)**

f = 0,9 for **IN(x ≤ 1,2)**

f = 0,8 for **IN**

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

m : Boundary coefficient to be taken, in general, equal to:

- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members.

Other values of m may be considered, on a case by case basis, for other boundary conditions

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design load, in kN/ m^2

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

z : Z co-ordinate, in m, of the calculation point of a structural element.

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_m : Partial safety factor covering uncertainties regarding material:

γ_m = 1,02

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Tab 1

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

- γ_{W1} = 1,0 for **IN**
- γ_{W1} = 1,15 for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- γ_{W2} = 1,0 for **IN**
- γ_{W2} = 1,2 for **IN(x ≤ 2)**

η : Coefficient taken equal to:

$\eta = 1 - s / (2\ l)$

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the scantling and arrangement of fore part structures as defined in Ch 1, Sec 1, [2.1], for all vessels made of steel or aluminium alloy.

As to the requirements which are not explicitly dealt with in the present Section, refer to the previous Chapters.

1.1.2 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.1.3 Vessels with length L < 40 m

Where alternative requirements in Ch 5, Sec 6 have been adopted for the vessel central part, the associated fore part structure scantlings are to be determined from this Section considering a hull girder normal stress $\sigma_{X1} = 0$.

1.2 Net scantlings

1.2.1 As specified in Ch 2, Sec 5, all scantlings referred to in this Section, with the exception of those indicated in [7], are net scantlings, i.e. they do not include any margin for corrosion.

1.3 Resistance partial safety factor

1.3.1 The resistance partial safety factor γ_R to be considered for the checking of the fore part structures is specified in Tab 1.

Table 1 : Resistance partial safety factor γ_R

Structures	Plating	Ordinary stiffeners	Primary supporting members
In general			
Fore peak structures	1,20	1,40	1,60
Structures located aft of the collision bulkhead	1,20	1,02	1,20
In testing conditions			
All fore peak structures	1,05	1,02	1,02
In flooding conditions			
All fore peak structures **(1)**	1,05	1,02	1,02
(1) For collision bulkhead structural members: γ_R = 1,25			

1.4 Connections of the fore peak with structures located aft of the collision bulkhead

1.4.1 Tapering

Adequate tapering is to be ensured between the scantlings in the fore peak and those aft of the collision bulkhead. The tapering is to be such that the scantling requirements for both areas are fulfilled.

2 Design loads

2.1 Local loads

2.1.1 Strength check in service conditions

The design pressure in service conditions is to be determined in compliance with applicable requirements of Ch 3, Sec 4.

2.1.2 Strength check in flooding conditions

The design pressure in flooding conditions is to be determined according to Ch 3, Sec 4, [4].

2.1.3 Strength check in testing conditions

The lateral pressure in testing conditions is taken equal to:

- $p_{ST} - p_S$ for bottom and side structures, if the testing is carried out afloat
- p_{ST} otherwise

where:

p_{ST} : Testing pressure defined in Ch 3, Sec 4, [5]

p_S : Still water river pressure defined in Ch 3, Sec 4, [2.1] for the draught T_1 at which the testing is carried out.

If T_1 is not known, it may be taken as specified in Ch 3, Sec 1, [2.4.3].

2.2 Hull girder normal stresses

2.2.1 The requirements in Pt D, Ch 2, Sec 12, [4.2] apply in addition to vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**.

2.2.2 The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm2, from the following formulae:

- in general

  $\sigma_{X1} = \sigma_{S1} + \gamma_{W1} C_{FV}\, \sigma_{WV1}$

- for structural members not contributing to the hull girder longitudinal strength:

  $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV1}: Hull girder normal stresses, in N/mm², defined in:

- Tab 3, for plating subjected to lateral loads
- Tab 4, for plating in-plane hull girder compression normal stresses
- Tab 5, for ordinary stiffeners and primary supporting members subjected to lateral pressure

C_{FV} : Combination factors defined in Tab 2.

Table 2 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
"d"	
Flooding	0,6

Table 3 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1} , in N/mm²	σ_{WV1} , in N/mm²
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} \geq 1$	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} < 1$	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0. **(1)**

Note 1:
- For range of navigation **IN**, $\gamma_W = 1{,}00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0{,}625$

Table 4 : In-plane hull girder compression normal stresses - Plating

Condition	σ_{S1} , in N/mm²	σ_{WV1} , in N/mm²
$z \geq N$	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
$z < N$	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

Note 1:
- For range of navigation **IN**, $\gamma_W = 1{,}00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0{,}625$

Table 5 : Hull girder normal stresses - Ordinary stiffeners and primary supporting members subjected to lateral pressure

Condition	σ_{S1} , in N/mm² **(1)**	σ_{WV1} , in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:		
• $z \geq N$ in general $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
Lateral pressure applied on the same side as the ordinary stiffener:		
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:
- For range of navigation **IN**, $\gamma_W = 1{,}00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0{,}625$

3 Bottom scantlings and arrangements

3.1 Longitudinally framed bottom

3.1.1 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than the values obtained from Tab 6.

3.1.2 Bottom transverses

Bottom transverses are to be fitted at every 8 frame spacings and generally spaced no more than 4 m apart.

The arrangements of bottom transverses are to be as required in the midship region.

Their scantlings are not to be less than required in Tab 7 nor lower than those of the corresponding side transverses, as defined in [4.2.2].

3.1.3 Fore peak arrangement

Where no centreline bulkhead is fitted, a centre bottom girder having the same dimensions and scantlings as required for bottom transverses is to be provided.

The centre bottom girder is to be connected to the collision bulkhead by means of a large end bracket.

Side girders, having the same dimensions and scantlings as required for bottom transverses, are generally to be fitted every two longitudinals, in line with bottom longitudinals located aft of the collision bulkhead. Their extension is to be compatible in each case with the shape of the bottom.

3.2 Transversely framed bottom

3.2.1 Plating

The scantling of plating is to be not less than the value obtained from the formulae in Tab 6.

3.2.2 Floors

Floors are to be fitted at every frame spacing.

The floor net scantlings are to be not less than those derived from Tab 7.

A relaxation from the Rules of dimensions and scantlings may be granted by the Society for very low draught vessels.

3.2.3 Where no centreline bulkhead is fitted, a centre bottom girder is to be provided according to [3.1.3].

3.3 Keel plate

3.3.1 The thickness of the keel plate is to be not less than that of the adjacent bottom plating.

Adequate tapering is to be ensured between the bottom and keel plating in the central part and the stem.

Table 6 : Net scantlings of bottom plating and structural members

Item	Strength characteristic		Minimum net thickness (mm)
Bottom plating	Net thickness, in mm:	$t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 1,1 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$ • transverse framing: $t_1 = 1,85 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$
Bottom longitudinals	Net section modulus, in cm³: Net shear sectional area, in cm²:	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$ $A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Floors Bottom transverses/reinforced floors	Net section modulus, in cm³: Net shear sectional area, in cm²: **(1)**	$w = \gamma_R \gamma_m \beta_b \dfrac{p}{m R_y} a \ell^2 10^3$ $A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} \eta a \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
Bottom girders	Net section modulus, in cm³: Net shear sectional area, in cm²:	$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$ $A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

Note 1:

a : Structural member spacing, in m
- a = s for floors
- a = S for bottom transverses and reinforced floors

λ : Coefficient taken equal to:
- In service conditions
  for longitudinally framed bottom $\lambda = \lambda_L$

  $$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{x1}}{R_y}$$

  for transversely framed bottom $\lambda = \lambda_T$

  $$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{x1}}{R_y}$$

- In testing and flooding conditions
  $\lambda = 1$, in general

(1) $\eta = 1$ for bottom transverses and reinforced floors

Table 7 : Net scantling of side plating and structural members

Item		Strength characteristic	Minimum net thickness (mm)
Plating		Net thickness, in mm: $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 1,25 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ • transverse framing: $t_1 = 1,68 + 0,025\ L\ (k_0 k)^{0,5} + 3,6\ s$
Side longitudinals		Net section modulus, in cm^3: $w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Side frames	• if $\ell_0 \leq \ell$	Net section modulus, in cm^3: $w = \gamma_R \gamma_m \beta_b \frac{s}{m R_y} (6 \ell \ell_0^2 + 1,45 \lambda_W p_F \ell_F^2) 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} \eta s \ell_0$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
	• if $\ell_0 > \ell$	Net section modulus, in cm^3: $w = \gamma_R \gamma_m \beta_b \frac{s}{m R_y} (\lambda_b p \ell^2 + 1,45 \lambda_W p_F \ell_F^2) 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \lambda_S \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	
Intermediate side frames	• if $\ell_0 \leq \ell$	Net section modulus, in cm^3: $w = 6 \gamma_R \gamma_m \beta_b \frac{\ell}{m R_y} s \ell_0^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} \eta s \ell_0$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
	• if $\ell_0 > \ell$	Net section modulus, in cm^3: $w = \gamma_R \lambda_b \gamma_m \beta_b \frac{p}{m R_y} s \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \lambda_S \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	
Side transverses and side web frames	• if $\ell_0 \leq \ell$	Net section modulus, in cm^3: $w = 6 \gamma_R \gamma_m \beta_b \frac{\ell}{m R_y} S \ell_0^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} S \ell_0$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
	• if $\ell_0 > \ell$	Net section modulus, in cm^3: $w = \gamma_R \lambda_b \gamma_m \beta_b \frac{p}{m R_y} S \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \lambda_S \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	

Item	Strength characteristic	Minimum net thickness (mm)
Side stringers	Net section modulus, in cm³: $w = \dfrac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} S \ell$	Web net thickness: $t = 3{,}8 + 0{,}016\ L\ (k_0 k)^{0,5}$

Note 1:

ℓ_0 : Span parameter, in m: $\ell_0 = p_d / g$
p_d : Total pressure, in kN/m², at the lower end of the stiffener
ℓ_F : Floor span, in m
p_F : Floor design load, in kN/ m²
λ_W : In transverse framing system: $\lambda_W = 0{,}08$
In combination framing system: $\lambda_W = 0$
λ : Coefficient taken equal to:

- In service conditions
  for longitudinally framed bottom $\lambda = \lambda_L$
  $$\lambda_L = \sqrt{1 - 0{,}95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0{,}225 \gamma_m \frac{\sigma_{x1}}{R_y}$$
  for transversely framed bottom $\lambda = \lambda_T$
  $$\lambda_T = 1 - 0{,}89 \gamma_m \frac{\sigma_{x1}}{R_y}$$
- In testing and flooding conditions
  $\lambda = 1$, in general

4 Side scantlings and arrangements

4.1 Arrangement

4.1.1 In way of the anchors, the side plating thickness is to be increased by 50%, or a doubling plate is to be provided.

Where a break is located in the fore part deck, the thickness of the sheerstrake is to be increased by 40% in the region of the break.

4.1.2 The foreship of the vessels shall be built in such a way that the anchors do not stick out of the side shell.

4.2 Longitudinally framed side

4.2.1 Plating and ordinary stiffeners

The scantlings of plating and ordinary stiffeners are to be not less than the values obtained from Tab 7.

4.2.2 Side transverses

Side transverses are to be located in way of bottom transverses and are to extend to the upper deck. Their ends are to be amply faired in way of bottom and deck transverses.

Their net section modulus w, in cm³, and net shear sectional area A_{sh}, in cm², are to be not less than the values derived from Tab 7.

4.3 Transversely framed side

4.3.1 Plating and ordinary stiffeners (side frames)

Side frames fitted at every frame space are to have the same vertical extension as the collision bulkhead.

Where, due to the hull design, the distance between transverse stiffeners, measured on the plating, is quite greater than the frame spacing, this latter should be reduced, or intermediate frames with scantlings in compliance with Tab 7 are to be provided.

It is recommended to provide a side stringer where intermediate frames are fitted over a distance equal to the breadth B of the vessel.

The net scantlings of plating and side stiffeners are to be not less than the values obtained from the formulae in Tab 7.

The value of the side frame section modulus is generally to be maintained for the full extension of the side frame.

4.3.2 Web frames

The web frames in a transverse framing system are to be spaced not more than 4 m apart.

The web frame section modulus is to be equal to the section modulus of the floor connected to it.

4.3.3 Fore peak arrangement

Depending on the hull body shape and structure aft of the collision bulkhead, one or more adequately spaced side stringers per side are to be fitted.

The side stringer net section modulus w, in cm^3, and shear sectional area A_{sh}, in cm^2, are to be not less than the values obtained from Tab 7.

Non-tight platforms may be fitted in lieu of side girders. Their openings and scantlings are to be in accordance with [6.1] and their spacing is to be not greater than 2,5 m.

4.3.4 Access to fore peak

Manholes may be cut in the structural members to provide convenient access to all parts of the fore peak.

These manholes are to be cut smooth along a well rounded design and are not to be greater than that strictly necessary to provide the man access. Where manholes of greater sizes are needed, edge reinforcement by means of flat bar rings or other suitable stiffeners may be required.

5 Decks

5.1 Deck scantlings and arrangements

5.1.1 The scantlings of deck plating and structural members are to be not less than the values obtained from the formulae in Tab 8.

5.1.2 Where the hatchways form corners, the deck plating is to have the same thickness as the stringer plate.

The deck plating is to be reinforced in way of the anchor windlass and other deck machinery, bollards, cranes, masts and derrick posts.

5.1.3 Supporting structure of windlasses and chain stoppers

For the supporting structure under windlasses and chain stoppers the permissible stresses as stated in Ch 7, Sec 4, [4.3.3] are to be observed.

The acting forces are to be calculated for 80% or 45% of the rated breaking load of the chain cable as follows:

a) for chain stoppers: 80%

b) for windlasses:

- 80% when no chain stopper is fitted
- 45% when a chain stopper is fitted.

5.2 Stringer plate

5.2.1 The net thickness of stringer plate, in mm, is to be not less than the greater of:

- $t = 2 + 0{,}032\ L\ (k_0 k)^{0{,}5} + 3{,}6\ s$
- $t = t_0$

  where t_0 is the deck plating net thickness.

6 Non-tight bulkheads and platforms

6.1 Arrangements and scantlings

6.1.1 Non-tight platforms or bulkheads located inside the peak are to be provided with openings having a total area not less than 10% of that of the platforms, respectively bulkheads.

The scantlings of bulkheads and platforms are to comply with the requirements of non-tight bulkheads (see Ch 5, Sec 5, [8]).

The number and depth of non-tight platforms within the peak is considered by the Society on a case by case basis.

The platforms may be replaced by equivalent horizontal structures whose scantlings are to be supported by direct calculations.

7 Stems

7.1 General

7.1.1 Arrangement

Adequate continuity of strength is to be ensured at the connection of stems to the surrounding structure.

Abrupt changes in sections are to be avoided.

7.2 Plate stems

7.2.1 Thickness

The gross thickness, in mm, of the plate stem is to be not less than the value obtained, in mm, from the following formula:

$$t = 1{,}37(0{,}95 + \sqrt{L})\sqrt{k_0 k} \le 15\sqrt{k_0}$$

For non-propelled vessels, this value may be reduced by 20%.

This thickness is to be maintained from 0,1 m at least aft of the forefoot till the load waterline. Above the load waterline, this thickness may be gradually tapered towards the stem head, where it is to be not less than the local value required for the side plating or, in case of pontoon-shaped foreship, the local value required for the bottom plating.

7.2.2 Centreline stiffener

If considered necessary, and particularly where the stem radius is large, a centreline stiffener or web of suitable scantlings is to be fitted.

Where the stem plating is reinforced by a centreline stiffener or web, its thickness may be reduced by 10%.

7.2.3 Horizontal diaphragms

The plating forming the stems is to be supported by horizontal diaphragms spaced not more than 500 mm apart and connected, as far as practicable, to the adjacent frames and side stringers.

The diaphragm plate is to be at least 500 mm deep and its thickness is to be not less than 0,7 times that of the stem.

Table 8 : Net scantling of deck plating and structural members

Item	Strength characteristic	Minimum net thickness (mm)
Plating	Net thickness: $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 0,57 + 0,031\ L\ (k_0 k)^{0,5} + 3,6\ s$ • transverse framing: $t_1 = 0,9 + 0,034\ L\ (k_0 k)^{0,5} + 3,6\ s$
Deck beams	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} s \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Deck longitudinals	Net section modulus, in cm³: $w = \frac{\gamma_R \gamma_m \beta_b p}{m (R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Deck transverses	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} S \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
Deck girders	Net section modulus, in cm³: $w = \frac{\gamma_R \gamma_m \beta_b p}{m (R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

Note 1:

λ : Coefficient taken equal to:

- In service conditions
  for longitudinally framed bottom $\lambda = \lambda_L$

  $$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{x1}}{R_y}$$

  for transversely framed bottom $\lambda = \lambda_T$

  $$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{x1}}{R_y}$$

- In testing and flooding conditions
  $\lambda = 1$, in general

Table 9 : Stiffened bar stem

Sectional area A_p (cm^2) of the plate stiffener	Reduction on sectional area of the bar stem
1,50 t $\geq A_p >$ 0,95 t	10%
$A_p >$ 1,50 t	15%
Note 1: t : Web thickness, in mm, of the plate stiffener.	

7.2.4 Pushing transom

Where self-propelled vessels are equipped for pushing other vessels in case of pontoon-shaped foreship, a pushing transom is to be fitted in compliance with Ch 7, Sec 6, [2.2].

7.3 Bar stems

7.3.1 Sectional area

The sectional area of bar stems constructed of forged or rolled steel is to be not less than the value obtained, in cm^2, from the following formula:

$A_p = k_0 k\ f\ (0{,}006\ L^2 + 12)$

7.3.2 Thickness

The gross thickness of the bar stems constructed of forged or rolled steel, is to be not less than the value obtained, in mm, from the following formula:

$t = 0{,}33\ L\ (k_0 k)^{0{,}5} + 10$

7.3.3 Extension

The bar stem is to extend beyond the forefoot over about 1 m.

Its cross-sectional area may be gradually tapered from the load waterline to the upper end.

7.3.4 Stiffened bar stem

Where the bar stem is reinforced by a flanged plate or a bulb flat stiffener, its sectional area may be reduced according to Tab 9.

8 Thruster tunnel

8.1 Scantlings of the thruster tunnel and connection with the hull

8.1.1 Net thickness of tunnel plating

The net thickness, in mm, of the tunnel plating is not to be less than that of the adjacent part of the hull, nor than that obtained from the following formula:

$t = 4{,}4 + 0{,}024\ L\ (k_0 k)^{0{,}5}$

8.1.2 Connection with the hull

The tunnel is to be fully integrated in the bottom structure.

Adequate continuity with the adjacent bottom structure is to be ensured.

SECTION 2 AFT PART

Symbols

A_{sh} : Net shear sectional area, in cm^2

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \leq 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \geq 0,5$$

where:

r : Radius of curvature, in m

f : Coefficient defined as follows:

f = 1,0 for **IN(1,2 < x ≤ 2)**

f = 0,9 for **IN(x ≤ 1,2)**

f = 0,8 for **IN**

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

m : Boundary coefficient to be taken, in general, equal to:

- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members.

Other values of m may be considered, on a case by case basis, for other boundary conditions

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design load, in kN/ m^2

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

z : Z co-ordinate, in m, of the calculation point of a structural element.

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_m : Partial safety factor covering uncertainties regarding material: γ_m = 1,02

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Ch 6, Sec 1, Tab 1

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

- γ_{W1} = 1,0 for **IN**
- γ_{W1} = 1,15 for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- γ_{W2} = 1,0 for **IN**
- γ_{W2} = 1,2 for **IN(x ≤ 2)**

η : Coefficient taken equal to: $\eta = 1 - s / (2\, l)$

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to scantling and arrangement of structures located aft of the after peak bulkhead, for all vessels made of steel or aluminium alloy.

As to the requirements which are not explicitly dealt with in the present Section, refer to the previous Chapters.

1.1.2 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.1.3 Vessels with length L < 40 m

Where alternative requirements in Ch 5, Sec 6 have been adopted for the vessel central part, the associated aft part structure scantlings are to be determined from this Section considering a hull girder normal stress σ_{X1} = 0.

1.2 Net scantlings

1.2.1 As specified in Ch 2, Sec 5, all scantlings referred to in this Section, with the exception of those indicated in [4], are net scantlings, i.e. they do not include any margin for corrosion.

1.3 Resistance partial safety factor

1.3.1 The resistance partial safety factor γ_R to be considered for the checking of the aft peak structures is specified in Tab 1.

Table 1 : Resistance partial safety factor γ_R

Conditions	Plating	Ordinary stiffeners	Primary supporting members
In general	1,20	1,40	1,60
In testing and flooding conditions	1,05	1,02	1,02

1.4 Connections of the aft part with structures located fore of the after bulkhead

1.4.1 Tapering

Adequate tapering is to be ensured between the scantlings in the aft part and those fore of the after bulkhead. The tapering is to be such that the scantling requirements for both areas are fulfilled.

2 Design loads

2.1 Local loads

2.1.1 Strength check in service conditions

The design pressure in service conditions is to be determined in compliance with applicable requirements of Ch 3, Sec 4.

2.1.2 Strength check in flooding conditions

The design pressure in flooding conditions is to be determined according to Ch 3, Sec 4, [4].

2.1.3 Strength check in testing conditions

The lateral pressure in testing conditions is taken equal to:

- $p_{ST} - p_S$ for bottom and side structures, if the testing is carried out afloat
- p_{ST} otherwise

where:

p_{ST} : Testing pressure defined in Ch 3, Sec 4, [5]

p_S : Still water river pressure defined in Ch 3, Sec 4, [2.1] for the draught T_1 at which the testing is carried out.

If T_1 is not known, it may be taken as specified in Ch 3, Sec 1, [2.4.3].

2.2 Hull girder normal stresses

2.2.1 The requirements in Pt D, Ch 2, Sec 12, [4.2] apply in addition to vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**.

2.2.2 The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm², from the following formulae:

- in general $\sigma_{X1} = \sigma_{S1} + \gamma_{W1} C_{FV}\, \sigma_{WV1}$
- for structural members not contributing to the hull girder longitudinal strength: $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV1}: Hull girder normal stresses, in N/mm², defined in:

- Tab 3, for plating subjected to lateral loads
- Tab 4, for plating in-plane hull girder compression normal stresses
- Tab 5, for ordinary stiffeners and primary supporting members subjected to lateral pressure

C_{FV} : Combination factors defined in Tab 2.

Table 2 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
"d"	
Flooding	0,6

Table 3 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
$\dfrac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} \geq 1$	$\left\lvert \dfrac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
$\dfrac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} < 1$	$\left\lvert \dfrac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:

- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

Table 4 : In-plane hull girder compression normal stresses - Plating

Condition	σ_{S1} , in N/mm²	σ_{WV1} , in N/mm²
$z \geq N$	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
$z < N$	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

Note 1:

- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

**Table 5 : Hull girder normal stresses -
Ordinary stiffeners and primary supporting members subjected to lateral pressure**

Condition	σ_{S1} , in N/mm² **(1)**	σ_{WV1} , in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:		
• $z \geq N$ in general $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
Lateral pressure applied on the same side as the ordinary stiffener:		
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:

- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

3 After peak

3.1 Arrangement

3.1.1 General

The after peak is, in general, to be transversely framed.

3.1.2 Floors

Floors are to be fitted at every frame spacing.

The floor height is to be adequate in relation to the shape of the hull. Where a sterntube is fitted, the floor height is to extend at least above the sterntube. Where the hull lines do not allow such an extension, plates of suitable height with upper and lower edges stiffened and securely fastened to the frames are to be fitted above the sterntube.

In way of and near the rudder post and propeller post, higher floors of increased thickness are to be fitted. The increase will be considered by the Society on a case by case basis, depending on the arrangement proposed.

3.1.3 Side frames

Side frames are to be extended up to the deck.

Where, due to the hull design, the actual spacing between transverse stiffeners, measured on the plating, is quite greater than the frame spacing, this later should be reduced, or intermediate frames with scantlings in compliance with Tab 7 are to be provided.

3.1.4 Platforms and side girders

Platforms and side girders within the peak are to be arranged in line with those located in the area immediately forward.

Where this arrangement is not possible due to the shape of the hull and access needs, structural continuity between the peak and the structures of the area immediately forward is to be ensured by adopting wide tapering brackets.

3.1.5 Longitudinal bulkheads

A longitudinal non-tight bulkhead is to be fitted on the centreline of the vessel, in general in the upper part of the peak, and stiffened at each frame spacing.

Where no longitudinal bulkhead is fitted, centre line bottom and deck girders having the same dimensions and scantlings as required respectively for bottom and deck transverses are to be provided.

Table 6 : Net scantlings of bottom plating and structural members

Item	Strength characteristic	Minimum net thickness (mm)
Bottom plating	Net thickness, in mm: $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 1,1 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$ • transverse framing: $t_1 = 1,85 + 0,03\ L\ (k_0 k)^{0,5} + 3,6\ s$
Bottom longitudinals	Net section modulus, in cm³: $w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Floors	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} s \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
Bottom transverses / reinforced floors	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} S \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
Bottom girders	Net section modulus, in cm³: $w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

Note 1:

λ : Coefficient taken equal to:

- In service conditions
  for longitudinally framed bottom $\lambda = \lambda_L$

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{x1}}{R_y}$$

  for transversely framed bottom $\lambda = \lambda_T$

$$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{x1}}{R_y}$$

- In testing and flooding conditions
  $\lambda = 1$, in general

3.1.6 Local reinforcement

The deck plating is to be reinforced in way of the anchor windlass, steering gear and other deck machinery, bollards, cranes, masts and derrick posts.

3.2 Bottom scantlings

3.2.1 Bottom plating and structural members

The net scantlings of bottom plating and structural members are to be not less than those obtained from formulae in Tab 6.

The floor scantlings are to be increased satisfactorily in way of the rudder stock.

3.3 Side scantlings

3.3.1 Plating and structural members

The net scantlings of plating and structural members are to be not less than those obtained from formulae in Tab 7.

3.3.2 Side transverses

Side transverses are to be located in way of bottom transverses and are to extend to the upper deck. Their ends are to be amply faired in way of bottom and deck transverses.

3.3.3 Side stringers

Where the vessel depth exceeds 2 m, a side stringer is to be fitted at about mid-depth.

Table 7 : Net scantlings of side plating and structural members

Item		Strength characteristic	Minimum net thickness (mm)
Side plating		Net thickness: $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 1,25 + 0,02\ L\ (k_0k)^{0,5} + 3,6\ s$ • transverse framing: $t_1 = 1,68 + 0,025\ L\ (k_0k)^{0,5} + 3,6\ s$
Transom plating		Net thickness: $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{R_y}}$	Plating net thickness: $t_1 = 1,68 + 0,025\ L\ (k_0k)^{0,5} + 3,6\ s$
Side longitudinals		Net section modulus, in cm^3: $w = \frac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}s\ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta s\ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
Transom horizontal stiffeners		Net section modulus, in cm^3: $w = \gamma_R\gamma_m\beta_b\frac{p}{mR_y}s\ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta s\ell$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
Side frames	• if $\ell_0 \leq \ell$	Net section modulus, in cm^3: $w = \gamma_R\gamma_m\beta_b\frac{s}{mR_y}(6\ell\ell_0^2 + 1,45\lambda_W p_F\ell_F^2)10^3$ Net shear sectional area, in cm^2: $A_{sh} = 68\gamma_R\gamma_m\beta_s\frac{\ell}{R_y}\eta s\ell_0$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
	• if $\ell_0 > \ell$	Net section modulus, in cm^3: $w = \gamma_R\gamma_m\beta_b\frac{s}{mR_y}(\lambda_b p\ell^2 + 1,45\lambda_W p_F\ell_F^2)10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10\lambda_S\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta s\ell$	
Intermediate side frames Transom vertical stiffeners	• if $\ell_0 \leq \ell$	Net section modulus, in cm^3: $w = 6\gamma_R\gamma_m\beta_b\frac{\ell}{mR_y}s\ell_0^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 68\gamma_R\gamma_m\beta_s\frac{\ell}{R_y}\eta s\ell_0$	Web net thickness: $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$
	• if $\ell_0 > \ell$	Net section modulus, in cm^3: $w = \gamma_R\gamma_m\lambda_b\beta_b\frac{p}{mR_y}s\ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_s\frac{p}{R_y}\eta s\ell$	

Item		Strength characteristic	Minimum net thickness (mm)
Side transverses Side web frames	• if $\ell_0 \le \ell$	Net section modulus, in cm³: $w = 6\gamma_R\gamma_m\beta_b\frac{\ell}{mR_y}S\ell_0^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 68\gamma_R\gamma_m\beta_s\frac{\ell}{R_y}S\ell_0$	Web net thickness: $t = 3{,}8 + 0{,}016\ L\ (k_0k)^{0{,}5}$
	• if $\ell_0 > \ell$	Net section modulus, in cm³: $w = \gamma_R\gamma_m\lambda_b\beta_b\frac{p}{mR_y}S\ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_s\frac{p}{R_y}S\ell$	
Side stringers		Net section modulus, in cm³: $w = \frac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}S\ell^2 10^3$ Net shear sectional area, in cm²: $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}S\ell$	Web net thickness: $t = 3{,}8 + 0{,}016\ L\ (k_0k)^{0{,}5}$

Note 1:

- ℓ_0 : Span parameter, in m:
  $\ell_0 = p_d / g$
- p_d : Total pressure, in kN/m², at the lower end of the stiffener
- ℓ_F : Floor span, in m
- p_F : Floor design load, in kN/m²
- λ_W : In transverse framing system: $\lambda_W = 0{,}08$
  In combination framing system: $\lambda_W = 0$
- λ : Coefficient taken equal to:
  - In service conditions
    for longitudinally framed bottom $\lambda = \lambda_L$

    $$\lambda_L = \sqrt{1 - 0{,}95\left(\gamma_m\frac{\sigma_{x1}}{R_y}\right)^2} - 0{,}225\gamma_m\frac{\sigma_{x1}}{R_y}$$

    for transversely framed bottom $\lambda = \lambda_T$

    $$\lambda_T = 1 - 0{,}89\gamma_m\frac{\sigma_{x1}}{R_y}$$

  - In testing and flooding conditions
    $\lambda = 1$, ιν γενεραλ

3.4 Deck scantlings and arrangements

3.4.1 Plating and ordinary stiffeners

The net scantlings of deck plating and structural members are not to be less than those obtained from the formulae in Tab 8.

Where a break is located in the after part deck, the thickness of the sheerstrake is to be increased by 40% in the region of the break.

3.4.2 The deck plating is to be reinforced in way of the anchor windlass and other deck machinery, bollards, cranes, masts and derrick posts.

The supporting structure of windlasses and chain stoppers is to be in compliance with Ch 6, Sec 1, [5.1.3].

3.4.3 Stringer plate

The net thickness of stringer plate, in mm, is to be not less than the greater of:

- $t = 2 + 0{,}032\ L\ (k_0k)^{0{,}5} + 3{,}6\ s$
- $t = t_0$

  where t_0 is the deck plating net thickness.

Table 8 : Net scantlings of deck plating and structural members

Item	Strength characteristic	Minimum net thickness (mm)
Deck plating	Net thickness: $t_2 = 14,9 C_a C_r s \sqrt{\frac{\gamma_R \gamma_m p}{\lambda R_y}}$	Plating net thickness: • longitudinal framing: $t_1 = 0,57 + 0,031\,L\,(k_0 k)^{0,5} + 3,6\,s$ • transverse framing: $t_1 = 0,90 + 0,034\,L\,(k_0 k)^{0,5} + 3,6\,s$
Deck beams	Net section modulus, in cm^3: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} s \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\,L\,(k_0 k)^{0,5} + 4,5\,s$
Deck longitudinals	Net section modulus, in cm^3: $w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} \eta s \ell$	Web net thickness: $t = 1,63 + 0,004\,L\,(k_0 k)^{0,5} + 4,5\,s$
Deck transverses	Net section modulus, in cm^3: $w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} S \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\,L\,(k_0 k)^{0,5}$
Deck girders	Net section modulus, in cm^3: $w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$ Net shear sectional area, in cm^2: $A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$	Web net thickness: $t = 3,8 + 0,016\,L\,(k_0 k)^{0,5}$

Note 1:

λ : Coefficient taken equal to:

- In service conditions
  for longitudinally framed bottom $\lambda = \lambda_L$

  $$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{x1}}{R_y}$$

  for transversely framed bottom $\lambda = \lambda_T$

  $$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{x1}}{R_y}$$

- In testing and flooding conditions
  $\lambda = 1$, in general

4 Sternframes

4.1 General

4.1.1 Sternframes may be made of cast or forged steel, with a hollow section, or fabricated from plate.

4.2 Connections

4.2.1 Heel

Sternframes are to be effectively attached to the aft structure. The propeller post heel is to extend forward over a length, in m, including the scarf, at least equal to:

$d = 0,01\ L + 0,6 \quad \text{with } 1,2 \le d \le 1,8$

in order to provide an effective connection with the keel. However, the sternframe need not extend beyond the after peak bulkhead.

The value of d may, however, be reduced to 1 m where no centreline propeller is fitted.

4.2.2 Connection with hull structure

The thickness of shell plating connected with the sternframe is to be not less than the rule thickness of the bottom plating amidships.

4.2.3 Connection with the keel

The thickness of the lower part of the sternframes is to be gradually tapered to that of the solid bar keel or keel plate.

Where a keel plate is fitted, the lower part of the sternframe is to be so designed as to ensure an effective connection with the keel.

4.2.4 Connection with transom floors

Propeller post and rudder post should in their upper part be led and connected in suited and safe manner to the vessel structure. In the range where the forces of the rudder post are led into the vessel structure, the shell plating has to be strengthened.

The shape of the vessel's stern, the thickness of the rudder and of the propeller well should be such that forces coming from the propeller are as small as possible.

In vessel's transverse direction, the propeller post has to be fastened to strengthened and higher floor plates, which are connected by a longitudinal girder in plane of the propeller post over a range of several frames. Plates of longitudinal webs supporting floorplates, which the propeller post is directly connected to, should have a thickness of 0,30 times the thickness of the bar propeller post according to [4.3.1].

4.2.5 Connection with centre keelson

Where the sternframe is made of cast steel, the lower part of the sternframe is to be fitted, as far as practicable, with a longitudinal web for connection with the centre keelson.

4.3 Propeller posts

4.3.1 Scantlings of propeller posts

The gross scantlings of propeller posts are to be not less than those obtained from the formulae in Tab 9 for single and twin screw vessels.

These scantlings are to be maintained from the bottom to above the propeller boss. At the upper part, the scantlings may be reduced gradually to those of the rudder post, where the latter joins the propeller post.

In vessels having a high engine power with respect to their size, or subjected to abnormal stresses, strengthening of the propeller post may be called for by the Society.

Scantlings and proportions of the propeller post which differ from those above may be considered acceptable provided that the section modulus of the propeller post section about its longitudinal axis is not less than that calculated with the propeller post scantlings in Tab 9.

4.3.2 Welding of fabricated propeller post with the propeller shaft bossing

Welding of a fabricated propeller post with the propeller shaft bossing is to be in accordance with Ch 8, Sec 2, [3.4.1].

4.4 Propeller shaft bossing

4.4.1 Thickness

In single screw vessels, the thickness of the propeller shaft bossing, included in the propeller post, in mm, is to be not less than:

$$t = 6\sqrt{fk_0k(0,7L + 6)} \qquad \text{for } L \le 40$$

$$t = 6\sqrt{fk_0k(L - 6)} \qquad \text{for } L > 40$$

where:

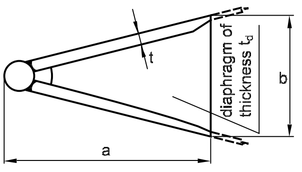
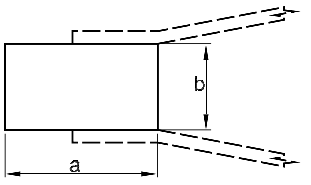
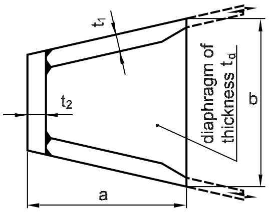
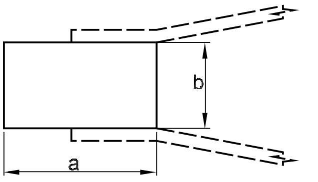
f : Coefficient defined in the head of the Section.

4.5 Stern tubes

4.5.1 The stern tube thickness is to be considered by the Society on a case by case basis. In no case, it may be less than the thickness of the side plating adjacent to the sternframe.

Where the materials adopted for the stern tube and the plating adjacent to the sternframe are different, the stern tube thickness is to be at least equivalent to that of the plating.

Table 9 : Gross scantlings of propeller posts

Single screw vessels		Twin screw vessels	
Fabricated propeller post	Bar propeller post, cast or forged, having rectangular section	Fabricated propeller post	Bar propeller post, cast or forged, having rectangular section
			
a (mm) = 29 $L^{1/2}$	a (mm) = 14,1 $A^{1/2}$	a (mm) = 29 $L^{1/2}$	a (mm) = 14,1 $A^{1/2}$
b/a = 0,7	b/a = 0,5	b/a = 0,7	b/a = 0,5
t (mm) = 2,5 $(k_0kL)^{1/2}$ with t ≥ 1,3 $t_{bottom\ midship}$	thickness: NA	t_1 (mm) = 2,5 $(k_0kL)^{1/2}$ with t_1 ≥ 1,3 $t_{bottom\ midship}$ t_2 (mm) = 3,2 $(k_0kL)^{1/2}$ with t_2 ≥ 1,3 $t_{bottom\ midship}$	thickness: NA
sectional area: NA	for L ≤ 40:A(cm^2) =f(1,4k_0k L+12) for L > 40: A(cm^2) =f(2 k_0kL–12)	sectional area: NA	A (cm^2) = f(0,005 k_0kL^2 + 20)
t_d (mm) = 1,3 $(k_0kL)^{1/2}$	t_d : NA	t_d (mm) = 1,3 $(k_0kL)^{1/2}$	t_d : NA

Note 1:
f : Coefficient defined in the head of the Section
A : Sectional area, in cm^2, of the propeller post.
Note 2: NA = not applicable.

SECTION 3 MACHINERY SPACE

Symbols

A_{sh} : Net shear sectional area, in cm^2

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

where:

r : Radius of curvature, in m

I_Y : Moment of inertia, in cm^4, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

m : Boundary coefficient to be taken, in general, equal to:

- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members

Other values of m may be considered, on a case by case basis, for other boundary conditions

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design load, in kN/ m^2

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

z : Z co-ordinate, in m, of the calculation point of a structural element

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

- γ_{W1} = 1,0 for **IN**
- γ_{W1} = 1,15 for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- γ_{W2} = 1,0 for **IN**
- γ_{W2} = 1,2 for **IN(x ≤ 2)**

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Tab 1

γ_m : Partial safety factor covering uncertainties regarding material: γ_m = 1,02

η : Coefficient taken equal to: $\eta = 1 - s / (2\ \ell)$

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to scantling and arrangement of machinery space structures for all vessels made of steel or aluminium alloy.

As to the requirements which are not explicitly dealt with in the present Section, refer to the previous Chapters.

1.1.2 Alternative arrangements and scantlings on the basis of direct calculations are to be submitted to the Society on a case by case basis.

1.1.3 Buckling strength check

The buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.1.4 Vessels with length L < 40 m

On vessels with machinery space located in the aft part, where alternative requirements in Ch 5, Sec 6 have been adopted for the vessel central part, the associated machinery space structure scantlings are to be determined from this Section considering a hull girder normal stress $\sigma_{X1} = 0$.

1.2 Net scantlings

1.2.1 As specified in Ch 2, Sec 5, all scantlings referred to in this Section are net scantlings, i.e. they do not include any margin for corrosion.

1.3 Resistance partial safety factor

1.3.1 The resistance partial safety factor γ_R to be considered for the checking of the fore part structures is specified in Tab 1.

Table 1 : Resistance partial safety factor γ_R

Machinery space structures	Plating	Ordinary stiffeners	Primary supporting members
In general			
Bottom and side girders **(1)**	1,20	1,02	1,15
Other primary supporting members			1,02
In testing / flooding conditions			
All structures	1,05	1,02	1,02
(1) Includes bottom girders, bottom transverses, reinforced floors, side stringers, side transverses and web frames.			

1.4 Connections of the machinery space with the structures located aft and forward

1.4.1 Tapering

Adequate tapering is to be ensured between the scantlings in the machinery space and those located aft and forward. The tapering is to be such that the scantling requirements for all areas are fulfilled.

1.4.2 Deck discontinuities

a) Decks which are interrupted in the machinery space are to be tapered on the side by means of horizontal brackets.

Where the deck is inclined, the angle of inclination is to be limited. The end of slope is to be located in way of reinforced ring.

b) Where the inclination of deck is limited by transverse bulkheads, the continuity of the longitudinal members is to be ensured.

In way of breaks in the deck, the continuity of longitudinal strength is to be ensured. To that effect, the stringer of the lower deck is to:

- extend beyond the break, over a length at least equal to three times its width
- stop at a web frame of sufficient scantlings.

c) At the ends of the sloped part of the deck, suitable arrangements are required to take into account the vertical component of the force generated in the deck.

1.5 Arrangements

1.5.1 Every engine room must normally have two exits. The second exit may be an emergency exit. If a skylight is permitted as an escape, it must be possible to open it from the inside. See also Pt C, Ch 4, Sec 5, [3.1].

1.5.2 For the height of entrances to machinery space, see Ch 2, Sec 1, [5.4].

2 Design loads

2.1 Local loads

2.1.1 Strength check in service conditions

The design pressure in service conditions is to be determined in compliance with applicable requirements of Ch 3, Sec 4.

2.1.2 Strength check in flooding conditions

The design pressure in flooding conditions is to be determined according to Ch 3, Sec 4, [4].

2.1.3 Strength check in testing conditions

The lateral pressure in testing conditions is taken equal to:

- $p_{ST} - p_S$ for bottom and side structures, if the testing is carried out afloat
- p_{ST} otherwise

where:

p_{ST} : Testing pressure defined in Ch 3, Sec 4, [5]

p_S : Still water river pressure defined in Ch 3, Sec 4, [2.1] for the draught T_1 at which the testing is carried out

If T_1 is not known, it may be taken as specified in Ch 3, Sec 1, [2.4.3].

2.2 Hull girder normal stresses

2.2.1 The requirements in Pt D, Ch 2, Sec 12, [4.2] apply in addition to vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**.

2.2.2 The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm2, from the following formulae:

- in general: $\sigma_{X1} = \sigma_{S1} + \gamma_{W1} C_{FV} \sigma_{WV1}$
- for structural members not contributing to the hull girder longitudinal strength: $\sigma_{X1} = 0$

Table 2 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
"d"	
Flooding	0,6

Table 3 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1} , in N/mm² **(1)**	σ_{WV1} , in N/mm²
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} \geq 1$	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} < 1$	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:

- For range of navigation **IN**, γ_W = 1,00
- For range of navigation **IN(x ≤ 2)**, γ_W = 0,625

Table 4 : In-plane hull girder compression normal stresses - Plating

Condition	σ_{S1} , in N/mm²	σ_{WV1} , in N/mm²
z ≥ N	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
z < N	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

Note 1:

- For range of navigation **IN**, γ_W = 1,00
- For range of navigation **IN(x ≤ 2)**, γ_W = 0,625

Table 5 : Hull girder normal stresses -
Ordinary stiffeners and primary supporting members subjected to lateral pressure

Condition	σ_{S1} , in N/mm² **(1)**	σ_{WV1} , in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:		
• z ≥ N in general z < N for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
• z < N in general z ≥ N for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
Lateral pressure applied on the same side as the ordinary stiffener:		
• z ≥ N in general z < N for stiffeners simply supported at both ends	$\left\lvert \frac{M_H}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$
• z < N in general z ≥ N for stiffeners simply supported at both ends	$\left\lvert \frac{M_S}{I_Y}(z - N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z - N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:

- For range of navigation: **IN**, γ_W = 1,00
- For range of navigation: **IN(x ≤ 2)**, γ_W = 0,625

where:

σ_{S1}, σ_{WV1}: Hull girder normal stresses, in N/mm², defined in:
- Tab 3, for plating subjected to lateral loads
- Tab 4, for plating in-plane hull girder compression normal stresses
- Tab 5, for ordinary stiffeners and primary supporting members subjected to lateral pressure

C_{FV} : Combination factors defined in Tab 2.

3 Hull scantlings

3.1 Shell plating

3.1.1 Where the machinery space is located aft, the shell plating thickness is to be determined as specified in Tab 6.

Otherwise, the requirements of Ch 5, Sec 2, Ch 5, Sec 3 and Ch 5, Sec 4 are to be complied with.

Table 6 : Hull plating net scantlings

Item	Transverse framing	Longitudinal framing
Bottom plating	t = max (t_1 , t_2) t_1 = 1,85 + 0,03 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 17,2C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	t = max (t_1 , t_2) t_1 = 1,1 + 0,03 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_L R_y}}$
Side plating	t = max (t_1 , t_2) t_1 = 1,68 + 0,025 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 17,2C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	t = max (t_1 , t_2) t_1 = 1,25 + 0,02 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_L R_y}}$
Deck plating	t = max (t_1 , t_2) t_1 = 0,9 + 0,034 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 17,2C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_T R_y}}$	t = max (t_1 , t_2) t_1 = 0,57 + 0,031 L $(k_0k)^{0,5}$ + 3,6 s $t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{\lambda_L R_y}}$

Note 1:

$$\lambda_L = \sqrt{1-0,95\left(\gamma_m\frac{\sigma_{x1}}{R_y}\right)^2}-0,225\gamma_m\frac{\sigma_{x1}}{R_y}$$

$$\lambda_T = 1-0,89\gamma_m\frac{\sigma_{x1}}{R_y}$$

Note 2: In testing and flooding conditions

$$t_2 = 14,9C_aC_rs\sqrt{\frac{\gamma_R\gamma_m p}{R_y}}$$

Table 7 : Hull structural member net scantlings

Item		Strength characteristic **(1)**	Minimum web thickness
Bottom longitudinals Side longitudinals Deck longitudinals		$w = \frac{\gamma_R\gamma_m\beta_b p}{m(R_y-\gamma_R\gamma_m\sigma_{X1})}s\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta s\ell$	• for L < 120 m: t = 1,63 + 0,004 L $(k_0k)^{0,5}$ + 4,5 s • for L ≥ 120 m: t = 3,9 $(k_0k)^{0,5}$ + s
Deck beams		$w = \gamma_R\gamma_m\beta_b\frac{p}{mR_y}s\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta s\ell$	• for L < 120 m: t = 1,63 + 0,004 L $(k_0k)^{0,5}$ + 4,5 s • for L ≥ 120 m: t = 3,9 $(k_0k)^{0,5}$ + s
Floors Bottom transverses/reinforced floors Deck transverses **(2)**		$w = \gamma_R\gamma_m\beta_b\frac{p}{mR_y}a\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\beta_s\frac{p}{R_y}\eta a\ell$	t = 3,8 + 0,016 L $(k_0k)^{0,5}$
Side frames	• if $\ell_0 \le \ell$	$w = \gamma_R\gamma_m\beta_b\frac{s}{mR_y}(6\ell\ell_0^2+1,45\lambda_W p_F\ell_F^2)10^3$ $A_{sh} = 68\gamma_R\gamma_m\beta_s\frac{\ell}{R_y}\eta s\ell_0$	• for L < 120 m: t = 1,63 + 0,004 L $(k_0k)^{0,5}$ + 4,5 s • for L ≥ 120 m: t = 3,9 $(k_0k)^{0,5}$ + s
	• if $\ell_0 > \ell$	$w = \gamma_R\gamma_m\beta_b\frac{s}{mR_y}(\lambda_b p\ell^2+1,45\lambda_W p_F\ell_F^2)10^3$ $A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_s\frac{p}{R_y}\eta s\ell$	

Item		Strength characteristic (1)	Minimum web thickness
Side web frames Side transverses	• if $\ell_0 \le \ell$	$w = 6\gamma_R\gamma_m\beta_b\dfrac{\ell}{mR_y}S\ell_0^2 10^3$ $A_{sh} = 68\gamma_R\gamma_m\beta_s\dfrac{\ell}{R_y}S\ell_0$	$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
	• if $\ell_0 > \ell$	$w = \gamma_R\gamma_m\lambda_b\beta_b\dfrac{p}{mR_y}S\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\lambda_S\beta_s\dfrac{p}{R_y}S\ell$	$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
Side stringers		$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}S\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}S\ell$	$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$
Bottom girders		$w = \dfrac{\gamma_R\gamma_m\beta_b p}{m(R_y - \gamma_R\gamma_m\sigma_{X1})}b\ell^2 10^3$ $A_{sh} = 10\gamma_R\gamma_m\beta_s\dfrac{p}{R_y}b\ell$	$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

(1) w : Net section modulus, in cm³
A_{sh} : Net shear sectional area, in cm².
(2) $\eta = 1$ for transverses and reinforced floors
Note 1:
a : Structural member spacing, in m:
a = s for floors
a = S for transverses and reinforced floors
p_F : Floor design load, in kN/m²
ℓ_0 : Span parameter, in m:
$\ell_0 = p_d / 9,81$
p_d : Total pressure, in kN/m², at the lower end of the stiffener
ℓ_F : Floor span, in m
λ_W : In transverse framing system:
$\lambda_W = 0,08$
In combination framing system:
$\lambda_W = 0$
b : Bottom girder parameter, in m, to be obtained from the following formula:

$$b = \frac{B_1 - n_E S_E}{2(n_E + 1)} + \frac{S_E}{2}$$

n_E : Number of engines
S_E : Spacing of longitudinal girders under main engines
B_1 : Width of the machinery space, in m.

3.2 Shell structure

3.2.1 Where the machinery space is located aft, the scantlings of ordinary stiffeners and primary supporting members are to be as required by Tab 7.

Otherwise, the requirements of Ch 5, Sec 2, Ch 5, Sec 3 and Ch 5, Sec 4 are to be complied with.

3.3 Topside structure

3.3.1 The scantlings and arrangement of the topside structure are to be in compliance with Ch 5, Sec 4, [3.1] and Ch 5, Sec 4, [3.3].

4 Bottom structure

4.1 General

4.1.1 Where the hull is shaped, the bottom is to be transversely framed. In all other cases, it may be transversely or longitudinally framed.

4.2 Transversely framed bottom

4.2.1 Arrangement of floors

Where the bottom in the machinery space is transversely framed, floors are to be arranged at every frame. Furthermore, reinforced floors are to be fitted in way of important machinery and at the end of keelsons not extending up to the transverse bulkhead.

The floors are to be fitted with welded face plates, which are preferably to be symmetrical. Flanges are forbidden.

4.3 Longitudinally framed bottom

4.3.1 Arrangement of transverses

Where the bottom in the machinery space is longitudinally framed, transverses are to be arranged every 4 frame spacings. Additional transverses are to be fitted in way of important machinery.

The bottom transverses are to be fitted with welded face plates, which are preferably to be symmetrical. Flanges are forbidden.

5 Side structure

5.1 General

5.1.1 The type of side framing in machinery spaces is generally to be the same as that adopted in the adjacent areas. In any case, it is to be continuous over the full length of the machinery space.

5.2 Transversely framed side

5.2.1 Web frames

In vessels built on transverse system, web frames are to be aligned with floors. One is preferably to be located in way of the forward end and another in way of the after end of the machinery casing.

The mean web frame spacing in the machinery space is in general not more than 5 frame spacings.

5.2.2 Side stringers

In the machinery space, where the mean value of the depth exceeds 2 m, a side stringer is generally to be fitted at half the vessel's depth. Its scantlings are to be the same as those of the web frames.

The plate connecting the stringer to the shell plating is to be an intercostal plate between web frames.

Stringer strength continuity in way of the web frames is to be obtained by a suitable assembly.

Stringers located in fuel bunkers are determined in the same way as bulkhead stringers.

In the case a side stringer is fitted in the engine room, it is to be continued behind the aft bulkhead by a bracket at least over two frame spacings.

5.3 Longitudinally framed side

5.3.1 Extension of the hull longitudinal structure within the machinery space

For vessels where the machinery space is located aft and where the side is longitudinally framed, the longitudinal structure is preferably to extend for the full length of the machinery space.

In any event, the longitudinal structure is to be maintained for at least 0,3 times the length of the machinery space, calculated from the forward bulkhead of the latter, and abrupt structural discontinuities between longitudinally and transversely framed structures are to be avoided.

5.3.2 Side transverses

Side transverses are to be aligned with floors. One is preferably to be located in way of the forward end and another in way of the after end of the machinery casing.

The side transverse spacing is to be not greater than 4 frame spacings.

6 Machinery casing

6.1 Arrangement

6.1.1 Ordinary stiffener spacing

Ordinary stiffeners are to be located:

- at each frame, in longitudinal bulkheads
- at a distance of not more than 750 mm, in transverse bulkheads.

6.2 Openings

6.2.1 General

All machinery space openings, which are to comply with the requirements in Ch 2, Sec 1, [5], are to be enclosed in a steel casing leading to the highest open deck. Casings are to be reinforced at the ends by deck transverses and girders associated to pillars.

In the case of large openings, the arrangement of cross-ties as a continuation of deck beams may be required.

6.2.2 Access doors

Access doors to casings are to comply with Ch 2, Sec 1, [5.4].

6.3 Scantlings

6.3.1 Design loads

Design loads for machinery casing scantling are to be determined as stated under Ch 6, Sec 4, [4].

6.3.2 Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners are to be not less than those obtained according to the applicable requirements in Ch 6, Sec 4.

7 Engine foundation

7.1 Arrangement

7.1.1 General

The scantlings of seatings of main engines and thrust bearings are to be adequate in relation to the weight and power of engines and the static and dynamic forces transmitted by the propulsive installation.

7.1.2 Floors

Floor strength continuity is to be obtained as shown in Fig 1 or Fig 2, or according to any other method considered equivalent by the Society.

7.2 Scantlings

7.2.1 The net scantlings of the structural elements in way of the seatings of engines are to be determined by the engine manufacturer. They are to be checked on the basis of justificative calculations supplied by the engine manufacturer. If these calculations are not supplied, the net scantlings of the structural elements in way of the seatings of engines are to be not less than those obtained from the formulae in Tab 8.

7.2.2 Longitudinal girders

The net scantlings of longitudinal girders in way of engine foundation are not to be less than the values derived from Tab 8.

The section modulus of longitudinal girders in way of engine foundation may be reduced when additional bottom girders are provided over the full length of the engine room.

7.2.3 Floors

The net scantlings of floors in way of the engine foundation, are not to be less than the values derived from Tab 8.

The section modulus of the floors in the section A-A (see Fig 1 and Fig 2) is to be at least 0,6 times that determined according to the formula given in Tab 8.

7.2.4 Bottom plating

The minimum net thickness of bottom plating in way of engine foundation is given in Tab 8.

7.2.5 Longitudinal girders

The longitudinal girders under the engine are to extend over the full length of the engine room and extend beyond the bulkheads, at least for one frame spacing, by means of thick brackets.

Where such an arrangement is not practicable aft, because of the lines, the girders may end at a deep floor strengthened to that effect and in way of which the frames are to be fitted.

As a rule, longitudinal girders under the engine are to be continuous and the floors are to be intercostal, except for large size engine rooms. Strength continuity is anyhow to be ensured over the full girder length. More specially, cutouts and other discontinuities are to be carefully compensated.

Figure 1 : Floor in way of main engine seating: 1st version

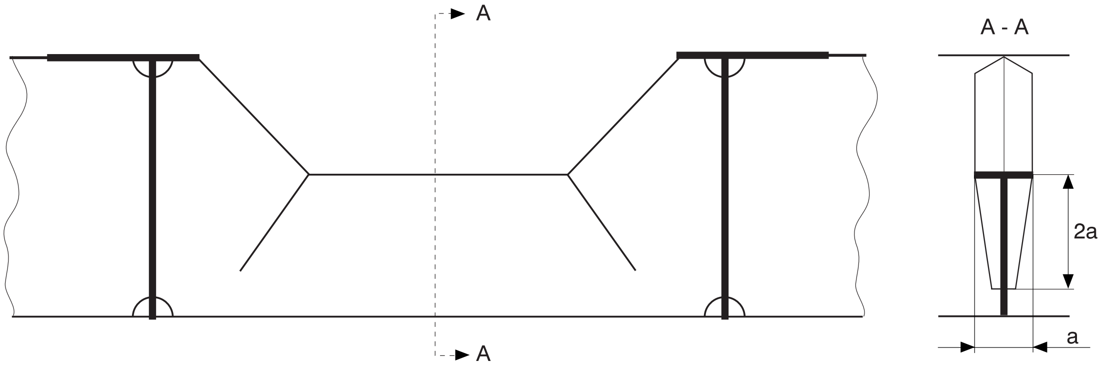


Figure 2 : Floor in way of main engine seating: 2nd version

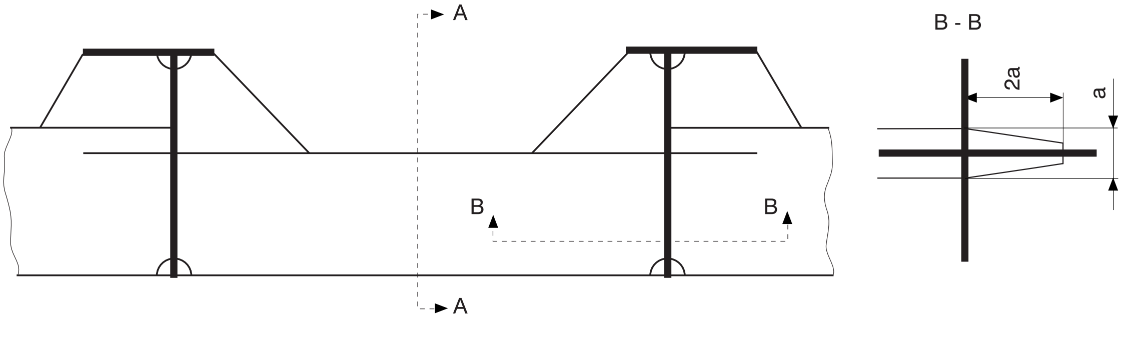


Table 8 : Minimum net scantlings of the structural elements in way of engine foundation

Foundation item	Strength characteristic
Cross-sectional area, in cm², of each bedplate of the seatings	$S = 40 + 70 k_0 k \frac{P}{n_r L_E}$
Thickness, in mm, of each bedplate of the seatings	$t = \sqrt{240 + 175 k_0 k \frac{P}{n_r L_E}}$
Web thickness, in mm, of girders fitted in way of each bedplate of the seatings	$t = \sqrt{\left(95 + 65 k_0 k \frac{P}{n_r L_E}\right)}$
Section modulus of floors, in cm³	$w = \gamma_R \gamma_m \beta_b \frac{p}{m R_y} s \ell^2 10^3 + 175 k_0 k \frac{P}{n_r L_E}$
Web thickness, in mm, of transverse members fitted in way of bedplates of the seating	$t = \sqrt{55 + 40 k_0 k \frac{P}{n_r L_E}}$
Thickness of bottom plating, in mm	$t = t_0 + 2,3 \frac{P}{n_r} \sqrt{k_0 k}$

Note 1:

- P : Maximum power, in kW, of the engine
- n_r : Number of revolutions per minute of the engine shaft at power equal to P
- L_E : Effective length, in m, of the engine foundation plate required for bolting the engine to the seating, as specified by the engine manufacturer
- t_0 : Net thickness of the bottom plating, in mm, in the central part.

SECTION 4 SUPERSTRUCTURES AND DECKHOUSES

Symbols

A_{sh} : Net shear sectional area, in cm²

C_a : Aspect ratio, equal to:

$$C_a = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

C_r : Coefficient of curvature:

$$C_r = 1 - 0,5\frac{s}{r} \ge 0,5$$

where:

r : Radius of curvature, in m

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

I_Y : Moment of inertia, in cm⁴, of the hull girder transverse section defined in Ch 4, Sec 1, [2.1], about its horizontal neutral axis

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Ch 3, Sec 2, [3.2]

m : Boundary coefficient to be taken, in general, equal to:

- m = 12 for ordinary stiffeners
- m = 8 for primary supporting members.

Other values of m may be considered, on a case by case basis, for other boundary conditions

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

p : Design load, in kN/ m²

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

t : Thickness, in mm, of plating

w : Net section modulus, in cm³, of ordinary stiffeners or primary supporting members

z : Z co-ordinate, in m, of the calculation point of a structural element

β_b, β_s : Span correction coefficients defined in Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Tab 1

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

- γ_{W1} = 1,0 for **IN**
- γ_{W1} = 1,15 for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- γ_{W2} = 1,0 for **IN**
- γ_{W2} = 1,2 for **IN(x ≤ 2)**

η : Coefficient taken equal to:

$\eta = 1 - s / (2\ l)$

λ_b, λ_s : Coefficients for pressure distribution correction defined in Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members defined in Ch 2, Sec 4, [4.2] or Ch 2, Sec 4, [5.2].

1 General

1.1 Application

1.1.1 The requirements of this Section apply to scantling and arrangement of superstructures and deckhouses, which may or may not contribute to the longitudinal strength, on vessels made of steel or aluminium alloy.

As to the requirements which are not explicitly dealt with in the present Section, refer to the previous Chapters.

1.1.2 Buckling strength check

For superstructures and deckhouses contributing to the hull girder strength, the buckling strength check of plating, stiffeners and primary supporting members is to be performed according to the applicable requirements of Ch 2, Sec 7.

1.2 Definitions

1.2.1 Superstructures and deckhouses

Superstructures and deckhouses are defined in Ch 1, Sec 2, [2.8] and Ch 1, Sec 2, [2.9], respectively.

A closed deckhouse is a construction consisting of strong bulkheads permanently secured to the deck and made watertight. The openings are to be fitted with efficient weathertight means of closing.

Superstructures and deckhouses may be:

- closed, where they are enclosed by front, side and aft bulkheads complying with the requirements of this Section, the openings of which are fitted with weathertight means of closing
- open, where they are not enclosed.

1.2.2 Superstructures and deckhouses contributing to the longitudinal strength

A superstructure or deckhouse may be considered as contributing to the longitudinal strength if its deck satisfies the basic criteria given in Ch 4, Sec 1, [2.2].

1.2.3 Tiers of superstructures and deckhouses

The lowest tier is normally that which is directly situated above the strength deck defined in Ch 1, Sec 2, [2.10].

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

1.3 Net scantlings

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

The gross scantlings are obtained as specified in Ch 2, Sec 5.

1.4 Partial safety factors

1.4.1 The partial safety factors γ_R and γ_m to be considered for the checking of the superstructure and deckhouse structures are specified in Tab 1.

Table 1 : Superstructures and deckhouses Partial safety factors γ_R and γ_m

Uncertainties regarding:	Symbol	Plating	Ordinary stiffeners	Primary supporting members
Resistance	γ_R	1,20	1,02	1,02
Material	γ_m	1,02	1,02	1,02

2 Arrangements

2.1 Connections of superstructures and deckhouses with the hull structure

2.1.1 Superstructure and deckhouse frames are to be fitted as far as practicable as extensions of those underlying and are to be effectively connected to both the latter and the deck beams above.

Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, diaphragms, webs or pillars.

Where hatchways are fitted close to the ends of superstructures, additional strengthening may be required.

2.1.2 Connection to the deck of corners of superstructures and deckhouses is considered by the Society on a case by case basis. Where necessary, doublers or reinforced welding may be required.

2.1.3 As a rule, the frames of sides of superstructures and deckhouses are to have the same spacing as the beams of the supporting deck.

Web frames are to be arranged to support the sides and ends of superstructures and deckhouses.

2.1.4 The side plating at ends of superstructures is to be tapered into the bulwark or sheerstrake of the strength deck.

Where a raised deck is fitted, this arrangement is to extend over at least a 3-frame spacing.

2.2 Structural arrangement of superstructures and deckhouses

2.2.1 Strengthening in way of superstructures and deckhouses

Web frames, transverse partial bulkheads or other equivalent strengthening are to be fitted inside deckhouses of at least 0,5 B in breadth extending more than 0,15 L in length within 0,4 L amidships. These transverse strengthening reinforcements are to be arranged, where practicable, in line with the transverse bulkheads below.

Web frames are also to be arranged in way of large openings, boats davits and other areas subjected to point loads.

Web frames, pillars, partial bulkheads and similar strengthening are to be arranged, in conjunction with deck transverses, at ends of superstructures and deckhouses.

2.2.2 Strengthening of the raised quarter deck stringer plate

When a superstructure is located above a raised quarter deck, the thickness of the raised quarter deck stringer plate is to be increased by 30% and is to be extended within the superstructure.

The increase above may be reduced when the raised quarter deck terminates outside 0,5 L amidships.

2.2.3 Openings

Openings are to be in accordance with Ch 4, Sec 1, [2.1.6] Ch 4, Sec 1, [2.1.8].

Continuous coamings are to be fitted above and below doors or similar openings.

2.2.4 Strengthening of deckhouses in way of lifeboats and rescue boats

Sides of deckhouses are to be strengthened in way of lifeboats and rescue boats and the top plating is to be reinforced in way of their lifting appliances.

2.2.5 Constructional details

Lower tier stiffeners are to be welded to the decks at their ends.

Brackets are to be fitted at the upper and preferably also the lower ends of vertical stiffeners of exposed front bulkheads of engine casings and superstructures or deckhouses protecting pump room openings.

2.2.6 Gastight bulkheads

The accommodation shall be separated from engine rooms, boiler rooms and holds by gastight bulkheads.

2.2.7 Local reinforcements

Local reinforcements are to be foreseen in way of areas supporting cars or ladders.

3 Design loads

3.1 Local loads

3.1.1 Strength check in service conditions

The design pressure in service conditions is to be determined in compliance with applicable requirements of Ch 3, Sec 4.

The design pressure, in kN/m², on sides and external bulkheads is to be taken not less than:

$P = 2 + p_{WD}$

Where p_{WD} is the wind pressure defined in Ch 3, Sec 4, [2.1.3] Ch 3, Sec 4, [2.1.3].

3.2 Hull girder normal stresses

3.2.1 The requirements in Pt D, Ch 2, Sec 12, [4.2] apply in addition to vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**.

3.2.2 The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm², from the following formulae:

- in general

  $\sigma_{X1} = \sigma_{S1} + \gamma_{W1} C_{FV}\, \sigma_{WV1}$

- for structural members not contributing to the hull girder longitudinal strength:

  $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV1}: Hull girder normal stresses, in N/mm², defined in:
- Tab 3, for plating subjected to lateral loads
- Tab 4, for plating in-plane hull girder compression normal stresses
- Tab 8, for ordinary stiffeners and primary supporting members subjected to lateral pressure

C_{FV} : Combination factors defined in Tab 2.

Table 2 : Combination factors C_{FV}

Load case	C_{FV}
"a"	0
"b"	1,0
"c"	Except vessels assigned a range of navigation **IN(1,2 < x ≤ 2)**, the hull girder wave loads in inclined condition may generally be disregarded.
"d"	

Table 3 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} \geq 1$	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
$\frac{M_S + \gamma_W \gamma_{W1} C_{FV} M_{WV}}{M_H + \gamma_W \gamma_{W1} C_{FV} M_{WV}} < 1$	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.
Note 1:
- For range of navigation **IN**, $\gamma_W = 1{,}00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0{,}625$

Table 4 : In-plane hull girder compression normal stresses - Plating

Condition	σ_{S1}, in N/mm²	σ_{WV1}, in N/mm²
z ≥ N	$\left\lvert \frac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
z < N	$\left\lvert \frac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

Note 1:
- For range of navigation **IN**, $\gamma_W = 1{,}00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0{,}625$

4 Scantlings

4.1 Scantling requirements

4.1.1 General

The Society may ask additional arrangements deemed necessary in order to keep, in acceptable limits, the level of stresses liable to occur in the superstructure structural members.

4.1.2 Web plating of ordinary stiffeners

The net thickness, in mm, of the web plating of ordinary stiffeners is not to be less than:

- for $L < 120$ m: $t = 1,63 + 0,004\ L\ (k_0 k)^{0,5} + 4,5\ s$
- for $L \geq 120$ m: $t = 3,9\ (k_0 k)^{0,5} + s$

Table 5 : Net scantlings for non-contributing superstructures and deckhouses

Item	Strength characteristic	Scantling
Plating of sides Plating of aft end bulkheads Plating of not exposed deck	thickness, in mm	$t = \max(t_1\ ;\ t_2)$ $t_1 = 3,5 + 0,01\ L\ (k_0 k)^{0,5}$ $t_2 = 11 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{R_y}}$
Plating of exposed decks Plating of front bulkheads	thickness, in mm	$t = \max(t_1\ ;\ t_2)$ $t_1 = 4 + 0,01\ L\ (k_0 k)^{0,5}$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{R_y}}$
Ordinary stiffeners	section modulus, in cm³	$w = k_1 \gamma_R \gamma_m \beta_b \dfrac{p}{m R_y} s \ell^2 10^3$
Primary supporting members	section modulus, in cm³	$w = k_1 \gamma_R \gamma_m \beta_b \dfrac{p}{m R_y} S \ell^2 10^3$

Note 1:
k_1 :
- in general: $k_1 = 1$
- for vertical stiffeners: $k_1 = 1 + 0,1\ n_t$

n_t : Number of tiers above the tier considered.

Table 6 : Plating net thickness, in mm, for contributing superstructures and deckhouses

Item	Transverse framing	Longitudinal framing
Side plating	$t = \max(t_1\ ;\ t_2)$ $t_1 = 1,68 + 0,025\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t = \max(t_1\ ;\ t_2)$ $t_1 = 1,25 + 0,02\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Deck plating	$t = \max(t_1\ ;\ t_2)$ $t_1 = 0,9 + 0,034\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 17,2 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_T R_y}}$	$t = \max(t_1\ ;\ t_2)$ $t_1 = 0,57 + 0,031\ L\ (k_0 k)^{0,5} + 3,6\ s$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{\lambda_L R_y}}$
Plating of aft end bulkheads	$t = \max(t_1\ ;\ t_2)$ $t_1 = 3,5 + 0,01\ L\ (k_0 k)^{0,5}$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{R_y}}$	
Plating of front bulkheads	$t = \max(t_1\ ;\ t_2)$ $t_1 = 4 + 0,01\ L\ (k_0 k)^{0,5}$ $t_2 = 14,9 C_a C_r s \sqrt{\dfrac{\gamma_R \gamma_m p}{R_y}}$	

Note 1:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225 \gamma_m \frac{\sigma_{X1}}{R_y}$$

$$\lambda_T = 1 - 0,89 \gamma_m \frac{\sigma_{X1}}{R_y}$$

Table 7 : Structural member net scantlings for contributing superstructures

Item	w, in cm^3	A_{Sh}, in cm^2
Longitudinal ordinary stiffeners	$w = \gamma_R \gamma_m \beta_b \dfrac{p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} s \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} s \ell$
Other ordinary stiffeners	$w = k_1 \gamma_R \gamma_m \beta_b \dfrac{p}{m R_y} s \ell^2 10^3$	
Longitudinal primary supporting members	$w = \gamma_R \gamma_m \beta_b \dfrac{p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} S \ell$
Other primary supporting members	$w = k_1 \gamma_R \gamma_m \beta_b \dfrac{p}{m R_y} S \ell^2 10^3$	

Note 1:

k_1 :
- $k_1 = 1,0$ in general
- $k_1 = 1 + 0,1\ n_t$ for vertical stiffeners,
  with n_t : Number of tiers above the tier considered

**Table 8 : Hull girder normal stresses -
Ordinary stiffeners and primary supporting members subjected to lateral pressure**

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:		
• $z \geq N$ in general $z < N$ for stiffeners simply supported at both ends	$\left\lvert \dfrac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \dfrac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
Lateral pressure applied on the same side as the ordinary stiffener:		
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert \dfrac{M_H}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert \dfrac{M_S}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \dfrac{\gamma_W M_{WV}}{I_Y}(z-N) \right\rvert 10^{-3}$

(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.

Note 1:
- For range of navigation **IN**, $\gamma_W = 1,00$
- For range of navigation **IN(x ≤ 2)**, $\gamma_W = 0,625$

4.1.3 Web plating of primary supporting members

The net thickness, in mm, of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$t = 3,8 + 0,016\ L\ (k_0 k)^{0,5}$

4.1.4 Superstructures and deckhouses not contributing to the longitudinal strength

The net scantlings of superstructures and deckhouses not contributing to the longitudinal strength are to be derived from formulae given in Tab 5.

4.1.5 Superstructures and deckhouses contributing to the longitudinal strength

The net scantlings of superstructures contributing to the longitudinal strength are to be not less than those determined in accordance with Tab 6 and Tab 7.

5 Additional requirements applicable to movable wheelhouses

5.1 General

5.1.1 The structures of movable wheelhouses are to be checked in low and high position.

5.1.2 The lifting mechanism is to be designed in such a way that exceeding the terminal positions is not possible.

5.1.3 Mechanical locking devices are to be fitted in addition to hydraulic systems.

The supports or guide of movable wheelhouses, connections with the deck, under deck reinforcements and locking devices are to be checked considering the following forces:

a) Structural and non-structural inertial horizontal loads under vessel acceleration to be determined according to Ch 3, Sec 3, [2.1.4], where the roll amplitude is not to be taken less than 0,21 rad (12°)

b) Wind force, corresponding to a lateral pressure determined according to Ch 3, Sec 4, [2.1.3]

5.1.4 The wheelhouse can be fixed in different positions along the vertical axis, and the access to the wheelhouse shall be possible at any position.

Structural and non-structural still water horizontal loads under list or roll angle to be taken not less than 0,21 rad (12°)

During the movement of the wheelhouse, operations carried out from the wheelhouse shall not be hindered.

5.1.5 The safety of persons on board is to be guaranteed at any position of the wheelhouse.

Movements of the wheelhouse are to be signaled by optical and acoustic means.

5.1.6 In the case of emergency, it should be possible to lower the wheelhouse by means independent of the power drive. Emergency lowering of the wheelhouse is to be effected by its own weight and is to be smooth and controllable. It should be possible from both inside and outside the wheelhouse and can be effected by one person under all conditions.

5.2 Arrangement

5.2.1 The hoisting mechanism is to be capable to hoist at least 1,5 times the weight of the wheelhouse fully equipped and manned.

5.2.2 The feed cables for systems inside the wheelhouse are to be arranged in such a way as to exclude the possibility of mechanical damage to them.

6 Elastic bedding of deckhouses

6.1 General

6.1.1 The structural members of elastically bedded deckhouses may, in general, be dimensioned in accordance with [4].

6.1.2 Strength calculations for the load bearing rails, elastic elements and antilift-off devices as well as for supporting structure of the deckhouse bottom and the hull are to be carried out assuming the following loads:

- vertical loads: P = 1,2 G
- horizontal loads: P = 0,3 G

where:

G : Total weight of the complete deckhouse, outfit and equipment included.

Additional loads due to vessel's heel need not be considered, in general.

SECTION 5 HATCH COVERS

Symbols

A_{sh} : Net shear sectional area, in cm^2

h_2 : Reference value, in m, of the relative motion in the inclined vessel condition in Ch 3, Sec 3, [2.2.1]

m : Boundary coefficient, to be taken, in general, equal to:

m = 12 for ordinary stiffeners

m = 8 for primary supporting members

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing of primary supporting members, in m

s : Spacing of ordinary stiffeners, in m

t : Net thickness, in mm

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

γ_m : Partial safety factor covering uncertainties regarding material

$\gamma_m = 1,02$

ℓ : Span, in m, of ordinary stiffeners or primary supporting members.

1 General

1.1 Application

1.1.1 The requirements of this Section apply to hatchways which are closed with self-bearing hatch covers. These are to bear on coamings.

1.1.2 Hatch covers supported by hatchway beams and other supporting systems are to be considered by the Society on a case by case basis. In any case, they are to ensure the same degree of strength and weathertightness.

1.2 Definitions

1.2.1 Weathertightness

Weathertightness is ensured when, for all the navigation conditions envisaged, the closing devices are in compliance with Ch 2, Sec 2, [1.2.7].

Systems to ensure the weathertightness are mentioned in [2.1.3].

1.2.2 Watertightness

Watertightness is ensured when, for all the navigation conditions envisaged, the closing devices are in compliance with Ch 2, Sec 2, [1.2.8].

1.3 Materials

1.3.1 Hatch covers are to be made of steel or aluminium alloy. The use of other materials is to be considered by the Society on a case by case basis.

2 Arrangements

2.1 General

2.1.1 Hatch covers on exposed decks

Hatchways on exposed decks are to be fitted with weathertight hatch covers of adequate strength and rigidity.

The height of the hatch coaming above the deck h_C, in m, is to be such that:

$$z_{hc} \geq T + h_2 + 0,15$$

where:

z_{hc} : z co-ordinate, in m, of the top of hatch coaming.

2.1.2 Hatch covers in closed superstructures

Hatch covers in closed superstructures need not be weathertight.

However, hatch covers fitted in way of ballast tanks, fuel oil tanks or other tanks are to be watertight.

2.1.3 Weathertightness of hatch covers

The hatch cover tightness is not subjected to a test.

Tightness may be obtained by fitting of flanged metal hatch-covers which constitute baffles intended to prevent water penetrating into the hold below.

Hatch covers are to have a mean slope of not less than 0,1, unless they are covered by tarpaulins. Where tarpaulins are fitted, they are to have adequate characteristics of strength and weathertightness. The tarpaulin is to be secured by means of batten, cleats and wedges.

2.1.4 Securing of hatch covers

The positioning and securing of hatch covers are to be ensured by supports or guides of efficient construction. Where metallic broaches or bolts are used, their diameter is to be such that the mean shearing stress, under the action of design loads does not exceed 44 N/mm^2.

Efficient arrangements are to be made to prevent unexpected displacement or lifting of the hatch covers.

2.1.5 The width of each bearing surface for hatch covers is to be at least 65 mm.

2.1.6 Hatch covers carrying containers

The design, construction and arrangement of hatch covers carrying containers are to be in compliance with Pt D, Ch 1, Sec 4.

2.1.7 Hatch covers carrying wheeled loads

The design, construction and arrangement of hatch covers carrying wheeled loads are to be in compliance with Pt D, Ch 1, Sec 5.

3 Design loads

3.1 Design loads

3.1.1 General

The design loads to be considered for the scantling of hatch covers are, on one hand, the structural weight of the items themselves, and on the other, the expected deck load, if any, defined in [3.1.2].

3.1.2 Hatch covers carrying uniform cargoes

The pressure due to uniform load carried on hatch covers, in kN/m², is given by the formula:

$p = p_S + \gamma_{W2}\, p_W$

where:

p_S : Expected hatch cover still water pressure, in kN/m², to be defined by the Designer.

In any case, p_S is not to be taken less than:

$p_S = \max(1{,}5\ ;\ 31y - 1{,}5)$

whith:

y : Coefficient to be taken as:

- $y = 0{,}099$ fof **IN**
- $y = n$ for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- $\gamma_{W2} = 1{,}0$ for **IN**
- $\gamma_{W2} = 1{,}2$ for **IN(x ≤ 2)**

p_W : Inertial pressure, in kN/m²:

$$p_W = p_S \frac{a_{Z1}}{9,81}$$

with:

a_{Z1} : Reference value of the acceleration in Z direction, defined in Ch 3, Sec 3, [2.3].

4 Scantlings

4.1 Application

4.1.1 The following scantling rules are applicable to rectangular hatch covers subjected to a uniform pressure.

In the case of hatch covers arranged with primary supporting members as a grillage, the scantlings are to be determined by direct calculations.

4.2 Plating of hatch covers

4.2.1 Minimum net thickness of hatch covers

In any case, the thickness of hatch covers is not to be less than:

- for steel
  - galvanized steel: 2 mm
  - other cases: 3 mm.
- for aluminium alloys: 4,5 mm.

4.2.2 Net thickness of metal hatch covers

The net thickness of metal hatch covers subjected to lateral uniform load is not to be less than:

$$t = 16,3s\sqrt{\frac{\gamma_R \gamma_m p}{R_y}}$$

where:

γ_R : Partial safety factor covering uncertainties regarding resistance, equal to:

$\gamma_R = 1{,}20$

4.3 Stiffening members of hatch covers

4.3.1 Width of attached plating

The width of the attached plating is to be in compliance with Ch 2, Sec 4, [4.3] or Ch 2, Sec 4, [5.3], as applicable.

4.3.2 Minimum web thickness

The minimum thickness of the web of the stiffeners, in mm, is to be not less than the thickness of the plating of the hatch covers, given in [4.2].

4.3.3 Section modulus and shear sectional area

The net section modulus w, in cm³, and the net shear sectional area A_{Sh}, in cm², of self-bearing hatch cover ordinary stiffeners and primary supporting members are not to be less than those obtained from the following formulae:

$$w = \frac{\gamma_R \gamma_m p}{m R_y} a \ell^2 10^3$$

$$A_{sh} = 10 \gamma_R \gamma_m \frac{p}{R_y} a \ell$$

where:

a : Stiffener spacing, in m:

$a = s$ for ordinary stiffeners

$a = S$ for primary supporting members

γ_R : Partial safety factor covering uncertainties regarding resistance, equal to:

$\gamma_R = 1{,}02$

SECTION 6 MOVABLE DECKS AND RAMPS

1 Movable decks and inner ramps

1.1 Materials

1.1.1 The movable decks and inner ramps are to be made of steel or aluminium alloys complying with the requirements of Ch 2, Sec 3. Other materials of equivalent strength may be used, subject to a case by case examination by the Society.

1.2 Net scantlings

1.2.1 As specified in Ch 2, Sec 5, [2]**, all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.**

The gross scantlings are to be obtained as specified in Ch 2, Sec 5, [2].

1.3 Plating

1.3.1 The net thickness of plate panels subjected to wheeled loads is not to be less than the value obtained from Pt D, Ch 1, Sec 5, [4.3], where ($n_P \cdot F$) is not to be taken less than 50 kN,

with:

n_P : Number of wheels on the plate panel, taken equal to:

- 1 in the case of a single wheel
- the number of wheels in the case of double or triple wheels

F : Wheeled force, in kN.

1.4 Ordinary stiffeners

1.4.1 The net section modulus and the net shear sectional area of ordinary stiffeners subjected to wheeled loads are not to be less than the value obtained from Pt D, Ch 1, Sec 5, [4.4.1].

1.5 Primary supporting members

1.5.1 General

The supporting structure of movable decks and inner ramps is to be verified through direct calculation, considering the following cases:

- movable deck stowed in upper position, empty and locked in navigation conditions
- movable deck in service, loaded, in lower position, resting on supports or supporting legs and locked in navigation conditions
- movable inner ramp in sloped position, supported by hinges at one end and by a deck at the other, with possible intermediate supports, loaded, at harbour
- movable inner ramp in horizontal position, loaded and locked, in navigation conditions.

1.5.2 Loading cases

The scantlings of the structure are to be verified in both navigation and harbour conditions for the following cases:

- loaded movable deck or inner ramp under loads according to the load distribution indicated by the Designer
- loaded movable deck or inner ramp under uniformly distributed loads corresponding to a pressure, in kN/m^2, taken equal to $p_0 + p_1$
- empty movable deck under uniformly distributed masses corresponding to a pressure, in kN/m^2, taken equal to p_0 ,

where:

$$p_0 = \frac{P_P}{A_P}$$

$$p_1 = \frac{n_V P_V}{A_P}$$

P_P : Weight of the movable deck or inner ramp, in kN

P_V : Weight of a vehicle, in kN

n_V : Maximum number of vehicles loaded on the movable deck or inner ramp

A_P : Effective area of the movable deck or inner ramp, in m^2.

1.5.3 Lateral pressure

The lateral pressure is constituted by still water pressure and inertial pressure. The lateral pressure is to be obtained, in kN/m^2, from the following formula:

$p = p_S + \gamma_{W2}\, p_W$

where:

p_S , p_W : Still water and inertial pressures transmitted to the movable deck or inner ramp structures, obtained, in kN/m^2, from Tab 1.

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads

- $\gamma_{W2} = 1,0$ for **IN**
- $\gamma_{W2} = 1,2$ for **IN($x \le 2$)**

1.5.4 Checking criteria

It is to be checked that the combined stress σ_{VM}, in N/mm^2, is in compliance with the criteria defined in Ch 2, Sec 8, [2.4.4], item c).

Table 1 : Movable decks and inner ramps Still water and inertial pressures

Ship condition	Load case	Still water pressure p_S and inertial pressure p_W, in kN/m²	
Still water condition		$p_S = p_0$ in harbour condition during lifting $p_S = p_0 + p_1$ in other cases	
Upright navigation condition	"a"	No inertial pressure	
	"b"	$p_{W,X} = \frac{a_{X1}}{g}(p_0 + p_1)$	in x direction
		$p_{W,Z} = \frac{a_{Z1}}{g}(p_0 + \alpha p_1)$	in z direction
Inclined navigation condition (negative roll angle)	"c"	$p_{W,Y} = \frac{C_{FA} a_{Y2}}{g}(p_0 + p_1)$	in y direction
	"d"	$p_{W,Z} = \frac{C_{FA} a_{Z2}}{g}(p_0 + \alpha p_1)$	in z direction
Harbour condition **(1)**	during lifting	$p_{W,X} = 0,035\ p_0$ $p_{W,Y} = 0,087\ p_0$ $p_{W,Z} = 0,200\ p_0$	in x direction in y direction in z direction
	at rest	$p_{W,X} = 0,035\ (p_0 + p_1)$ $p_{W,Y} = 0,087\ (p_0 + p_1)$ $p_{W,Z} = 0,100\ (p_0 + p_1)$	in x direction in y direction in z direction

(1) For harbour conditions, a heel angle of 5° and a trim angle of 2° are taken into account. In case the designer is proposing a heel angle of less than 5° based on specific operational conditions, the used angle is to be clearly specified.

Note 1:

p_0, p_1 : Pressures, in kN/m², to be calculated according to [1.5.2] for the condition considered

α : Coefficient taken equal to 0,5

a_{X1}, a_{Z1}, a_{Y2}, a_{Z2}: Reference values of the accelerations defined in Ch 3, Sec 3, Tab 5.

C_{FA} : Combination factor, to be taken equal to:

- $C_{FA} = 0,7$ for load case "c"
- $C_{FA} = 1,0$ for load case "d"

1.5.5 Allowable deflection

The scantlings of main stiffeners and the distribution of supports are to be such that the deflection of the movable deck or inner ramp does not exceed 5 mm/m.

1.6 Supports, suspensions and locking devices

1.6.1 Scantlings of supports and wire suspensions are to be determined by direct calculation on the basis of the loads in [1.5.2] and [1.5.3], taking account of a safety factor at least equal to 5.

1.6.2 It is to be checked that the combined stress σ_{VM}, in N/mm², in rigid supports and locking devices is in compliance with the criteria defined in Ch 2, Sec 8, [2.4.4], item c).

1.7 Tests and trials

1.7.1 Tests and trials defined in [1.7.2] to [1.7.4] are to be carried out in the presence of the Surveyor. Upon special request, these conditions of tests and trials may be modified to comply with any relevant national regulations in use.

1.7.2 The wire ropes are to be submitted to a tensile test on test-piece.

1.7.3 The loose gears used for the platform and ramp handling (chain, shackles, removable blocks, etc.) are to have a maximum safe working load (SWL) and are to be submitted to an individual test before fitting on board.

The test of these loose gears are to be in accordance with the applicable requirements of Rule Note NR526, Rules for the Certification of Lifting Appliances on board Ships and Offshore Units.

1.7.4 A trial to verify the correct operation of lowering and lifting devices of the platform is to be carried out before going into service.

This trial is made without overload unless special requirement of National Authorities.

2 External ramps

2.1 General

2.1.1 The external ramps are to be able to operate with a heel angle of 5° and a trim angle of 2°.

2.1.2 The net thicknesses of plating and the net scantlings of ordinary stiffeners and primary supporting members are to be determined under vehicle loads in harbour condition, at rest, as defined in Tab 1.

2.1.3 The external ramps are to be examined for their watertightness, if applicable.

2.1.4 The locking of external ramps in stowage position in navigation conditions is examined by the Society on a case by case basis.

2.1.5 The vessel's structure under the reactions due to the ramp is examined by the Society on a case by case basis.

SECTION 7 MISCELLANEOUS FITTINGS

Symbols

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:
- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

s : Spacing, in m, of stiffeners

γ_R : Partial safety factor covering uncertainties regarding resistance
- γ_R =1,20, for plating
- γ_R =1,02, for ordinary stiffeners and primary supporting members

γ_m : Partial safety factor covering uncertainties regarding material: γ_m =1,02

ℓ : Span, in m, of stiffeners, defined in Ch 2, Sec 4, [4.2]

1 Sidescuttles, windows and skylights

1.1 General

1.1.1 Application

The requirements in [1.1] and [1.3] apply to sidescuttles and rectangular windows providing light and air, located on exposed hull structures.

1.1.2 Sidescuttle definition

Sidescuttles are round or oval openings with an area not exceeding 0,16 m². Round or oval openings having areas exceeding 0,16 m² are to be treated as windows.

1.1.3 Window definition

Windows are rectangular openings generally, having a radius at each corner relative to the window size in accordance with recognised national or international standards, and round or oval openings with an area exceeding 0,16 m².

1.1.4 Number of openings in the shell plating

The number of openings in the shell plating are to be reduced to the minimum compatible with the design and proper working of the vessel.

1.2 Watertight sidescuttles and windows

1.2.1 General

Windows and sidescuttles may be situated below the bulkhead deck if they are watertight, cannot be opened and comply with [1.2.2] and [1.2.3], or equivalent requirements.

Only pre-stressed glass complying with International Standard ISO 614 :2012 shall be used.

1.2.2 Sidescuttles

The construction and strength of sidescuttles fitted below the bulkhead deck are to be in compliance with ISO 1751:2012, series B: medium heavy-duty windows type: non-opening windows.

1.2.3 Windows

The construction and strength of windows fitted below the bulkhead deck are to be in compliance with ISO 3903:2012, series E: heavy-duty windows type: non-opening windows.

1.2.4 Manholes and flush scuttles

Manholes and flush scuttles exposed to the weather are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

1.3 Glasses

1.3.1 General

In general, toughened glasses or laminated glasses with frames of special type are to be used in compliance with, or equivalent to, recognised national or international standards.

Direct metal to glass contact is to be avoided.

The use of clear plate glasses is considered by the Society on a case by case basis.

1.3.2 Design loads

The design load, p, is to be determined in accordance with the applicable requirements of Ch 3, Sec 4, [2] or Ch 2, Sec 5, [3.1].

1.3.3 Scantling

The windows and sidescuttles scantling defined in this sub-article are equivalent to Standard ISO 11336-1:2012.

Window scantling defined in this Sub-article are provided for the following types of window:
- monolithic window (see [1.3.4])
- laminated window (see [1.3.5])
- double windows unit with gap (see [1.3.9]).

The edge condition of window and sidescuttle are considered as supported.

1.3.4 Thickness of monolithic windows

The thicknesses, in mm, of monolithic windows and sidescuttles are not to be less than 6 mm nor than the values obtained from the following formulae:

- rectangular window or sidescuttle:

$$t = 31,6s\sqrt{\frac{\beta p S_f}{R_m}}$$

- circular window or sidescuttle:

$$t = 17,4d\sqrt{\frac{p S_f}{R_m}}$$

where:

s : Shorter side, in m, of rectangular window or sidescuttle

d : Diameter, in m, of circular window or sidescuttle

β : Aspect ratio coefficient of the rectangular window or sidescuttle, defined in Tab 1, where:

ℓ : Longer side, in m, of rectangular window or sidescuttle

Where the window is supported only by 2 edges, β is to be taken equal to 1,0.

p : Design load, in kN/m² (see [1.3.2])

S_f : Safety factor taken equal to:

- 4,0 for thermally or chemically toughened glass:
- 3,5 for polymethylmethacrilate (PMMA) or polycarbonate (PC) glass

R_m : Guaranteed minimum flexural strength, in N/mm², of material used. For guidance only, the guaranteed minimum flexural strength R_m for glass window is:

- for thermally or chemically toughened glass:

  R_m = 160 N/mm²
- for polymethylmethacrilate (PMMA) glass:

  R_m = 100 N/mm²
- for polycarbonate (PC) glass:

  R_m = 90 N/mm²

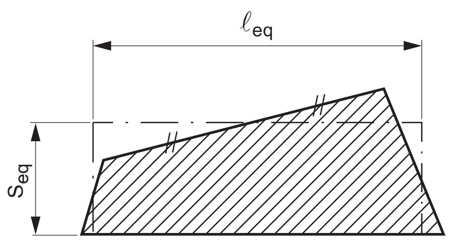
The thickness of windows or sidescuttles having other shapes may be obtained by considering rectangles or circles of equivalent dimensions s_{eq}, ℓ_{eq} or d_{eq} as defined in Tab 2.

Table 1 : Coefficient β

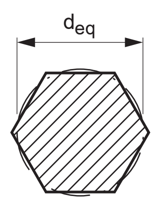
ℓ/s	β
1,0	0,284
1,5	0,475
2,0	0,608
2,5	0,684
3,0	0,716
3,5	0,734
≥ 4,0	0,750

Table 2 : Equivalent dimensions for windows having other shapes

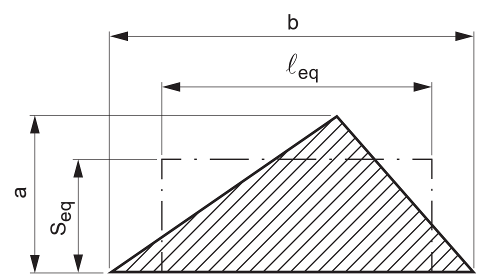
a) Quadrangle
The equivalent rectangle has the same area



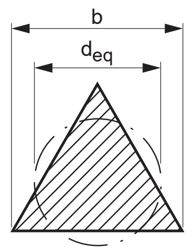
b) Polygon
The equivalent circle has the same area



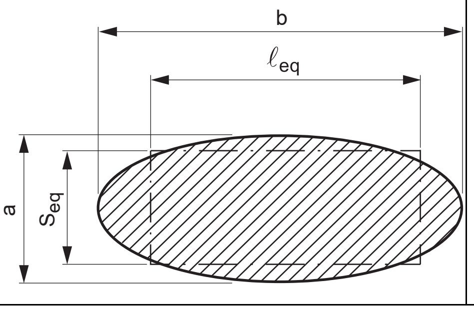
c) Triangle
s_{eq} = 2a/3
l_{eq} = 3b/4



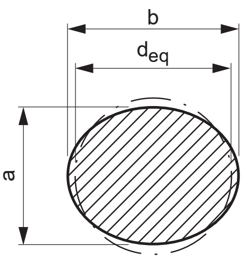
d) Equilateral triangle
d_{eq} = 3b/4



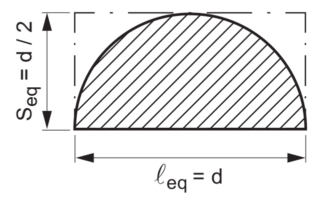
e) Flat ellipse
s_{eq} = 0,87a
l_{eq} = 0,87b



f) Round ellipse
$d_{eq} = \sqrt{ab}$



g) Semi circle
s_{eq} = d/2
l_{eq} = d



1.3.5 Laminated windows

Laminated windows are windows realized by placing a layer of resin (polyvinyle butyral as a general rule) between plies of same or different materials.

For laminated windows made with plies of the same material:

- When the mechanical properties of the interlayer material (the laminating adhesive material) are not known, the plies of the laminated window are considered as mechanically independent, and the equivalent thickness is to be calculated as defined in [1.3.6].
- When the mechanical properties of the interlayer material are known in terms of shear modulus, G, in N/mm², the plies of the laminated window are considered as mechanically collaborating, and the equivalent thickness is to be calculated as defined in [1.3.7].

When the laminated window is made with plies of different materials, they are considered as mechanically independent, and the eq.uivalent thickness is to be calculated as defined in [1.3.8].

1.3.6 Thickness of laminated window with independent plies

The equivalent thickness t_{eq}, in mm, of laminates made of n independent plies of thicknesses $t_{p,1}$, $t_{p,2}$, …, $t_{p,n}$, is to comply with the following formula:

$$t_{eq} \geq t$$

where:

$$t_{eq} = \min[t_{eq,j}]$$

$$t_{eq,j} = \sqrt{\frac{\sum_{j=1}^{n} t_{p,j}^3}{t_{p,j}}}$$

j : Ply index, ranging from 1 to n

t : Thickness, in mm, of a monolithic window, calculated according to [1.3.4].

1.3.7 Thickness of laminated window with collaborating plies

The equivalent thickness t_{eq}, in mm, of laminates made of two collaborating plies of the same material, and of thicknesses t_1 and t_2 separated by an interlayer of thickness t_I is to comply with the following formula:

$$t_{eq} \geq t$$

where:

$$t_{eq} = \min[t_{1eq,s}, t_{2eq,s}]$$

$t_{1eq,s}$, $t_{2eq,s}$: Equivalent thickness for strength as obtained from the following formulae:

$$t_{1eq,s} = \sqrt{\frac{t_{eq,d}^3}{t_1 + 2\Gamma t_{s2}}}$$

$$t_{2eq,s} = \sqrt{\frac{t_{eq,d}^3}{t_2 + 2\Gamma t_{s1}}}$$

$t_{eq,d}$: Equivalent thickness for deflection as obtained from the following formula:

$$t_{1eq,d} = \sqrt[3]{t_1^3 + t_2^3 + 12\Gamma I_S}$$

Γ : Shear transfer coefficient as obtained from the following formula, without being taken less than 0 (independent plies behaviour) and more than 1,0 (monolithic behaviour):

$$\Gamma = \frac{1}{1 + 9{,}6\,\frac{E}{G} \cdot \frac{I_S}{hs^2} \cdot \frac{t_I}{s^2} \cdot \frac{1}{10^6}}$$

$$t_{s1} = \frac{hs \cdot t_1}{t_1 + t_2}$$

$$t_{s2} = \frac{hs \cdot t_2}{t_1 + t_2}$$

$$I_S = t_1 t_{s2}^2 + t_2 t_{s1}^2$$

$$hs = 0{,}5(t_1 + t_2) + t_I$$

G : Shear modulus of the interlayer at 25°C, in N/mm², generally taken equal to 1,6 N/mm² for polyvinyl butyral (PVB).

For other interlayer materials the shear modulus value at 25 °C for short time duration load (60 s) shall be declared by the interlayer material manufacturer

E : Young's modulus of the plies, in N/mm²

s : Shorter side, in m, of rectangular window or sidescuttle.

In case of multiple (more than two plies) laminates the calculation is to be iterated. The iteration is to start from the outer ply (the one directly loaded by water pressure) and end with the inner ply.

1.3.8 Thickness of laminated window with plies of different materials

The equivalent thickness t_{eq}, in mm, of laminates made of n plies of different materials, of thicknesses $t_{p,1}$, $t_{p,2}$, …, $t_{p,n}$ and of Young's modulus $E_{p,1}$, $E_{p,2}$, ..., $E_{p,n}$ is to comply with the following formula:

$$t_{eq} \geq t$$

where:

$$t_{eq} = \min[t_{eq,j}]$$

$$t_{eq,j} = \sqrt{\frac{\sum_{j=1}^{n} E_{p,j} t_{p,j}^3}{t_{p,j}}}$$

j : Ply index, ranging from 1 to n

t : Thickness, in mm, of a monolithic window, calculated according to [3.3.4] for the same material than the ply giving the minimum value of $t_{eq,j}$.

1.3.9 Thickness of double windows

Double windows are glass windows made of two plies of glass separated by an hermetically sealed spacebar.

The thickness of the ply exposed to the loads defined in [1.3.2] is to be calculated as per monolithic windows according to [1.3.4].

1.3.10 Thickness of glasses forming screen bulkheads or internal boundaries of deckhouses

The thickness of glasses forming screen bulkheads on the side of enclosed promenade spaces and that for rectangular windows in the internal boundaries of deckhouses which are protected by such screen bulkheads are considered by the Society on a case by case basis.

The Society may require both limitations on the size of rectangular windows and the use of glasses of increased thickness in way of front bulkheads which are particularly exposed.

1.4 Skylights

1.4.1 Fixed or opening skylights are to have glass thickness appropriate to their size and position as required for windows and sidescuttles. Skylight glasses in any position are to be protected from mechanical damage. They are to be provided with permanently attached robust deadlights.

2 River chests

2.1 Shell plating

2.1.1 The shell plate gross thickness, in mm, in way of river chests as well as the gross thickness of all boundary walls of the river chests are not to be less than:

$$t = 17,2s\sqrt{\frac{\gamma_R\gamma_m p}{R_y}} + 1,5$$

where:

p : Pressure at the safety relief valve, in kN/m²:

- in general: $p \geq 200$ kN/m²
- for river chests without any compressed air connection and which are accessible at any time: $p \geq 100$ kN/m².

2.2 Stiffeners

2.2.1 The gross section modulus, in cm³, of river chest stiffeners is not to be less than:

$$w = \frac{\gamma_R\gamma_m p}{8R_y} s\ell^2 10^3$$

where:

p : Design pressure, in kN/m², defined in [2.1.1].

3 Independent tanks

3.1 General

3.1.1 These requirements for scantling apply to steel tanks not forming part of the vessel's structure. Scantling of tanks not made of steel will be given special consideration.

The meaning of the symbols used in this sub-article is as follows:

p_{ST} : Testing pressure defined in Ch 3, Sec 4, [5], to be determined in way of the calculation point (see Ch 2, Sec 4, [6.3])

λ_b :
- for horizontal stiffeners: $\lambda_b = 1,0$
- for other stiffeners: $\lambda_b = 1,2$

λ_S :
- for horizontal stiffeners: $\lambda_b = 1,0$
- for other stiffeners: $\lambda_b = 1,4$

3.2 Net thickness of plating

3.2.1 The net thickness, in mm, of plating of tanks not forming part of the vessel's structure is not to be less than t1 nor than t2 derived from the following:

$t_1 = 2,5$

$$t_2 = 14,9s\sqrt{\frac{\gamma_R\gamma_m p_{ST}}{R_y}}$$

3.3 Scantling of ordinary stikffeners

3.3.1 Scantlings of ordinary stiffeners

For tanks not forming part of the vessel's structure, the net section modulus w, in cm³, and the net shear sectional area A_{Sh}, in cm², of ordinary stiffeners are not to be less than:

$$w = \frac{\gamma_R\gamma_m p_{ST}}{8R_y} s\ell^2 10^3$$

$$A_{sh} = 10\gamma_R\gamma_m\frac{p_{ST}}{R_y}s\ell$$

where:

p : Testing pressure, in kN/m², defined in Ch 3, Sec 4, [5].

4 Scuppers and discharges

4.1 Material

4.1.1 The scuppers and discharge pipes are to be constructed of steel. Other equivalent materials are considered by the Society on a case by case basis.

4.2 Pipe connections at the shell plating

4.2.1 Scupper pipes and valves are to be connected to the shell by weld flanges. Instead of weld flanges short-flanged sockets with an adequate thickness may be used if they are welded to the shell in an appropriate manner.

4.3 Wall thickness

4.3.1 The wall gross thickness of scuppers and discharge pipes is to be not less than the shell plating thickness in way of the scuppers, respectively discharge pipes, but need not exceed 8 mm.

SECTION 8 HELICOPTER DECKS AND PLATFORMS

Symbols

g : Gravitational acceleration:

$g = 9,81\ m/s^2$

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

W_H : Maximum weight of the helicopter, in t.

1 Application

1.1 General

1.1.1 The requirements of this Section apply to areas equipped for the landing and take-off of helicopters with wheels or helicopters with landing skids, and located on a deck or on a platform permanently connected to the hull structure.

1.1.2 Helicopter deck or platform intended for the landing of helicopters having landing devices other than wheels or skids are to be examined by the Society on a case by case basis.

2 Definition

2.1 Landing gear

2.1.1 A landing gear may consist of a single wheel or a group of wheels.

3 General arrangement

3.1 Landing area and approach sector

3.1.1 The main dimensions of the landing area, its location on board, the approach sector for landing and take-off are to comply with the applicable requirements from National or other Authorities.

3.1.2 The landing area and the approach sector are to be free of obstructions above the level of the helicopter deck or platform.

Note 1: The following items may exceed the height of the landing area, but not more than 100 mm:

- guttering or slightly raised kerb
- lightning equipment
- outboard edge of the safety net
- foam monitors
- those handrails and other items associated with the landing area which are incapable of complete retraction or lowering for helicopter operations.

3.2 Sheathing of the landing area

3.2.1 Within the landing area, a non-skid deck covering is recommended.

Where the helicopter deck or platform is wood sheathed, special attention is to be paid to the fire protection.

3.3 Safety net

3.3.1 It is recommended to provide a safety net at the sides of the helicopter deck or platform.

3.4 Drainage system

3.4.1 Gutterways of adequate height and a drainage system are recommended on the periphery of the helicopter deck or platform.

4 Design principle

4.1 General

4.1.1 Local deck strengthening is to be fitted at the connection of diagonals and pillars supporting platform.

4.2 Partial safety factors

4.2.1 The partial safety factors to be considered for the checking of helicopter decks and platforms structures are specified in Tab 1.

Table 1 : Helicopter decks and platforms Partial safety factors γ_{S2} and γ_{W2}

Uncertainties regarding:	Symbol	Plating	Ordinary stiffeners	Primary supporting members
Still water pressure	γ_{S2}	1,00	1,00	1,00
Wave pressure	γ_{W2}	1,20	1,20	1,10

Table 2 : Helicopter platforms - Still water and inertial forces

Vessel condition	Still water force F_S and inertial force F_W, in kN	
Still water condition	$F_S = (W_H + W_P)\ g$	
Upright condition	$F_{W,\ X} = (W_H + W_P)\ a_{X1} + 1,2\ A_{HX}$ $F_{W,\ Z} = (W_H + W_P)\ a_{Z1}$	in x direction in z direction
Inclined condition (negative roll angle) **(1)**	$F_{W,\ Y} = 0,7\ (W_H + W_P)\ a_{Y2} + 1,2\ A_{HY}$ $F_{W,\ Z} = 0,7\ (W_H + W_P)\ a_{Z2}$	in y direction in z direction

(1) Inclined condition is not applicable for vessels less than 40 m in length.

Note 1:

- W_p : Structural weight of the helicopter platform, in t, to be evenly distributed, and to be taken not less than the value obtained from the following formula:
  $W_p = 0,2\ A_H$
- A_H : Area, in m², of the entire landing area
- a_{X1} , a_{Z1} : Accelerations, in m/s², determined at the helicopter centre of gravity for the upright vessel condition, and defined in Ch 3, Sec 3, [2.3]
- a_{Y2} , a_{Z2} : Accelerations, in m/s², determined at the helicopter centre of gravity for the inclined vessel condition, and defined in Ch 3, Sec 3, [2.3]
- A_{HX} , A_{HY} : Vertical areas, in m², of the helicopter platform in x and y directions respectively. Unless otherwise specified, A_{HX} and A_{HY} may be taken equal to $A_H / 3$.

5 Design loads

5.1 Emergency landing load

5.1.1 The emergency landing force F_{EL} resulting from the crash of the helicopter, and transmitted trough one wheel or a group of wheels or one skid to the helicopter deck or platform, is to be obtained, in kN, from the following formula:

$F_{EL} = 1,25g\ W_H$

The point of application of the force F_{EL} is to be taken so as to produce the most severe stresses on the supporting structure.

5.2 Garage load

5.2.1 Where a garage zone is fitted in addition to the landing area, the still water and inertial forces transmitted trough each landing gear or each landing skid to the helicopter deck or platform are to be obtained, in kN, as specified in Ch 3, Sec 4, [3.5], where M is to be taken equal to:

- for helicopter with landing gears:

  M is the landing gear load, in t, to be specified by the Designer. If the landing gear load is not known, M is to be taken equal to:

  $$M = \frac{1,25}{n} W_H$$

  where n is the total number of landing gears

- for helicopter with landing skids:

  $M = 0,5\ W_H$

5.3 Specific loads for helicopter platforms

5.3.1 The still water and inertial forces applied to an helicopter platform are to be determined, in kN, as specified in Tab 2.

6 Scantlings for steel and aluminium deck and platform structure

6.1 General

6.1.1 The scantlings of the structure of an helicopter deck or platform are to be obtained according to [6.2], [6.3] and [6.4]. They are to be considered in addition to scantlings obtained from other applicable loads, in particular from river pressures.

6.1.2 As specified in Ch 2, Sec 5, all scantlings referred to in this section are net, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Ch 2, Sec 5.

6.2 Plating

6.2.1 Load model

The following forces P_0 are to be considered independently:

- $P_0 = F_L$

  where F_L is the force corresponding to the landing load, as defined in [4.1]

- $P_0 = \gamma_{S2}\ F_S + \gamma_{W2}\ F_{W,\ Z}$

  where F_S and $F_{W,\ Z}$ are the forces corresponding to the garage load, as defined in [5.2], if applicable.

6.2.2 Net thickness of plating

The net thickness of an helicopter deck or platform subjected to forces defined in [6.2.1] is not to be less than the value obtained according to Pt D, Ch 1, Sec 5, [4.3.1], with

A_T : Tyre or skid print area, in m².

For helicopter with skids in emergency landing case, only the extremity of skid of 0,3 m x 0,01 m is to be considered.

For other cases, where the print area A_T is not specified by the Designer, the following values are to be taken into account:

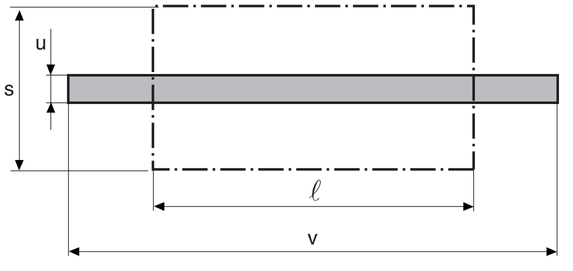
- for one tyre: 0,3 m x 0,3 m
- for one skid: 1 m x 0,01 m

λ : Coefficient defined in Pt D, Ch 1, Sec 5, [4.3.1] and taken equal to 1 in the particular case of a platform.

6.2.3 Helicopter with skids

For helicopters with skids, in the particular case where $v > \ell$, the skid print outside of the plate panel is to be disregarded. In such a case, the load is to be considered as being fully distributed on the span ℓ only (see Fig 1).

Figure 1 : Skid print with v > ℓ



6.3 Ordinary stiffeners

6.3.1 Load model

The following forces P_0 are to be considered independently:

- $P_0 = F_{EL}$

  where F_{El} is the force corresponding to the emergency landing load, as defined in [5.1]
- $P_0 = \gamma_{S2}\ F_S + \gamma_{W2}\ F_{W,\ Z}$

  where F_S and $F_{W,\ Z}$ are the forces corresponding to the garage load, as defined in [5.2], if applicable
- $P_0 = \gamma_{S2}\ F_S + \gamma_{W2}\ F_{W,\ Z}$

  for an helicopter platform, where F_S and $F_{W,\ Z}$ are the forces defined in [5.3].

6.3.2 Normal and shear stresses

The normal stress σ and the shear stress τ induced by forces defined in [6.3.1] in an ordinary stiffener of an helicopter deck or platform are to be obtained, in N/mm², according to:

$$\sigma = \frac{P_0 \ell}{mW} 10^3 + \sigma_{X1,\ Wh}$$

$$\tau = \frac{10 P_0}{A_{Sh}}$$

where:

m : Coefficient to be taken equal to:

- m = 6 in the case of an helicopter with wheels
- m = 10 in the case of an helicopter with landing skids.

In addition, in both cases of helicopter with wheels and helicopter with landing skids, the hull girder stresses $\sigma_{X1,\ Wh}$ are to be taken equal to 0 in the particular case of an helicopter platform.

6.3.3 Checking criteria

It is to be checked that the normal stress σ and the shear stress τ calculated according to [6.3.2], are in compliance with the following formulae:

$$\frac{R_Y}{\gamma_R \gamma_m} \geq \sigma$$

$$0{,}5 \frac{R_Y}{\gamma_R \gamma_m} \geq \tau$$

where:

γ_m : Partial safety factor covering uncertainties on the material, to be taken equal to 1,02

γ_R : Partial safety factor covering uncertainties on the resistance:

- for landing area located above accommodation spaces:

  $\gamma_R = 1{,}30$
- for landing area located outside a zone covering accommodation spaces:

  $\gamma_R = 1{,}05$
- for emergency condition:

  $\gamma_R = 1{,}00$

6.4 Primary supporting members

6.4.1 Load model

The following loads are to be considered independently:

- emergency landing load, as defined in [5.1]
- garage load, as defined in [5.2], if applicable
- specific loads as defined in [5.3], for an helicopter platform.

The most unfavorable case, i.e. where the maximum number of landing gears is located on the same primary supporting members, is to be considered.

6.4.2 Normal and shear stresses

In both cases of helicopter with wheels and helicopter with landing skids, the normal stress σ and the shear stress τ induced by loads defined in [6.4.1] in a primary supporting member of an helicopter deck or platform are to be obtained as follows:

- for analyses based on finite element models:

  $\sigma = \max(\sigma_1, \sigma_2)$ and $\tau = \tau_{12}$

  where σ_1, σ_2 and τ_{12} are to be obtained according to Ch 2, App 2, [5.2]
- for analyses based on beam models:

  $\sigma = \sigma_1$ and $\tau = \tau_{12}$

  where σ_1 and τ_{12} are to be obtained according to Ch 2, App 2, [5.3].

In addition, the hull girder stresses are to be taken equal to 0 in the particular case of an helicopter platform.

6.4.3 Checking criteria

It is to be checked that the normal stress σ and the shear stress τ calculated according to [6.4.2] are in compliance with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0,5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

where:

γ_m : Partial safety factor covering uncertainties on the material to be taken equal to 1,02

γ_R : Partial safety factor covering uncertainties on the resistance, to be taken equal to:

- for garage load: γ_R = 1,02
- for emergency landing load.: γ_R = 1,00

7 Scantlings for composite deck structure

7.1 Bending moments and transverse shear forces calculation for deck panel

7.1.1 Bending moments and transverse shear forces in deck panels are to be calculated taking into account the forces defined in [6.2] by direct calculation.

The panel analysis is to be carried out by a "ply by ply" analysis of the laminate taking into account the maximum stress criteria combined stress in each layer criteria as defined in NR546 Composite Ships, Sec 6 [5.1.2].

7.2 Bending moment and shear forces calculation for secondary stiffeners

7.2.1 The bending moment M, in KN.m, and the shear force T, in KN, induced by forces defined in [6.3.1] in an ordinary stiffener of an helicopter deck are obtained, in N/mm^2, as follows:

$$M = \frac{P_0 l}{m}$$

$$T = P_0$$

where:

m : Coefficient to be taken equal to:

- for an helicopter with wheels:

  m = 6
- for an helicopter with landing skids:

  m = 10

The strains and stresses induced by the bending moment and shear force in the secondary stiffener are to be calculated as defined in NR546 Composite Ships, Sec 7 [3.1].

7.3 Primary supporting members

7.3.1 The primary structure check is to be carried out by direct calculation as defined in [6.4.1].

The strains and stresses induced by the bending moment and shear force in the primary supporting members are to be calculated as defined in NR546 Composite Ships, Sec 7 [3.1].

7.4 Checking criteria

7.4.1 The structure check is to be carried out as defined in NR546 Composite Ships for deck panels and stiffeners, taking into account the safety factors defined for local loads in Ch 2, Sec 6, [4.2].

Part B
Hull Design and Construction

Chapter 7
HULL OUTFITTING

SECTION 1 RUDDERS

SECTION 2 BULWARKS AND GUARD RAILS

SECTION 3 PROPELLER SHAFT BRACKETS

SECTION 4 EQUIPMENT

SECTION 5 LIFTING APPLIANCES - HULL CONNECTIONS

SECTION 6 VESSEL COUPLING

SECTION 1 RUDDERS

Symbols

A : Total area of the rudder blade, in m², bounded by the blade external contour, including the mainpiece and the part forward of the centreline of the rudder pintles, if any

C_R : Rudder force, in N, acting on the rudder blade, defined in [2.1.2]

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

k_1 : Material factor, defined in [1.4.1]
- [1.4.1] for steel
- [1.4.2] for aluminium alloys

M_B : Bending moment, in N.m, in the rudder stock, defined in [5.1]

M_{TR} : Rudder torque, in N.m, acting on the rudder blade, defined in [2.1.3]

n : Navigation coefficient defined in Ch 3, Sec 1, [5.2]

R_{eH} :
- for hull steel:

  R_{eH} is the nominal yield point, in N/mm²
- for aluminium alloys:

  R_{eH} is 0,2% proof stress, $R_{P0,2}$, in N/mm²

T : Scantling draught, in m, defined in Ch 1, Sec 2, [2.4]

V_{AD} : Maximum astern speed, in km/h, to be taken not less than 0,5 V_{AV}

V_{AV} : Maximum ahead service speed, in km/h, at maximum draught, T; this value is not to be taken less than 8.

1 General

1.1 Application

1.1.1 Ordinary profile rudders

The requirements of this Section apply to ordinary profile rudders, without any special arrangement for increasing the rudder force, whose maximum orientation at maximum vessel speed is limited to 35° on each side.

In general, an orientation greater than 35° is accepted for manoeuvres or navigation at very low speed.

1.1.2 High efficiency rudders

The requirements of this Section also apply to rudders fitted with flaps to increase rudder efficiency. For these rudder types, an orientation at maximum speed greater than 35° may be accepted. In these cases, the rudder forces are to be calculated by the Designer for the most severe combinations between orientation angle and vessel speed. These calculations are to be considered by the Society on a case-by-case basis.

The rudder scantlings are to be designed so as to be able to sustain possible failures of the orientation control system, or, alternatively, redundancy of the system itself may be required.

1.1.3 Steering nozzles

The requirements for steering nozzles are given in [8].

1.1.4 Special rudder types

Rudders others than those in [1.1.1], [1.1.2] and [1.1.3] will be considered by the Society on a case-by- case basis.

1.2 Gross scantlings

1.2.1 With reference to Ch 2, Sec 5, [2], all scantlings and dimensions referred to in this section are gross, i.e. they include the margins for corrosion.

1.3 Arrangements

1.3.1 Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by means of a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

1.3.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

In addition, structural rudder stops of suitable strength are to be provided, except where the steering gear is provided with its own rudder stopping devices, as detailed in Pt C, Ch 1, Sec 11, [5.6.1].

1.3.3 In rudder trunks which are open to the river/sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

1.4 Materials

1.4.1 Steel rudders

a) Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled steel, steel forgings or steel castings according to the applicable requirements of NR216 Materials and Welding, Chapter 2.

b) The material used for rudder stocks, pintles, keys and bolts is to have a specified minimum yield stress not less than 200 N/mm².

c) The requirements relevant to the determination of scantlings contained in this Section apply to steels having a specified minimum yield stress equal to 235 N/mm².

Where the material used for rudder stocks, pintles, coupling bolts, keys and cast parts of rudders has a specified yield stress different from 235 N/mm², the scantlings calculated with the formulae contained in the requirements of this Section are to be modified, as indicated, depending on the material factor k_1, to be obtained from the following formula:

where:

$$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$$

R_{eH} : Specified yield stress, in N/mm², of the steel used, and not exceeding the lower of 0,7 R_m and 450 N/mm²

R_m : Tensile strength, in N/mm², of the steel used

n_1 : Coefficient to be taken equal to:

- $n_1 = 0{,}75$ for $R_{eH} > 235$ N/mm²
- $n_1 = 1{,}00$ for $R_{eH} \le 235$ N/mm².

d) Significant reductions in rudder stock diameter due to the application of steels with specified yield stresses greater than 235 N/mm² may be accepted by the Society subject to the results of a check calculation of the rudder stock deformations (refer to [3.2.1]).

1.4.2 Aluminium alloy rudders

For rudder built in aluminium alloys, the material factor k_1 to be taken into account in the scantling formulae of rudder stocks, pintles, coupling bolts, keys and cast parts of rudders is to be taken equal to:

$$k_1 = \frac{235}{R_y}$$

where:

R_y : Minimum yield stress of aluminium, in N/mm², defined in Ch 2, Sec 3, [3.4].

1.4.3 Welded parts of rudders are to be made of approved rolled hull materials. For these members, the material factor k defined is to be used.

1.4.4 Rudders in composite materials

Rudders built in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 6, [4.2] where Rules safety factors are to be increased by a coefficient to be taken at least equal to 1,3.

2 Force and torque acting on the rudder

2.1 Rudder blade

2.1.1 Rudder blade description

A rudder blade may have trapezoidal or rectangular contour.

2.1.2 Rudder force

The rudder force C_R is to be obtained, in N, from the following formula:

$$C_R = 28{,}86\ (1 + 5{,}15\ y)^{0{,}15}\ A\ V^2\ r_1\ r_2\ r_3$$

where:

y : Coefficient to be taken as:

- Range of navigation **IN**:

  $y = 0{,}099$

- Range of navigation **IN(x ≤ 2)**:

  $y = n$

V : V_{AV}, or V_{AD}, depending on the condition under consideration (for high lift profiles see [1.1.2])

r_1 : Shape factor, to be taken equal to:

$$r_1 = \frac{\lambda + 2}{3}$$

λ : Coefficient, to be taken equal to:

$$\lambda = \frac{h^2}{A_T}$$

and not greater than 2

h : Mean height, in m, of the rudder area to be taken equal to (see Fig 1):

$$h = \frac{z_3 + z_4 - z_2}{2}$$

A_T : Area, in m², to be calculated by adding the rudder blade area A to the area of the rudder post or rudder horn, if any, up to the height h

r_2 : Coefficient to be obtained from Tab 1

r_3 : Coefficient to be taken equal to:

- $r_3 = 0{,}80$ for rudders outside the propeller jet (centre rudders on twin screw vessels, or similar cases)
- $r_3 = 1{,}15$ for rudders behind a fixed propeller nozzle
- $r_3 = 1{,}00$ in the other cases.

2.1.3 Rudder torque

The rudder torque M_{TR}, for both ahead and astern conditions, is to be obtained, in N.m, from the following formula:

$$M_{TR} = C_R\ r$$

where:

r : Lever of the force C_R, in m, equal to:

$$r = b\left(\alpha - \frac{A_F}{A}\right)$$

and to be taken not less than 0,1 b for the ahead condition

A_F : Area, in m², of the rudder blade portion in front of the centreline of rudder stock (see Fig 1).

b : Mean breadth, in m, of rudder area to be taken equal to (see Fig 1):

$$b = \frac{x_2 + x_3 - x_1}{2}$$

α : Coefficient to be taken equal to:
- $\alpha = 0{,}33$ for ahead condition
- $\alpha = 0{,}66$ for astern condition

Figure 1 : Geometry of rudder blade without cut-outs

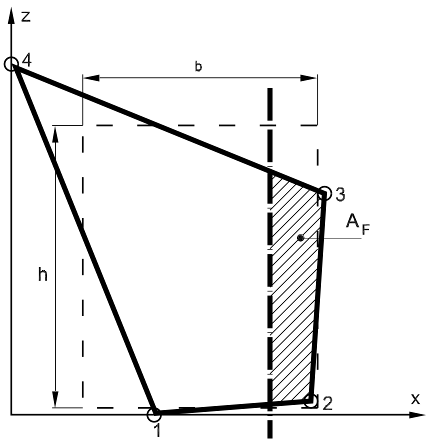
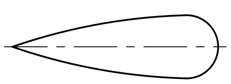
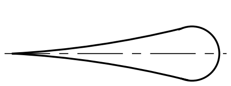
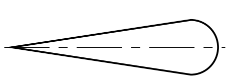
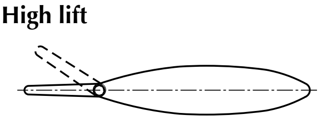
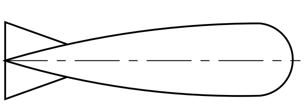
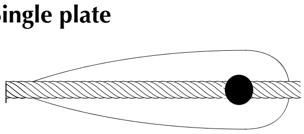


Table 1 : Values of coefficient r_2

Rudder profile type	r_2 for ahead condition	r_2 for astern condition
NACA 00 - Goettingen 	1,10	0,80
Hollow 	1,35	0,90
Flat side 	1,10	0,90
High lift 	1,70	1,30
Fish tail 	1,40	0,80
Single plate 	1,00	1,00

3 Rudder stock scantlings

3.1 Rudder stock diameter

3.1.1 Basic formulation

The scantling of the rudder stock diameter is based on the Von Mises equivalent stress criterion, written for a state of stress induced by a combined torque, M_{TR}, and a bending moment, M_B, acting on the rudder stock. The Von Mises equivalent stress, σ_E, calculated for this state of stress, has to be in compliance with the following formula:

$\sigma_E \leq \sigma_{E,ALL}$

where:

σ_E : Equivalent stress, in N/mm², to be obtained from the following formula:

$$\sigma_E = \sqrt{\sigma_B^2 + 3\tau_T^2}$$

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

$$\sigma_B = \frac{10{,}2 M_B}{d_S^3} \cdot 10^3$$

τ_T : Torsional stress, in N/mm², to be obtained from the following formula:

$$\tau_T = \frac{5{,}1 M_{TR}}{d_S^3} \cdot 10^3$$

d_S : Stock diameter, in mm

$\sigma_{E,ALL}$: Allowable equivalent stress, in N/mm², equal to:

$\sigma_{E,ALL} = 118 / k_1$

For this purpose, the rudder stock diameter is to be not less than the value obtained, in mm, from the following formula:

$$d_{TFi} = 4,2(M_{TR}\, k_1)^{1/3}\left[1 + \frac{4}{3}\left(\frac{M_{Bi}}{M_{TR}}\right)^2\right]^{1/6}$$

where M_{Bi} is to be obtained according to [5.1], for each type of rudder.

3.1.2 Rudder stock subjected to torque only

For rudder stocks subjected to torque only, the diameter is to be not less than the value obtained, in mm, from the following formula:

$d_T = 4{,}2\ (M_{TR}\ k_1)^{1/3}$

This is equivalent to check that the torsional shear stress τ_T, in N/mm², induced by the torque only, is in compliance with the following formula:

$\tau_T \leq \tau_{ALL}$

where:

τ_{ALL} : Allowable torsional shear stress, in N/mm²:

$\tau_{ALL} = 68 / k_1$

τ_T : Torsional stress, in N/mm², defined in [3.1.1].

Table 2 : Scantling of parts, rudder stock couplings and relevant loads

Item identification	Relevant loads
Rudder stock scantlings	• either torque only, or • both, torque and bending moment See [3]
Rudder stock couplings	• either torque only, or • both, torque and bending moment See [4]
Rudder stock bearings	Horizontal reaction forces, F_{Ai}, See [5.2]
Pintle bearings	Horizontal reaction forces, F_{Ai}, See [5.3]
Scantling of pintles	Horizontal reaction forces, F_{Ai}, See [5.4]
Rudder blade scantlings	Bending moment and shear force See [6]
Solepiece scantlings	Bending moment and shear force See [7]

3.1.3 Rule rudder stock diameter

The rudder stock diameter, at the lower part, is to be not less than the value obtained, in mm, from the following formula:

$$d_{TF} = 4,2(M_{TR}k_1)^{1/3}\left[1+\frac{4}{3}\left(\frac{M_B}{M_{TR}}\right)^2\right]^{1/6}$$

where:

M_B : Maximum absolute value of bending moment M_{Bi} over the rudder stock length, to be obtained according to [5.1].

If not otherwise specified, the notation d_1 used in this Section is equivalent to d_{TF}.

3.1.4 Rule rudder stock diameter in way of the tiller

In general, the diameter of a rudder stock subjected to torque and bending may be gradually tapered above the lower stock bearing so as to reach, from d_{TF} value, the value of d_T in way of the quadrant or the tiller.

3.2 Deformation criterion

3.2.1 Rudder stock slope in way of the bearings

Large rudder stock deformations are to be avoided in order to avoid excessive edge pressures in way of bearings.

The Society may require an additional check of the rudder stock diameter to make sure that the rudder stock slopes in way of bearings are acceptable, by relating them to bearing lengths (see [5.2.3]) and bearing clearances (see [5.2.4]).

4 Rudder stock couplings

4.1 Horizontal flange couplings

4.1.1 General

In general, the coupling flange and the rudder stock are to be forged from a solid piece. A shoulder radius as large as practicable is to be provided for between the rudder stock and the coupling flange. This radius is to be not less than 0,15 d_1, where d_1 is the rudder stock diameter defined in [3.1.3].

4.1.2 Welding

The coupling flange may be welded onto the stock provided that its thickness is increased by 10%, and that the weld extends through the full thickness of the coupling flange and that the assembly obtained is subjected to heat treatment. This heat treatment is not required if the diameter of the rudder stock is less than 75 mm.

Where the coupling flange is welded, the material used is to be of weldable quality. The welding conditions (preparation before welding, choice of electrodes, pre- and post-heating, inspection after welding) are to be defined to the satisfaction of the Society. The throat weld at the top of the flange is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius:

- is to be not less than $0,15d_1$, where d_1 is defined in [3.1.2]
- may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld
- is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

The inspection is to include full non destructive tests at weld location (dye penetrant or magnetic particle test and ultrasonic test).

4.1.3 Bolts

Horizontal flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained, in mm, from the following formula:

$$d_B = 0,62\sqrt{\frac{d_1^3 k_{1B}}{n_B e_M k_{1S}}}$$

where:

d_1 : Rudder stock diameter, in mm, defined in [3.1.3]

e_M : Mean distance, in mm, of the bolt axes from the centre of the bolt system

k_{1B} : Material factor k_1 for the material used for the bolts

k_{1S} : Material factor k_1 for the material used for the rudder stock

n_B : Total number of bolts, which is to be not less than 6.

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of (0,25 d_T x 0,10 d_T) mm² and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B.

4.1.4 Coupling flange

The thickness of the coupling flange is to be not less than the value obtained, in mm, from the following formulae, whichever is the greater:

- $t_P = d_B \sqrt{\frac{k_{1F}}{k_{1B}}}$
- $t_p = 0{,}9\ d_B$

where:

d_B : Bolt diameter, in mm, calculated in accordance with [4.1.3], where the number of bolts n_B is to be taken not greater than 8

k_{1B} : Material factor k_1 for the material used for the bolts

k_{1F} : Material factor k_1 for the material used for the flange.

4.1.5 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

4.2 Couplings between rudder stocks and tillers

4.2.1 Application

The requirements of this sub-Article apply in addition to those specified in Pt C, Ch 1, Sec 11.

The requirements specified in [4.2.3] and [4.2.4] apply to solid rudder stocks in steel and to tiller bosses, either in steel or in SG iron, with constant external diameter. Solid rudder stocks other than those above will be considered by the Society on a case-by-case basis, provided that the relevant calculations, to be based on the following criteria, are submitted to the Society:

- Young's modulus:
  - $E = 2{,}06.10^5$ N/mm² for steel
  - $E = 1{,}67.10^5$ N/mm² for SG iron
- Poisson's ratio:
  - $\nu = 0{,}30$ for steel
  - $\nu = 0{,}28$ for SG iron
- Frictional coefficient:
  - $\mu = 0{,}15$ for contact steel/steel
  - $\mu = 0{,}13$ for contact steel/SG iron
- Torque C_T transmissible through friction: $C_T \geq \eta\ M_{TR}$

  where η is defined in [4.2.3]
- Combined stress in the boss:

  $$\sqrt{\sigma_R^{\,2} + \sigma_T^{\,2} - \sigma_R \sigma_T} \leq (0{,}5 + 0{,}2\ \eta) R_{eH}$$

  where:

  σ_R , σ_T : Algebraic values of, respectively, the radial compression stress and the tangent tensile stress, in N/mm², induced by the grip pressure and calculated at the bore surface ($\sigma_R = p_F$, where p_F is the grip pressure in the considered horizontal cross-section of the boss)

- Where the rudder stock is hollow, the following strength criterion is to be complied with, at any point of the rudder stock cross-section:

  $$\sqrt{\sigma_R^{\,2} + \sigma_T^{\,2} - \sigma_R \sigma_T + 3\tau^2} \leq 0{,}7\ R_{eH}$$

  where:

  σ_R , σ_T : Algebraic values of, respectively, the radial and the tangent compressive stresses, in N/mm², induced by the grip pressure

  τ : Shear stress, in N/mm², induced by the torque M_{TR} .

4.2.2 General

The entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

The right fit of the tapered bearing is to be checked before final fit up, to ascertain that the actual bearing is evenly distributed and at least equal to 80% of the theoretical bearing area; push-up length is measured from the relative positioning of the two parts corresponding to this case.

The required push-up length is to be checked after releasing of hydraulic pressures applied in the hydraulic nut and in the assembly.

4.2.3 Push up length of cone couplings with hydraulic arrangements for assembling and disassembling the coupling

It is to be checked that the push up length Δ_E of the rudder stock tapered part into the tiller boss is in compliance with the following formula:

$\Delta_0 \leq \Delta_E \leq \Delta_1$

where:

$$\Delta_0 = 6{,}2 \frac{M_{TR} \eta \gamma}{c d_M t_i \mu_A \beta} 10^{-3}$$

$$\Delta_1 = \frac{2\eta + 5}{1{,}8} \frac{\gamma d_0 R_{eH}}{c} 10^{-6}$$

η : Coefficient to be taken equal to:
- $\eta = 1$ for keyed connections
- $\eta = 2$ for keyless connections

c : Taper of conical coupling measured on diameter, to be obtained from the following formula:

$c = (d_U - d_0) / \ell_C$

t_i, ℓ_C, d_U, d_0: Geometrical parameters of the coupling, defined in Fig 2

β : Coefficient to be taken equal to:

$$\beta = 1 - \left(\frac{d_M}{d_E}\right)^2$$

d_M : Mean diameter, in mm, of the conical bore, to be obtained from the following formula:

$d_M = d_U - 0{,}5\ c\ \ell_C$

d_E : External boss diameter, in mm

μ_A : Coefficient to be taken equal to:

$$\mu_A = \sqrt{\mu^2 - 0{,}25 c^2}$$

μ, γ : Coefficients to be taken equal to:

- for rudder stocks and bosses made of steel:

  $\mu = 0,15$

  $\gamma = 1,0$

- for rudder stocks made of steel and bosses made of SG iron:

  $\mu = 0,13$

  $\gamma = 1,24 - 0,1\ \beta$

4.2.4 Boss of cone couplings with hydraulic arrangements for assembling and disassembling the coupling

The scantlings of the boss are to comply with the following formula:

$$\frac{1,8}{2\eta + 5}\frac{\Delta_E c}{\gamma d_0}10^6 \le R_{eH}$$

where:

Δ_E : Push-up length adopted, in mm

c, η, γ : Defined in [4.2.3]

d_0 : Defined in Fig 2.

4.2.5 Cylindrical couplings by shrink fit

It is to be checked that the diametral shrinkage allowance δ_E is in compliance with the following formula:

$$\delta_0 \le \delta_E \le \delta_1$$

where:

$$\delta_0 = 6,2\frac{M_{TR}\eta\gamma}{d_U t_i \mu \beta_1}10^{-3}$$

$$\delta_1 = \frac{2\eta + 5}{1,8}\gamma d_U R_{eH} 10^{-6}$$

η, μ, γ : Defined in [4.2.3]

d_U : Defined in Fig 2

β_1 : Coefficient to be taken equal to:

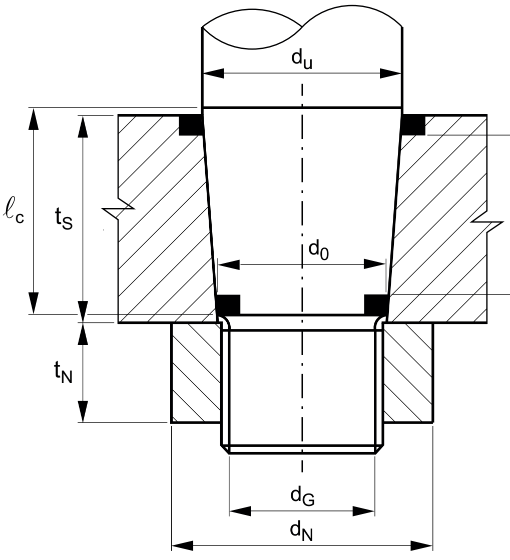
$$\beta_1 = 1 - \left(\frac{d_U}{d_E}\right)^2$$

4.2.6 Keyless couplings through special devices

The use of special devices for frictional connections, such as expansible rings, may be accepted by the Society on a case-by-case basis provided that the following conditions are complied with:

- evidence that the device is efficient (theoretical calculations and results of experimental tests, references of behaviour during service, etc.) are to be submitted to the Society
- the torque transmissible by friction is to be not less than 2 M_{TR}
- design conditions are to comply with [4.2.1]
- instructions provided by the manufacturer are to be complied with, notably concerning the pre-stressing of the tightening screws.

Figure 2 : Geometry of cone coupling



4.3 Cone couplings between rudder stocks and rudder blades

4.3.1 Taper on diameter

The taper on diameter of the cone couplings is to be in compliance with the following formulae:

- for cone couplings without hydraulic arrangements for assembling and disassembling the coupling:

$$\frac{1}{12} \le \frac{d_U - d_0}{l_C} \le \frac{1}{8}$$

- for cone couplings with hydraulic arrangements for assembling and disassembling the coupling (assembling with oil injection and hydraulic nut):

$$\frac{1}{20} \le \frac{d_U - d_0}{l_C} \le \frac{1}{12}$$

where:

d_U, ℓ_C, d_0,: Geometrical parameters of the coupling, defined in Fig 2.

4.3.2 Push-up pressure of cone coupling with hydraulic arrangements for assembling and disassembling the coupling

The push-up pressure, in N/mm², is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2Q_F}{d_M^2 t_i \pi \mu_0}10^3$$

$$p_{req2} = \frac{6M_{Bc}}{t_i^2 d_M}10^3$$

where:

Q_F : Design yield moment of rudder stock, in N.m, defined in [4.3.6]

d_M : Mean diameter, in mm, of the conical bore defined in [4.2.3]

t_i : Geometrical parameter of the coupling defined in Fig 2

μ_0 : Frictional coefficient, taken equal to 0,15, for contact steel/steel

M_{Bc} : Bending moment at mid-height of the cone coupling, in N.m, to be deduced from the calculation of the bending moment in the rudder stock, M_B, as defined in [5.1].

It has to be demonstrated by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, in N/mm², is to be determined by the following formula:

$$p_{perm} = \frac{0.95 R_{eH}(1-\alpha^2)}{\sqrt{3+\alpha^4}} - p_b$$

where:

p_b : Pressure due to rudder bending, to be taken as follows:

$$p_b = \frac{3.5 M_{Bc}}{t_i^2 d_M} 10^3$$

R_{eH} : Minimum yield stress for the steel used for the gudgeon

α : d_M/d_E

d_E : Minimum outer dimension (diameter or width) of the solid part in way of any horizontal cross section.

The outer diameter of the gudgeon is to be not less than 1,25 d_U, with d_U the rudder stock diameter, in mm, as defined in Fig 2.

4.3.3 Push up length of cone coupling with hydraulic arrangements for assembling and disassembling the coupling

It is to be checked that the push-up length Δ_E, in mm, of the rudder stock tapered part into the boss is in compliance with the following formula:

$$\Delta_0 \le \Delta_E \le \Delta_1$$

where:

$$\Delta_0 = \frac{p_{req} d_M}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8 R_{tm}}{c}$$

$$\Delta_1 = \frac{p_{perm} d_M}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8 R_{tm}}{c}$$

R_{tm} : Mean roughness, in mm, taken equal to 0,01

c : Taper on conical coupling defined in [4.2.3].

Note 1: In case of hydraulic pressure connections, the required push-up force P_e, in N, may be determined by the following formula:

$$P_e = p_{req} d_M \pi t_i \left(\frac{c}{2} + 0,02\right)$$

4.3.4 Lower rudder stock end

The lower rudder stock end is to be fitted with a threaded part having a core diameter, d_G, in mm, not less than (see Fig 2):

d_G = 0,65 d_U

where:

d_U : Rudder stock diameter, in mm, as defined in Fig 2.

This threaded part is to be fitted with an adequate slogging nut efficiently locked in rotation.

The contact length t_i, in mm, of the rudder stock coupling cone inserted in the massive part (see Fig 2), deduction made of the chamfers and sealing ring grooves (oil grooves may be disregarded), is to be such that:

$$t_i \ge 1,5 d_U \sqrt{k_1}$$

where:

k_1 : Material factor of the massive part.

When the foreseen contact surface ratio between the rudder stock and the massive part is greater than 70%, a lower t_i/d_U ratio may be accepted, on a case-by-case basis, provided that the contact percentage is proportionally higher, without however being taken less than 1,2.

The dimensions of the slogging nut are recommended to be as follows (see Fig 2):

- outer diameter: $d_N \ge$ Max (1,2 d_0 ; 1,5 d_G)
- thickness: $t_N \ge$ 0,60 d_G

where:

d_0 : As defined in Fig 2.

These dimensions and the core diameter d_G of the lower rudder stock end are given for guidance only, the determination of the adequate scantlings being left to the Designer.

4.3.5 Washer

For cone couplings with hydraulic arrangements for assembling and disassembling the coupling, a washer is to be fitted between the nut and the rudder gudgeon, having a thickness not less than 0,09 d_G and an outer diameter not less than 1,3 d_0 or 1,6 d_G, whichever is the greater.

The washer is not needed if the seat surface of the nut is flat and, at least, identical to the contact surface calculated for a washer with the required diameter.

4.3.6 Couplings with key

For cone couplings without hydraulic arrangements for assembling and disassembling the coupling, a key is to be fitted and keyways in both the tapered part and the rudder gudgeon.

The key is to be machined and located on the fore or aft part of the rudder. The key is to be inserted at half-thickness into stock and into the solid part of the rudder.

The key shear area a_S, in cm², is to be not less than:

$$a_S = \frac{17,55 Q_F}{d_k R_{eH1}}$$

where:

Q_F : Design yield moment of rudder stock, in N.m, obtained from the following formula:

$$Q_F = 0,02664 \frac{d_1^3}{k_{1S}}$$

Where the actual stock diameter is greater than the calculated diameter d_1, the actual diameter is to be used, without being taken greater than 1,145 d_1.

d_1 : Rudder stock diameter, in mm, taken equal to d_T, as defined in [3.1.2]

k_{1S} : Material factor k_1 for the material used for the rudder stock

d_k : Mean diameter of the conical part of the rudder stock at the key, in mm

R_{eH1} : Specified minimum yield stress R_{eH} for the material used for key.

The effective surface area a_k, in cm², of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5 Q_F}{d_k R_{eH2}}$$

where:

R_{eH2} : Specified minimum yield stress R_{eH} of the key, stock or coupling material, whichever is less.

It is to be proved that 50% of the design yield moment Q_F is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure p_{req} and push-up length Δ_E according to [4.3.2] and [4.3.3] for a torsional moment Q'_F equal to 0,5 Q_F.

In the specific case where the key is considered to transmit the entire rudder torque to the couplings, the scantlings of the key, as well as the push-up force and push-up length, are to be at the discretion of the Society.

4.3.7 Instructions

All necessary instructions for hydraulic assembly and disassembly of the nut, including indication of the values of all relevant parameters, are to be available on board.

4.4 Vertical flange couplings

4.4.1 Vertical flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained, in mm, from the following formula:

$$d_B = \frac{0{,}81 d_1}{\sqrt{n_B}} \sqrt{\frac{k_{1B}}{k_{1S}}}$$

where:

d_1 : Rudder stock diameter, in mm, defined in [3.1.3]

k_{1S}, k_{1B} : Material factors, defined in [4.1.3]

n_B : Total number of bolts, which is to be not less than 8.

4.4.2 The first moment of area of the sectional area of bolts about the vertical axis through the centre of the coupling is to be not less than the value obtained, in cm³, from the following formula:

$M_S = 0{,}43\ d_1^3\ 10^{-3}$

where:

d_1 : Rudder stock diameter, in mm, defined in [3.1.3].

4.4.3 The thickness of the coupling flange, in mm, is to be not less than d_B, where d_B is defined in [4.4.1].

4.4.4 The distance, in mm, from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B, where d_B is defined in [4.4.1].

4.4.5 A suitable locking device is to be provided to prevent the accidental loosening of nuts.

4.5 Couplings by continuous rudder stock welded to the rudder blade

4.5.1 When the rudder stock extends through the upper plate of the rudder blade and is welded to it, the thickness of this plate in the vicinity of the rudder stock is to be not less than 0,20 d_1, where d_1 is defined in [3.1.3].

4.5.2 The welding of the upper plate of the rudder blade with the rudder stock is to be made with a full penetration weld and is to be subjected to non-destructive inspection through dye penetrant or magnetic particle test and ultrasonic test.

The throat weld at the top of the rudder upper plate is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius:

- is to be not less than 0,15 d_1, where d_1 is defined in [3.1.3]
- may not be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld
- is to be checked with a template for accuracy. Four profiles, at least, are to be checked. A report is to be submitted to the Surveyor.

5 Rudder stock and pintle bearings

5.1 Forces on rudder stock and pintle bearings

5.1.1 Support forces F_{Ai}, for i = 1, 2, 3 are to be obtained according to [5.1.2] and [5.1.3].

The spring constant Z_C for the support in the solepiece (see Fig 3) is to be obtained, in N/m, from the following formula:

$$Z_C = \frac{3 E J_{50}}{\ell_{50}^3} \cdot 10^{-8}$$

where:

ℓ_{50} : Length, in m, of the solepiece

J_{50} : Moment of inertia about the z axis, in cm⁴, of the solepiece.

E : Young's modulus, in N/m²

5.1.2 Rudder supported by solepiece

The rudder structure is to be calculated according to load, shear force and bending moment diagrams shown in Fig 3.

The force per unit length p_R acting on the rudder body is to be obtained, in N/m, from the following formula:

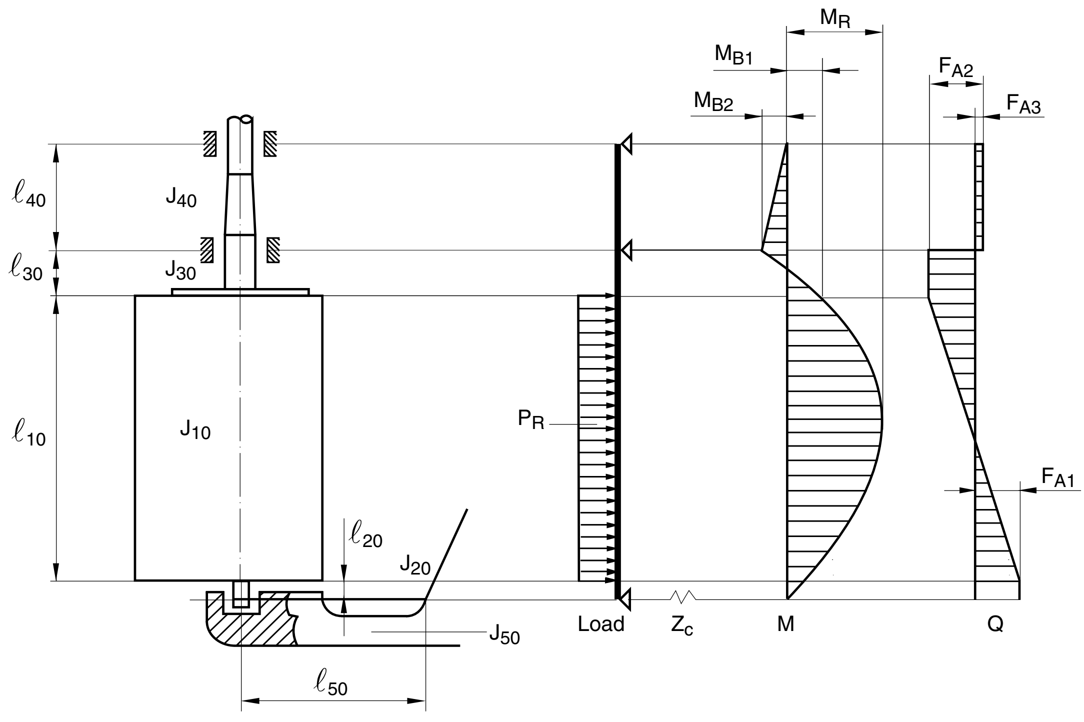
$$p_R = \frac{C_R}{\ell_{10}}$$

with:

ℓ_{10} : Height of the rudder blade, in m.

The spring constant Z_C is to be calculated according to [5.1.1].

Figure 3 : Rudder supported by solepiece



5.1.3 Spade rudder

The rudder structure is to be calculated according to load, shear force and bending moment diagrams shown in Fig 4.

The force per unit length p_R acting on the rudder body is to be obtained, in N/m, from the following formula (see also Fig 4):

$$p_{Rz} = p_{R1} + \left(\frac{p_{R2} - p_{R1}}{\ell_{10}}\right) z$$

where:

- z : Position of rudder blade section, in m, taken over ℓ_{10} length
- p_{Rz} : Force per unit length, in N/m, obtained at the z position
- p_{R1} : Force per unit length, in N/m, obtained for z equal to zero
- p_{R2} : Force per unit length, in N/m, obtained for z equal to ℓ_{10}.

For this type of rudder, the results of calculations performed according to diagrams shown in Fig 4 may also be obtained from the following formulae:

- maximum bending moment in the rudder stock, in N·m:

$$M_B = C_R\left[\ell_{20} + \frac{\ell_{10}(2C_1 + C_2)}{3(C_1 + C_2)}\right]$$

where C_1 and C_2 are the lengths, in m, defined in Fig 4

- support forces, in N:

$$F_{A3} = \frac{M_B}{\ell_{30}}$$

$$F_{A2} = C_R + F_{A3}$$

- maximum shear force in the rudder body, in N:

$$Q_R = C_R$$

5.2 Rudder stock bearing

5.2.1 The mean bearing pressure acting on the rudder stock bearing is to be in compliance with the following formula:

$$p_F \le p_{F,ALL}$$

where:

- p_F : Mean bearing pressure acting on the rudder stock bearings, in N/mm^2, equal to:

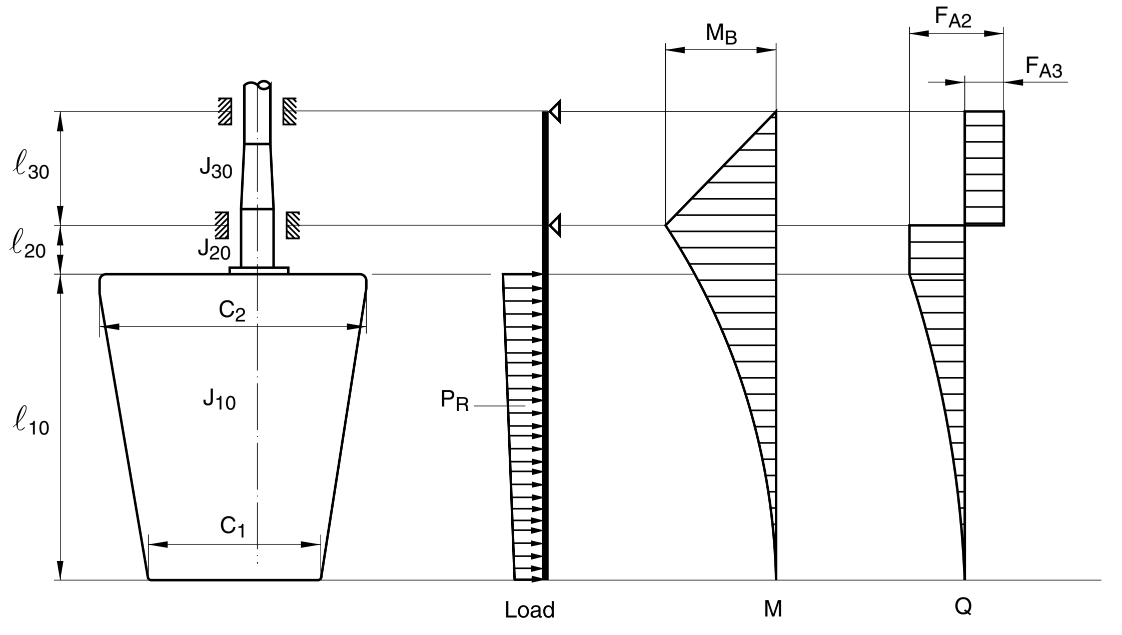
$$p_F = \frac{F_{Ai}}{d_m h_m}$$

- F_{Ai} : Force acting on the rudder stock bearing, in N, defined in Fig 3 and Fig 4
- d_m : Actual inner diameter, in mm, of the rudder Stock bearings (contact diameter)
- h_m : Bearing length, in mm (see [5.2.3])
- $p_{F,ALL}$: Allowable bearing pressure, in N/mm^2, defined inTab 3.

Values greater than those given in Tab 3 may be accepted by the Society on the basis of specific tests.

5.2.2 An adequate lubrication of the bearing surface is to be ensured.

Figure 4 : Spade rudder



5.2.3 The length / diameter ratio of the bearing surface is to be not greater than 1,2.

5.2.4 The manufacturing clearance t_0 on the diameter of metallic supports is to be not less than the value obtained, in mm, from the following formula:

$$t_0 = \frac{d_m}{1000} + 1$$

In the case of non-metallic supports, the clearances are to be carefully evaluated on the basis of the thermal and distortion properties of the materials employed.

In any case, for non-metallic supports, the clearance on support diameter is to be not less than 1,5 mm unless a smaller clearance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

5.2.5 Liners and bushes are to be fitted in way of the bearings. Their minimum thickness is to be equal to:

- 8 mm for metallic and synthetic materials
- 22 mm for lignum vitae material.

5.3 Pintle bearings

5.3.1 The mean bearing pressure acting on the gudgeons is to be in compliance with the following formula:

$p_F \le p_{F,ALL}$

where:

p_F : Mean bearing pressure acting on the gudgeons, in N/mm², equal to:

$$p_F = \frac{F_{Ai}}{d_{AC} h_L}$$

F_{Ai} : Force acting on the pintle, in N, calculated as specified in [5.1]

d_{AC} : Actual diameter, in mm, of the rudder pintles (contact diameter)

h_L : Bearing length, in mm (see [5.3.3])

$p_{F,ALL}$: Allowable bearing pressure, in N/mm², defined in Tab 3.

Values greater than those given in Tab 3 may be accepted by the Society on the basis of specific tests.

5.3.2 An adequate lubrication of the bearing surface is to be ensured.

5.3.3 The length / diameter ratio of the bearing surface is not to be less than 1 and not to be greater than 1,2.

Table 3 : Allowable bearing pressure

Bearing material	$p_{F,All}$, in N/mm²
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness greater than 60 Shore D **(1)**	5,5
Steel, bronze and hot-pressed bronze-graphite materials **(2)**	7,0

(1) Indentation hardness test at 23°C and with 50% moisture to be performed according to a recognised standard. Type of synthetic bearing materials is to be approved by the Society.
(2) Stainless and wear-resistant steel in combination with stock liner approved by the Society.

5.3.4 The manufacturing tolerance t_0 on the diameter of metallic supports is to be not less than the value obtained, in mm, from the following formula:

$$t_0 = \frac{d_{AC}}{1000} + 1$$

In the case of non-metallic supports, the tolerances are to be carefully evaluated on the basis of the thermal and distortion properties of the materials employed.

In any case, for non-metallic supports, the tolerance on support diameter is to be not less than 1,5 mm.

5.3.5 The thickness of any liner or bush, in mm, is to be not less than the greater of:

- $0,01\sqrt{F_{Ai}}$
- the minimum thickness defined in [5.2.5].

5.4 Pintles

5.4.1 Rudder pintles are to have a diameter not less than the value obtained, in mm, from the following formula:

$$d_A = \left(\frac{0,21 V_{AV}}{0,54 V_{AV} + 3}\sqrt{F_{Ai}} + 30\right)\sqrt{k_1}$$

where:

d_A : corresponds to d_U value shown in Fig 2

F_{Ai} : Force, in N, acting on the pintle, calculated as specified in [5.1.1].

5.4.2 Provision is to be made for a suitable locking device to prevent the accidental loosening of pintles.

5.4.3 The pintles are to have a conical coupling, with a taper on diameter in compliance with [4.3.1].

The conical coupling is to be secured by a nut. The dimensions of the massive part and slogging nut are to be in accordance with the following formulae:

$d_E \geq d_M + 0,6\ d_A$

$t_N \geq 0,60\ d_G$

$d_N \geq \max\ (1,2\ d_0\ ;\ 1,5\ d_G)$

where:

d_A : Pintle diameter defined in [5.4.1]

d_E : External diameter, in mm, of the massive part of Fig 2, having the thickness t_S

d_M : Mean diameter, in mm, of the conical bore, as defined in [4.2.3]

t_S, d_G, t_N, d_N, d_0 : Geometrical parameters of the coupling, defined in Fig 2.

The above minimum dimensions of the locking nut are only given for guidance, the determination of adequate scantlings being left to the Designer.

5.4.4 The length of the pintle housing in the gudgeon, which corresponds to t_S in Fig 2, is to be not less than the value obtained, in mm, from the following formulae:

$$h_L = 0,35\sqrt{F_{Ai} k_1}$$

$h_L = d_A$

where:

F_{Ai} : Force, in N, acting on the pintle, calculated as specified in [5.1.1].

The thickness of pintle housing in the gudgeon, in mm, is to be not less than 0,25 d_A, where d_A is defined in [5.4.1].

5.4.5 The required push-up pressure for pintle bearings, in N/mm2, is to be determined by the following formula:

$$p_{req} = 0.4\frac{F_{Ai} d_A}{d_M^2 t_i}$$

where:

d_M : Mean diameter, in mm, of the conical bore defined in [4.2.3]

t_i : Geometrical parameter of the coupling defined in Fig 2.

The push-up length is to be calculated according to [4.3.3] using required push-up pressure and pintle bearing properties.

6 Rudder blade scantlings

6.1 General

6.1.1 Application

The requirements in [6.1] to [6.5] apply to streamlined rudders and, when applicable, to rudder blades of single plate rudders.

6.1.2 Rudder blade structure

The structure of the rudder blade is to be such that stresses are correctly transmitted to the rudder stock and pintles. To this end, horizontal and vertical web plates are to be provided.

Horizontal and vertical webs acting as main bending girders of the rudder blade are to be suitably reinforced.

6.1.3 Access openings

Streamlined rudders, including those filled with pitch, cork or foam, are to be fitted with plug-holes and the necessary devices to allow their mounting and dismounting.

Access openings to the pintles are to be provided. If necessary, the rudder blade plating is to be strengthened in way of these openings.

The corners of openings intended for the dismantling of pintle or stock nuts are to be rounded off with a radius as large as practicable.

Where the access to the rudder stock nut is closed with a welded plate, a full penetration weld is to be provided.

6.2 Rudder blade plating

6.2.1 Plate thickness

The thickness of each rudder blade plate panel is to be not less than the value obtained, in mm, from the following formula:

$$t_F = 5,5 s\beta\sqrt{k_0 k\left(T + 3,1 y + \frac{C_R 10^{-4}}{A}\right)} + t_C$$

where:

β : Coefficient equal to:

$$\beta = \sqrt{1,1 - 0,5\left(\frac{s}{b_L}\right)^2}$$

to be taken not greater than 1,0 if $b_L/s > 2,5$

with:

b_L : Length, in m, of the longer side of the plate panel

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

t_C : Corrosion addition:

- t_C = 1,5 mm for steel rudder
- t_C = 1 for aluminium alloy rudder

y : Coefficient to be taken as:

- y = 0,099 fof **IN**
- y = n for **IN(x ≤ 2)**

6.2.2 Thickness of the top and bottom plates of the rudder blade

The thickness of the top and bottom plates of the rudder blade is to be taken as the maximum of:

- the thickness t_F defined in [6.2.1], by considering the relevant values of s and b_L, for both the top and bottom plates
- 1,2 times the thicknesses obtained for the attached side platings around the top and bottom plates, respectively, calculated according to [6.2.1], by considering the relevant values of s and b_L

Where the rudder is connected to the rudder stock with a coupling flange, the thickness of the top plate which is welded in extension of the rudder flange is to be not less than 1,1 times the thickness calculated above.

6.2.3 Web spacing

The spacing between horizontal web plates is to be not greater than 1,20 m.

Vertical webs are to have spacing not greater than twice that of horizontal webs.

6.2.4 Web thickness

Web thickness is to be at least 70% of that required for rudder plating and in no case is it to be less than 8 mm, except for the upper and lower horizontal webs. The thickness of each of these webs is to be uniform and not less than that of the web panel having the greatest thickness t_F, as calculated in [6.2.1]. In any case it is not required that the thickness is increased by more than 20% in respect of normal webs.

When the design of the rudder does not incorporate a mainpiece, this is to be replaced by two vertical webs closely spaced, having thickness not less than that obtained from Tab 4.

6.2.5 Thickness of side plating and vertical web plates welded to solid part or to rudder flange

The thickness, in mm, of the vertical web plates welded to the solid part where the rudder stock is housed, or welded to the rudder flange, as well as the thickness of the rudder side plating under this solid part, or under the rudder coupling flange, is to be not less than the value obtained, in mm, from Tab 4.

6.2.6 Welding

The welded connections of blade plating to vertical and horizontal webs are to be in compliance with the applicable requirements of NR216 Materials and Welding.

Where the welds of the rudder blade are accessible only from outside of the rudder, slots on a flat bar welded to the webs are to be provided to support the weld root, to be cut on one side of the rudder only.

Slot-welding is to be limited as far as possible. Slot-welding is not to be used in areas with large in-plane stresses transverse to the slots.

When slot welding is applied, the length of the slots is to be at least 75 mm with a breadth of 2 times the rudder plate thickness t_F, in mm. The distance between ends of slots is not to be greater than 125 mm. The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

6.2.7 Rudder nose plate thickness

Rudder nose plates are to have a thickness not less than:

- 1,25 t_F, without exceeding 22 mm, for t_F < 22 mm
- t_F, for t_F ≥ 22 mm,

where t_F is defined in [6.2.1].

The rudder nose plate thickness may be increased on a case by case basis to be considered by the Society.

6.3 Connections of rudder blade structure with solid parts in forged or cast steel

6.3.1 General

Solid parts in forged or cast steel which ensure the housing of the rudder stock or of the pintle are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

Table 4 : Thickness of the vertical webs and rudder side plating welded to solid part or to rudder flange

Type of rudder	Thickness of vertical web plates, in mm		Thickness of rudder plating, in mm	
	Rudder blade without opening	At opening boundary	Rudder blade without opening	Area with opening
Rudder supported by sole piece	1,2 t_F	1,6 t_F	1,2 t_F	1,4 t_F
Spade rudders	1,4 t_F	2,0 t_F	1,3 t_F	1,6 t_F
Note 1: t_F : Defined in [6.2.1].				

6.3.2 Minimum section modulus of the connection with the rudder stock housing

The section modulus of the cross-section of the structure of the rudder blade which is connected with the solid part where the rudder stock is housed, which is made by vertical web plates and rudder plating, is to be not less than that obtained, in cm^3, from the following formula:

$$w_S = c_S d_1^3 \left(\frac{H_E - H_X}{H_E}\right)^2 \frac{k_0 k}{k_1} 10^{-4}$$

where:

c_S : Coefficient, to be taken equal to:
- $c_S = 1{,}0$ if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate
- $c_S = 1{,}5$ if there is an opening in the considered cross-section of the rudder

d_1 : Rudder stock diameter, in mm, defined in [3.1.3]

H_E : Vertical distance, in m, between the lower edge of the rudder blade and the upper edge of the solid part

H_X : Vertical distance, in m, between the considered cross-section and the upper edge of the solid part

k, k_1 : Material factors, for the rudder blade plating and the rudder stock, respectively.

6.3.3 Calculation of the actual section modulus of the connection with the rudder stock housing

The actual section modulus of the cross-section of the structure of the rudder blade which is connected with the solid part where the rudder stock is housed is to be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating to be considered for the calculation of this actual section modulus is to be not greater than that obtained, in m, from the following formula:

$$b = s_V + 2\frac{H_X}{m}$$

where:

s_V : Spacing, in m, between the two vertical webs (see Fig 5)

H_X : Distance defined in [6.3.2]

m : Coefficient to be taken, in general, equal to 3.

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate according to [6.1.3], they are to be deducted (see Fig 5).

6.3.4 Thickness of horizontal web plates

In the vicinity of the solid parts, the thickness of the horizontal web plates, as well as that of the rudder blade plating between these webs, is to be not less than the greater of the values obtained, in mm, from the following formulae:

$$t_H = 1{,}2\ t_F$$

$$t_H = 0{,}045\frac{d_S^2}{s_H}$$

where:

t_F : Thickness, in mm, defined in [6.2.1]

d_S : Diameter, in mm, to be taken equal to:
- d_1 for the solid part connected to the rudder stock
- d_A for the solid part connected to the pintle

d_1 : Rudder stock diameter, in mm, defined in [3.1.3]

d_A : Pintle diameter, in mm, defined in [5.4.1]

s_H : Spacing, in mm, between the two horizontal web plates.

Different thickness may be accepted when justified on the basis of direct calculations submitted to the Society for review.

6.3.5 Thickness of side plating and vertical web plates welded to the solid part

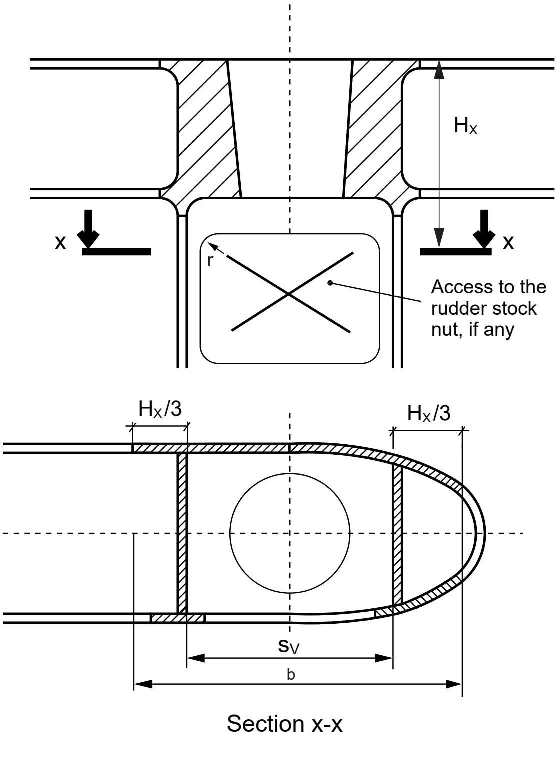
The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in mm, from Tab 4.

6.3.6 Solid part protrusions

The solid parts are to be provided with protrusions. Vertical and horizontal web plates of the rudder are to be butt welded to these protrusions.

These protrusions are not required when the web plate thickness is less than:
- 10 mm for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders
- 20 mm for the other web plates.

Figure 5 : Cross-section of the connection between rudder blade structure and rudder stock housing



6.4 Connection of the rudder blade with the rudder stock by means of horizontal flanges

6.4.1 Minimum section modulus of the connection

The section modulus of the cross-section of the structure of the rudder blade which is directly connected with the flange, which is made by vertical web plates and rudder blade plating, is to be not less than the value obtained, in cm³, from the following formula:

$$w_S = 1{,}3\ d_1^3\ 10^{-4}$$

where d_1 is the rudder stock diameter d_{TF}, in mm, to be calculated in compliance with the requirements in [3.1.3], taking k_1 equal to 1.

6.4.2 Actual section modulus of the connection

The section modulus of the cross-section of the structure of the rudder blade which is directly connected with the flange is to be calculated with respect to the symmetrical axis of the rudder.

For the calculation of this actual section modulus, the length of the rudder cross-section equal to the length of the rudder flange is to be considered.

Where the rudder plating is provided with an opening under the rudder flange, the actual section modulus of the rudder blade is to be calculated in compliance with [6.3.3].

6.4.3 Welding of the rudder blade structure to the rudder blade flange

The welds between the rudder blade structure and the rudder blade flange are to be full penetrated (or of equivalent strength) and are to be 100% inspected by means of non-destructive tests.

Where the full penetration welds of the rudder blade are accessible only from outside of the rudder, a backing flat bar is to be provided to support the weld root.

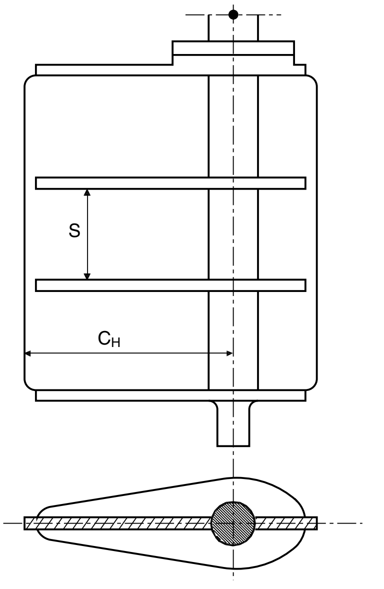
The external fillet welds between the rudder blade plating and the rudder flange are to be of concave shape and their throat thickness is to be at least equal to 0,5 times the rudder blade thickness.

Moreover, the rudder flange is to be checked before welding by non-destructive inspection for lamination and inclusion detection in order to reduce the risk of lamellar tearing.

6.4.4 Thickness of side plating and vertical web plates welded to the rudder flange

The thickness of the vertical web plates directly welded to the rudder flange as well as the plating thickness of the rudder blade upper strake in the area of the connection with the rudder flange is to be not less than the values obtained, in mm, from Tab 4.

Figure 6 : Single plate rudder



6.5 Single plate rudders

6.5.1 Mainpiece diameter

The mainpiece diameter is to be obtained from the formulae in [3.1.2] and [3.1.3].

In any case, the mainpiece diameter is to be not less than the stock diameter.

For spade rudders the lower third may taper down to 0,75 times the stock diameter.

6.5.2 Blade thickness

The blade thickness is to be not less than the value obtained, in mm, from the following formula:

$$t_B = 0{,}81\, s V_{AV} \sqrt{k_0 k} + t_C$$

where:

- s : Spacing of stiffening arms, in m, to be taken not greater than 1 m (see Fig 6).
- t_C : Corrosion addition
  - t_C = 2,5 mm for steel rudder
  - t_C = 1 for aluminium alloy rudder

6.5.3 Arms

The thickness of the arms is to be not less than the blade thickness.

The section modulus of the generic section is to be not less than the value obtained, in cm³, from the following formula:

$$Z_A = 0{,}15\ s\ C_H^2\ V_{AV}^2\ k_0 k$$

where:

- C_H : Horizontal distance, in m, from the aft edge of the rudder to the centreline of the rudder stock (see Fig 6)
- s : Defined in [6.5.2].

7 Solepiece scantlings

7.1 General

7.1.1 The weight of the rudder is normally supported by a carrier bearing inside the rudder trunk.

In the case of unbalanced rudders having more than one pintle, the weight of the rudder may be supported by a suitable disc fitted in the solepiece gudgeon.

Robust and effective structural rudder stops are to be fitted, except where adequate positive stopping arrangements are provided in the steering gear, in compliance with the requirements of Pt C, Ch 1, Sec 11.

7.2 Scantlings of steel and aluminium alloy solepieces

7.2.1 Bending moment

The bending moment acting on the generic section of the solepiece is to be obtained, in N·m, from the following formula:

$M_S = F_{A1} x$

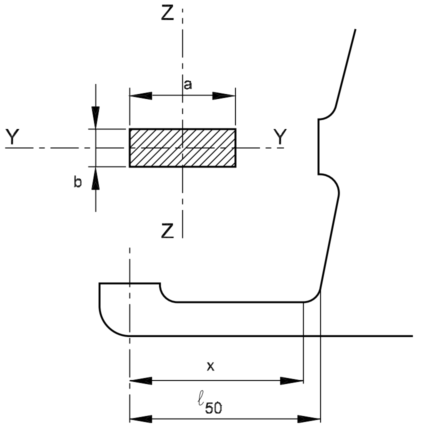
where:

F_{A1} : Supporting force, in N, in the pintle bearing, to be determined through a direct calculation; where such a direct calculation is not carried out, this force may be taken equal to:

$$F_{A1} = \frac{C_R}{2}$$

x : Distance, in m, defined in Fig 7.

Figure 7 : Solepiece geometry



7.2.2 Strength checks

For the generic section of the solepiece within the length l_{50}, defined in Fig 7, it is to be checked that:

$\sigma_B \leq \sigma_{B,ALL}$

$\tau \leq \tau_{ALL}$

where:

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

$$\sigma_B = \frac{M_S}{W_Z}$$

τ : Shear stress to be obtained, in N/mm², from the following formula:

$$\tau = \frac{F_{A1}}{A_S}$$

M_S : Bending moment at the section considered, in N·m, defined in [7.2.1]

F_{A1} : Force, in N, defined in [7.2.1]

W_Z : Section modulus, in cm³, around the vertical axis Z (see Fig 7)

A_S : Shear sectional area in Y direction, in mm²

$\sigma_{B,ALL}$: Allowable bending stress, in N/mm², equal to, depending on the solepiece material:

- For steel: $\sigma_{B,ALL} = 80 / k_1$ N/mm²
- For aluminium alloy: $\sigma_{B,ALL} = 35 / k_1$ N/mm²

τ_{ALL} : Allowable shear stress, in N/mm², equal to, depending on the solepiece material:

- For steel: $\tau_{ALL} = 48 / k_1$ N/mm²
- For aluminium alloy: $\tau_{ALL} = 20 / k_1$ N/mm²

Solepiece in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 6, [4] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1,9
- for the combined stress safety factor: 1,3

7.2.3 Minimum section modulus around the horizontal axis

The section modulus around the horizontal axis Y (see Fig 7) is to be not less than the value obtained, in cm³, from the following formula:

$W_Y = 0,5 W_Z$

where:

W_Z : Section modulus, in cm³, around the vertical axis Z (see Fig 7).

7.3 Scantlings of solepieces in composite materials

7.3.1 Solepieces in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 6, [4.2] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1,9
- for the combined stress safety factor: 1,3

8 Steering nozzles

8.1 General

8.1.1 The requirements of this Article apply to scantling steering nozzles for which the power transmitted to the propeller is less than the value obtained, in kW, from the following formula:

$$P = \frac{16900}{d_M}$$

where:

d_M : Inner diameter of the nozzle, in m.

Nozzles for which the power transmitted is greater than the value obtained from the above formula are considered on a case-by-case basis.

The following requirements may apply also to fixed nozzle scantlings.

8.1.2 Nozzles normally consist of a double skin cylindrical structure stiffened by ring webs and other longitudinal webs placed perpendicular to the nozzle.

At least two ring webs are to be fitted, one of which is to be placed in way of the axis of rotation of the nozzle.

For nozzles with an inner diameter d_M exceeding 3 m, the number of ring webs is to be suitably increased.

8.1.3 The section modulus W_N, in cm3, of the nozzle double skin profile (half nozzle cross section) around its neutral axis parallel to the center line, is not to be less than:

$W_N = 0{,}29 k_0 k n_N \, d^2 \, b \, V_{AV}^2$

where:

d : Inner diameter of nozzle, in m

b : Length of nozzle, in m

n_N : Coefficient taken equal to:

- 1,0 for steering nozzles
- 0,7 for fixed nozzles.

8.1.4 Care is to be taken in the manufacture of the nozzle to ensure the welded connection between plating and webs.

8.1.5 The internal part of the nozzle is to be adequately protected against corrosion.

8.2 Nozzle plating and internal diaphragms

8.2.1 The thickness of the inner plating of the nozzle is to be not less than the value obtained, in mm, from the following formula:

$t_F = (0{,}085\sqrt{P d_M} + 9{,}65)\sqrt{k_0 k}$

where:

P, d_M : Defined in [8.1.1].

The thickness t_F is to be extended to a length, across the transverse section containing the propeller blade tips, equal to one fourth of the total nozzle length.

Outside this length, the thickness of the inner plating is to be not less than (t_F – 7) mm and, in any case, not less than 7 mm.

8.2.2 The thickness of the outer plating of the nozzle is to be not less than (t_F – 9) mm, where t_F is defined in [8.2.1] and, in any case, not less than 7 mm.

8.2.3 The thicknesses of ring webs and longitudinal webs are to be not less than (t_F – 7) mm, where t_F is defined in [8.2.1], and, in any case, not less than 7 mm.

However, the thickness of the ring web, in way of the headbox and pintle support structure, is to be not less than t_F .

The Society may consider reduced thicknesses where an approved stainless steel is used, in relation to its type.

8.3 Nozzle stock

8.3.1 The diameter of the nozzle stock is to be not less than the value obtained, in mm, from the following formula:

$d_{NTF} = 6{,}42 \, (M_T \, k_1)^{1/3}$

where:

M_T : Torque, to be taken as the greater of those obtained, in N.m, from the following formulae:

- $M_{TAV} = 0{,}3 \, S_{AV} \, a$
- $M_{TAD} = S_{AD} \, b$

S_{AV} : Force, in N, equal to:

$S_{AV} = 43{,}7 \, V_{AV}^2 \, A_N$

S_{AD} : Force, in N, equal to:

$S_{AD} = 58{,}3 \, V_{AD}^2 \, A_N$

A_N : Area, in m², equal to:

$A_N = 1{,}35 \, A_{1N} + A_{2N}$

A_{1N} : Area, in m², equal to:

$A_{1N} = L_M \, d_M$

A_{2N} : Area, in m², equal to:

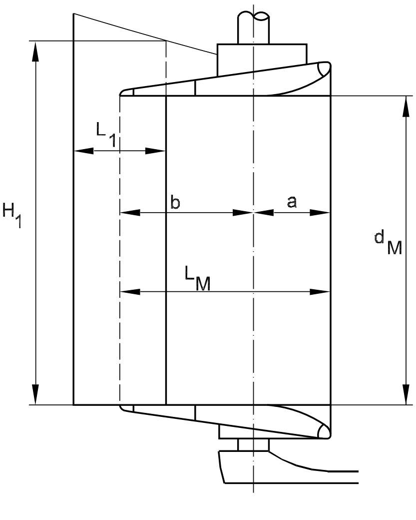
$A_{2N} = L_1 \, H_1$

a, b, L_M, d_M, L_1, H_1 : Geometrical parameters of the nozzle, in m, defined in Fig 8.

The diameter of the nozzle stock may be gradually tapered above the upper stock bearing so as to reach, in way of the tiller or quadrant, the value obtained, in mm, from the following formula:

$d_{NT} = 0{,}75 \, d_{NTF}$

Figure 8 : Geometrical parameters of the nozzle



8.4 Pintles

8.4.1 The diameter of the pintles is to be not less than the value obtained, in mm, from the following formula:

$$d_A = \left(\frac{0,19V_{AV}}{0,54V_{AV}+3}\sqrt{S_{AV}}+30\right)\sqrt{k_1}$$

where:

S_{AV} : Defined in [8.3.1].

8.4.2 The length/diameter ratio of the pintle is not to be less than 1,0 and not to be greater than 1,2.

Smaller values of h_A may be accepted provided that the pressure on the gudgeon bearing p_F is in compliance with the following formula:

$p_F \le p_{F,ALL}$

where:

p_F : Mean bearing pressure acting on the gudgeon, to be obtained in N/mm², from the following formula:

$$p_F = \frac{0,6S'}{d'_A h'_A}$$

S' : The greater of the values S_{AV} and S_{AD}, in N, defined in [8.3.1]

d'_A : Actual pintle diameter, in mm

h'_A : Actual bearing length of pintle, in mm

$p_{F,ALL}$: Allowable bearing pressure, in N/mm², defined in Tab 3.

8.5 Nozzle coupling

8.5.1 Diameter of coupling bolts

The diameter of the coupling bolts is to be not less than the value obtained, in mm, from the following formula:

$$d_B = 0,62\sqrt{\frac{d_{NTF}^3 k_{1B}}{n_B e_M k_{1S}}}$$

where:

d_{NTF} : Diameter of the nozzle stock, in mm, defined in [8.3.1]

k_{1S} : Material factor k_1 for the material used for the stock

k_{1B} : Material factor k_1 for the material used for the bolts

e_M : Mean distance, in mm, from the bolt axles to the longitudinal axis through the coupling centre (i.e. the centre of the bolt system)

n_B : Total number of bolts, which is to be not less than:

- 4 if $d_{NTF} \le 75$ mm
- 6 if $d_{NTF} > 75$ mm.

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of (0,25 d_{NT} x 0,10 d_{NT}) mm², where d_{NT} is defined in [8.3.1], and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 d_B.

8.5.2 Thickness of coupling flange

The thickness of the coupling flange is to be not less than the value obtained, in mm, from the following formula:

$$t_P = d_B\sqrt{\frac{k_{1F}}{k_{1B}}}$$

where:

d_B : Bolt diameter, in mm, defined in [8.5.1]

k_{1B}, : Material factor k_1 for the material used for the bolts

k_{1F} : Material factor k_1 for the material used for the coupling flange.

8.5.3 Push up length of cone couplings with hydraulic arrangements for assembling and disassembling the coupling

It is to be checked that the push up length Δ_E of the nozzle stock tapered part into the boss is in compliance with the following formula:

$\Delta_0 \le \Delta_E \le \Delta_1$

where:

Δ_0 : The greater of:

- $6,2\dfrac{M_{TR}\eta\gamma}{c d_M t_i \mu_A \beta}$
- $16\dfrac{M_{TR}\eta\gamma}{c t_i^2 \beta}\sqrt{\dfrac{d_{NTF}^6 - d_{NT}^6}{d_{NT}^6}}$

$$\Delta_1 = \frac{2\eta+5}{1,8}\,\frac{\gamma d_0 R_{eH}}{10^6 c(1+\rho_1)}$$

$$\rho_1 = \frac{80\sqrt{d_{NTF}^6 - d_{NT}^6}}{R_{eH} d_M t_i^2\left[1-\left(\dfrac{d_0}{d_E}\right)^2\right]}$$

d_{NTF}, d_{NT} : Nozzle stock diameter, in mm, to be obtained from the formula in [8.3.1], considering $k_1 = 1$

η, c, β, d_M, d_E, μ_A, μ, γ : Defined in [4.2.3]

t_i, d_0 : Defined in Fig 2

8.5.4 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

9 Azimuth propulsion system

9.1 General

9.1.1 Arrangement

The azimuth propulsion system is constituted by the following sub-systems (see Fig 9):

- the steering unit
- the bearing
- the hull supports
- the rudder part of the system
- the pod, which contains the electric motor in the case of a podded propulsion system.

9.1.2 Application

The requirements of this Article apply to the scantlings of the hull supports, the rudder part and the pod.

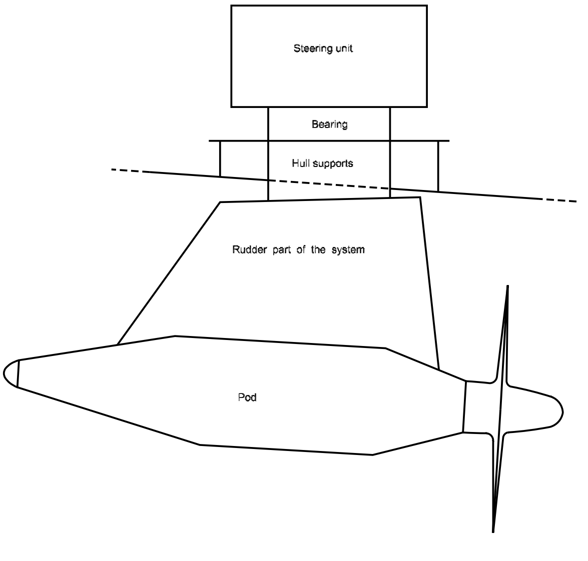
The steering unit and the bearing are to comply with the requirements in Pt C, Ch 1, Sec 11.

9.1.3 Operating conditions

The maximum angle at which the azimuth propulsion system can be oriented on each side when the vessel navigates at its maximum speed is to be specified by the Designer. Such maximum angle is generally to be less than 35° on each side.

In general, orientations greater than this maximum angle may be considered by the Society for azimuth propulsion systems during manoeuvres, provided that the orientation values together with the relevant speed values are submitted to the Society for review.

Figure 9 : Azimuth propulsion system



9.2 Arrangement

9.2.1 Plans to be submitted

In addition to the plans showing the structural arrangement of the pod and the rudder part of the system, the plans showing the arrangement of the azimuth propulsion system supports are to be submitted to the Society for review. The scantlings of the supports and the maximum loads which act on the supports are to be specified in these drawings.

9.2.2 Locking device

The azimuth propulsion system is to be mechanically lockable in a fixed position, in order to avoid rotations of the system and propulsion in undesirable directions in the event of damage.

9.3 Design loads

9.3.1 The lateral pressure to be considered for scantling of plating and ordinary stiffeners of the azimuth propulsion system is to be determined for an orientation of the system equal to the maximum angle at which the azimuth propulsion system can be oriented on each side when the vessel navigates at its maximum speed.

The total force which acts on the azimuth propulsion system is to be obtained by integrating the lateral pressure on the external surface of the system.

The calculations of lateral pressure and total force are to be submitted to the Society for information.

9.4 Plating

9.4.1 Plating of the rudder part of the azimuth propulsion system

The thickness of plating of the rudder part of the azimuth propulsion system is to be not less than that obtained, in mm, from the formulae in [6.2.1], in which the term C_R/A is to be replaced by the lateral pressure calculated according to [9.3].

9.4.2 Plating of the pod

The thickness of plating of the pod is to be not less than that obtained, in mm, from the following formula:

$$t = s\sqrt{k_0 k p}$$

where:

s : Stiffener spacing, in m

p : Design lateral pressure, in kN/m², calculated according to [9.3].

9.4.3 Webs

The thickness of webs of the rudder part of the azimuth propulsion system is to be determined according to [6.2.4], where the lateral pressure is to be calculated according to [9.3].

9.5 Ordinary stiffeners

9.5.1 Ordinary stiffeners of the pod

The scantlings of ordinary stiffeners of the pod are to be not less than those obtained from the following formulae:

Net section modulus, in cm³:

$$w = \frac{p}{m(226/(k_0 k))} s l^2 10^3$$

Net shear sectional area, in cm²:

$$A_{sh} = 10 \frac{p}{226/(k_0 k)} s l$$

where:

s, p : Parameters defined in [9.4.2]

ℓ : Unsupported span of stiffener, in m

m : Boundary coefficient taken equal to 8.

9.6 Primary supporting members

9.6.1 Analysis criteria

The scantlings of primary supporting members of the azimuth propulsion system are to be obtained through direct calculations, to be carried out according to the following requirements:

- the structural model is to include the pod, the rudder part of the azimuth propulsion system, the bearing and the hull supports
- the boundary conditions are to represent the connections of the azimuth propulsion system to the hull structures
- the loads to be applied are those defined in [9.6.2].

The direct calculation analyses (structural model, load and stress calculation, strength checks) carried out by the Designer are to be submitted to the Society for information.

9.6.2 Loads

The following loads are to be considered in the direct calculation of the primary supporting members of the azimuth propulsion system:

- gravity loads
- buoyancy
- maximum loads calculated for an orientation of the system equal to the maximum angle at which the azimuth propulsion system can be oriented on each side when the vessel navigates at its maximum speed
- maximum loads calculated for the possible orientations of the system greater than the maximum angle at the relevant speed (see [9.1.3])
- maximum loads calculated for the crash stop of the vessel obtained through inversion of the propeller rotation
- maximum loads calculated for the crash stop of the vessel obtained through a 180° rotation of the pod.

9.6.3 Strength check

It is to be checked that the Von Mises equivalent stress σ_E in primary supporting members, calculated, in N/mm², for the load cases defined in [9.6.2], is in compliance with the following formula:

$\sigma_E \le \sigma_{ALL}$

where:

σ_{ALL} : Allowable stress, in N/mm², to be taken equal to 0,55 R_{eH}

9.7 Hull supports of the azimuth propulsion system

9.7.1 Analysis criteria

The scantlings of hull supports of the azimuth propulsion system are to be obtained through direct calculations, to be carried out in accordance with the requirements in [9.6.1].

9.7.2 Loads

The loads to be considered in the direct calculation of the hull supports of the azimuth propulsion system are those specified in [9.6.2].

9.7.3 Strength check

It is to be checked that the Von Mises equivalent stress σ_E in hull supports, in N/mm², calculated for the load cases defined in [9.6.2], is in compliance with the following formula:

$\sigma_E \le \sigma_{ALL}$

where:

σ_{ALL} : Allowable stress, in N/mm², equal to:

$\sigma_{ALL} = 65 / (k_0 k)$

Values of σ_E greater than σ_{ALL} may be accepted by the Society on a case-by-case basis, depending on the localisation of σ_E and on the type of direct calculation analysis.

SECTION 2 BULWARKS AND GUARD RAILS

Symbols

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Ch 1, Sec 2, [2.1]

t : Gross thickness, in mm.

1 General

1.1 Introduction

1.1.1 The requirements of this Section apply to the arrangement and scantling of bulwarks and guard rails provided at the boundaries of decks and work stations.

1.1.2 The outer edges of decks as well as work stations where persons might fall more than 1 m, shall be fitted with bulwarks or guard rails.

1.1.3 In case of non-propelled cargo carriers without accommodation, bulwarks of guardrails shall not be required where:

a) foot-guards have been fitted to the outer edges of the decks and side decks, and

b) hand rails have been fitted to the coamings

1.1.4 In case of vessels with flush or trunk decks, it shall not be required that guardrails be fitted directly on the outer edges of those decks and side decks where:

a) the passageways run over those decks, and

b) the passageways and work stations on those decks are surrounded by fixed guard rails

1.1.5 Requirements other than those set out in this Section may be called for by national or international authorities, specially for vessels assigned the range of navigation **IN(x ≤ 2)**, in order to allow the crew to move about under adequate safety conditions.

2 Bulwarks

2.1 General

2.1.1 The height of bulwarks is to be at least 1 m from the deck. This height may be reduced subject to the agreement of the Society where required by operational necessities.

2.1.2 As a rule, plate bulwarks are to be stiffened at the upper edge by a suitable bar and supported either by stays or plate brackets spaced not more than 2 m apart.

Bulwark stays are to be aligned with the beams located below or are to be connected to them by means of local transverse stiffeners.

As an alternative, the lower end of the stay may be supported by a longitudinal stiffener.

2.1.3 Where bulwarks are cut completely, the scantlings of stays or brackets are to be increased with respect to those given in [2.2.2].

2.1.4 Openings in bulwarks are to be arranged so that the protection of the crew is to be at least equivalent to that provided by the horizontal courses in [3.1.4].

2.2 Scantlings

2.2.1 Plating thickness

The bulwark gross thickness, in mm, is not to be less than the values given in Tab 1.

Table 1 : Bulwark gross thickness, in mm

L, in m	Steel	Aluminium alloys
L ≤ 30 m	$t = 4k^{0,5}$	$t = 3(k_0k)^{0,5}$
30 m < L ≤ 90 m	$t = 5k^{0,5}$	$t = 4(k_0k)^{0,5}$
L > 90 m.	$t = 6k^{0,5}$	–

2.2.2 Scantlings of stays

The gross section modulus of stays in way of the lower part of the bulwark is to be not less than the value obtained, in cm^3, from the following formulae:

- for steel: $w = 40\ k\ s\ (1 + 0,01\ L_S)\ h_B^2$
- for aluminium alloys: $w = 32\ k_0\ k\ s\ (1 + 0,01\ L_S)\ h_B^2$

where:

L_S : Length, in m, defined as: L_S = min (L ; 100)

s : Spacing of stays, in m

h_B : Height of bulwark, in m, measured between its upper edge and the deck

The actual section of the connection between stays and deck structures is to be taken into account when calculating the above section modulus.

3 Guard rails

3.1 Passenger areas

3.1.1 Guard rails are to be at least 1 m high and shall comprise a hand rail, intermediate rails and a foot-guard. This height may be reduced subject to the agreement of the Society where required by operational necessities.

3.1.2 The spacing between railing stanchions is not to be greater than 2 m.

3.1.3 The foot-guard is to rise at least 50 mm above the weather deck.

The distance between inner edge of foot-guard and inner edge of the stanchion is not be greater than 100 mm.

3.1.4 The opening below the lower course is not to be greater than 230 mm. The other courses are not to be more than 380 mm apart.

3.2 Working areas

3.2.1 Guard rails are to be at least 0,9 m high and shall comprise a hand rail, intermediate rails and a foot-guard.

3.2.2 The spacing between railing stanchions is not to be greater than 2 m.

3.2.3 The foot-guard is to rise at least 50 mm above the weather deck.

3.3 Scantlings

3.3.1 Guard rails shall maintain loads in such a way that deflection without permanent deformation is not to exceed 50 mm in the centre between two stanchions when a load of 500 N/m is acting on the railing.

3.3.2 Hand rails are to be of circular section 40 to 50 mm in diameter.

3.3.3 Adequate strength of guard rails shall be proved by means of a direct calculation submitted to the Society for review, or the design shall be in compliance with an appropriate design standard recognised by the Society.

SECTION 3 PROPELLER SHAFT BRACKETS

Symbols

A : Sectional area, in cm^2, of the arm

A_S : Shear sectional area, in cm^2, of the arm

d_P : Propeller shaft diameter, in mm, measured inside the liner, if any

F_C : Force, in kN, taken equal to:

$$F_C = \left(\frac{2\pi N}{60}\right)^2 R_P m$$

m : Mass of a propeller blade, in t

N : Number of revolutions per minute of the propeller

R_P : Distance, in m, of the center of gravity of a blade in relation to the rotation axis of the propeller

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

with:

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

w_A : Section modulus, in cm^3, of the arm at the level of the connection to the hull with respect to a transversal axis

w_B : Section modulus, in cm^3, of the arm at the level of the connection to the hull with respect to a longitudinal axis

σ_{ALL} : Allowable stress, in N/mm^2: σ_{ALL} = 0,30 R_y

1 General

1.1

1.1.1 General

Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

1.2 Strength check

1.2.1 General

The strength check is to be carried out according to [2], [3], [4] or [5].

1.2.2 Vibration analysis

A vibration analysis according to Pt C, Ch 1, Sec 9 is recommended to be performed for single arm propeller shaft brackets.

2 Double arm propeller shaft brackets

2.1 General

2.1.1 Both arms of detached propeller brackets are to form an angle α to each other which differs from the angle included between propeller blades. Where 3- or 5-bladed propellers are fitted, it is recommended that the angle α should be approximately 90°. Where 4-bladed propellers are fitted, the angle α should be approximately 70° or 110°.

Where possible, the axes of the arms should intersect in the axis of the propeller shaft.

Exceptions to this will be considered by the Society on a case by case basis.

2.1.2 Scantlings of arms

The moment in the arm, in kN.m, is to be obtained from the following formula:

$$M = \frac{F_C}{\sin\alpha}\left(\frac{L}{\ell}d_1\cos\beta + L - \ell\right)$$

where:

α : Angle between the two arms

β : Angle defined in Fig 1

d_1 : Distance, in m, defined in Fig 1

L, ℓ : Lengths, in m, defined in Fig 2.

It is to be checked that the bending stress σ_F, the compressive stress σ_N and the shear stress τ are in compliance with the following formula:

$$\sqrt{(\sigma_F + \sigma_N)^2 + 3\tau^2} \le \sigma_{ALL}$$

where:

$$\sigma_F = \frac{M}{w_A}10^3$$

$$\sigma_N = 10F_C\frac{L\sin\beta}{A\ell\sin\alpha}$$

$$\tau = 10F_C\frac{L\cos\beta}{A_S\ell\sin\alpha}$$

2.1.3 Scantlings of propeller shaft bossing

The length of the propeller shaft bossing is to be not less than the length of the aft sterntube bearing bushes (see Pt C, Ch 1, Sec 7).

The thickness of the propeller shaft bossing is to be not less than 0,33 d_P.

Figure 1 : Angle β and length d_1

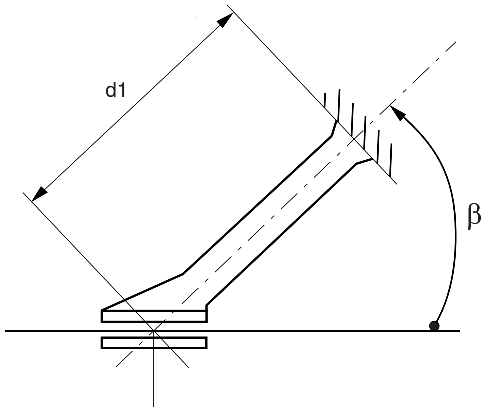
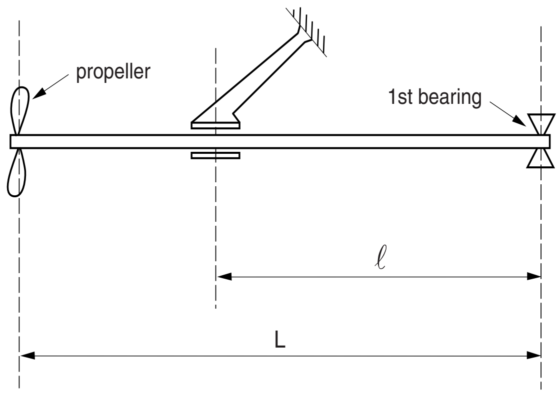


Figure 2 : Lengths L and ℓ



2.1.4 Bracket arm attachments

The bracket arms are to penetrate the hull plating and be connected to deep floors or girders of increased thickness. Moreover, in way of the attachments, the shell plating is to be increased in thickness by 50% or fitted with a doubling plate of same thickness, and suitably stiffened.

The securing of the arms to the hull structure is to prevent any displacement of the brackets with respect to the hull.

3 Single arm propeller shaft brackets

3.1 Scantlings

3.1.1 This type of propeller shaft bracket consists of one arm.

3.1.2 Scantlings of arms

The moment in case of a vertical single arm, in kN.m, is to be obtained from the following formula:

$$M = d_2 F_C \frac{L}{\ell}$$

where:

d_2 : Length of the arm, in m, measured between the propeller shaft axis and the hull

L, ℓ : Lengths, in m, defined in Fig 2.

It is to be checked that the bending stress σ_F and the shear stress τ are in compliance with the following formula:

$$\sqrt{\sigma_F^2 + 3\tau^2} \le \sigma_{ALL}$$

where:

$$\sigma_F = \frac{M}{w_B} 10^3$$

$$\tau = 10 F_C \frac{L}{A_S \ell}$$

3.1.3 Scantlings of propeller shaft bossing

The length of the propeller shaft bossing is to be not less than the length of the aft sterntube bearing bushes (see Pt C, Ch 1, Sec 7).

The thickness of the propeller shaft bossing is to be not less than 0,33 d_P.

3.1.4 Bracket arm attachments

The connection of bracket arms to the hull structure is to comply with [2.1.4].

4 Bossed propeller shaft brackets

4.1 General

4.1.1 Where bossed propeller shaft brackets are fitted, their scantlings are to be considered by the Society on a case by case basis.

4.1.2 Scantling of the boss

The length of the boss is to be not less than the length of the aft sterntube bearing bushes (see Pt C, Ch 1, Sec 7).

The thickness of the boss, in mm, is to be not less than 0,33 d_P.

The aft end of the bossing is to be adequately supported.

4.1.3 Scantling of the end supports

The scantlings of end supports are to be specially considered. Supports are to be adequately designed to transmit the loads to the main structure.

End supports are to be connected to at least two deep floors of increased thickness or connected to each other within the vessel.

4.1.4 Stiffening of the boss plating

Stiffening of the boss plating is to be specially considered. At the aft end, transverse diaphragms are to be fitted at every frame and connected to floors of increased scantlings.

At the fore end, web frames spaced not more than four frames apart are to be fitted.

5 Propeller shaft brackets in composite materials

5.1 General

5.1.1 For propeller shaft brackets built in composite materials, the scantling are to be checked by direct calculation, taking into account the checking criteria defined in Ch 2, Sec 6, [4.2] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1,8
- for the combined stress safety factor: 1,5.

SECTION 4 EQUIPMENT

Symbols

L_M : Maximum length of the hull, in m, excluding rudder and bowsprit

P : Required bow anchor mass, in kg

P_i : Increased required bow anchor mass, in kg

R : Minimum breaking load of anchor chain cable, in kN

R_{eH} :
- for hull steel:

  R_{eH} is the nominal yield point, in N/mm^2
- for aluminium alloys:

  R_{eH} is 0,2% proof stress, in N/mm^2

R_S : Minimum breaking load of mooring cables, in kN

T : Scantling draught, in m, defined in Ch 1, Sec 2, [2.4].

1 General

1.1 General requirements

1.1.1 The requirements in this Section provide the equipment in anchors, chain cables and ropes for all ranges of navigation defined in Pt A, Ch 1, Sec 3, [12.2].

1.1.2 Vessels have to be equipped with anchors, chain cables and ropes complying with the applicable requirements of NR216 Materials and Welding.

1.1.3 The required equipment of anchors, chain cables, ropes and cables of the vessels trading on the inland waterways has to be determined according to [2] to [4].

The actual Regulations of the Local Authority have to be observed.

1.1.4 The Society, taking into account the conditions on the waterway concerned, may consent to a reduction in equipment for vessel intended for use only in a certain waterway system or area of inland water provided that a note of this waterway system or area of inland water is appended to the character of classification.

1.1.5 Barges to be carried aboard seagoing ships

Barges to be carried aboard seagoing ships are to be exempted from the anchor equipment requirements.

1.1.6 Multi-hull vessels

The breath B to be considered for the application of these Rules to multi-hull vessels is to be determined using the following formula:

$$B = \sum B_i$$

where B_i is the individual breadth of each hull.

2 Anchors

2.1 General

2.1.1 Anchors are to be of an approved type.

2.1.2 Cast iron anchors shall not be permitted.

2.1.3 The mass of the anchors shall stand out in relief in a durable manner.

2.1.4 Anchors having a mass in excess of 50 kg shall be equipped with windlasses.

2.2 Bow anchors

2.2.1 Cargo carriers

The total mass P of the bow anchors of cargo carriers shall be calculated by the following formula:

P = k B T

where:
- for non-propelled cargo carriers: k = c
- otherwise:

$$k = c\left(\frac{L_M}{8B}\right)^{0,5}$$

with:

c : Coefficient defined in Tab 1.

Table 1 : Coefficient c

Deadweight	Coefficient c
≤ 400 t	45
> 400 t ≤ 650 t	55
> 650 t ≤ 1000 t	65
> 1000 t	70

2.2.2 Passenger vessels and other vessels without deadweight measurement

Passenger vessels and vessels not intended for the carriage of goods, apart from pushers, shall be fitted with bow anchors whose total mass P is obtained from the following formula:

P = k B T

where:

k : Coefficient corresponding to [2.2.1] but where, in order to obtain the value of the empirical coefficient c, the maximum displacement, in m^3, shall be taken instead of the deadweight tonnage.

2.2.3 Increased bow anchor mass

For passenger vessels and for vessels having a large windage area (container vessels), the bow anchor mass is to be increased as follows:

$P_i = P + 4\ A_f$

where:

A_f : Transverse profile view (windage area) of the hull above waterline at the draught T, in m^2.

For calculating the area A_f, all superstructures, deckhouses and cargos (e.g. containers) having a breadth greater than B/4 are to be taken into account.

2.2.4 Range of navigation IN

For the range of navigation **IN**, where the current velocity is lower than 6 km/h, the anchor masses according to [2.2.1] to [2.2.3] may be reduced by 13%.

2.3 Stern anchors

2.3.1 Stern anchors are to be fitted in compliance with the requirements [2.3.3] to [2.3.6].

2.3.2 The requirement [2.3.1] may be waived by the Society depending on specified operating conditions regarding for instance current speed or vessel positioning.

2.3.3 Self-propelled vessels shall be fitted with stern anchors whose total weight is equal to 25% of the mass P calculated in accordance with [2.2].

2.3.4 Vessels whose maximum length L_M exceeds 86 m shall, however, be fitted with stern anchors whose total mass is equal to 50% of the mass P or P_i calculated in accordance with [2.2].

2.3.5 Pushers

Vessels intended to propel rigid convoys not more than 86 m in length shall be fitted with stern anchors whose total mass is equal to 25% of the maximum mass P calculated in accordance with [2.2] for the largest formation considered as a nautical unit.

Vessels intended to propel downstream rigid convoys that are longer than 86 m shall be fitted with stern anchors whose total mass equals 50% of the greatest mass P calculated in accordance with [2.2] for the largest formation considered as a nautical unit.

2.3.6 The following vessels are exempted from the stern anchor requirement:

- vessels for which the stern anchor mass will be less than 150 kg
- vessels intended to operate on reservoirs, lakes and,
- non-propelled cargo carriers.

2.4 High-holding-power anchors

2.4.1 The anchor masses established in accordance with [2.2] and [2.3] may be reduced for certain special anchors. The types of anchors given in Tab 2 have so far been recognised by the Society as “high-holding-power anchors”.

Table 2 : Recognized types of anchors

Type of anchors	Mass reduction
HA - DU	30%
D’Hone Special	30%
Pool 1 (hollow)	35%
Pool 2 (solid)	40%
De Biesbosch - Danforth	50%
Vicinay - Danforth	50%
Vicinay AC 14	25%
Vicinay Type 1	45%
Vicinay Type 2	45%
Vicinay Type 3	40%
Stockes	35%
D’Hone - Danforth	50%
Schmitt high holding anchor	40%
SHI high holding anchor, type ST (standard)	30%
SHI high holding anchor, type FB (fully balanced)	30%
Klinsmann anchor	30%
HA-DU-POWER Anchor	50%

2.5 Number of anchors

2.5.1 The total mass P specified for bow anchors may be distributed among one or two anchors. It may be reduced by 15% where the vessel is equipped with only a single bow anchor and the mooring pipe is located amidships.

The required total weight of stern anchors for pushers and vessels whose maximum length exceeds 86 m may be distributed between one or two anchors.

The mass of the lightest anchor should be not less than 45% of that total mass.

3 Chain cables

3.1 General

3.1.1 Chains true to gauge size are to be used as anchor chain cables.

3.1.2 Short-link or stud-link chain cables may be used as anchor chain cables.

3.2 Minimum breaking loads

3.2.1 The minimum breaking load of chain cables shall be calculated by the formulae given in Tab 3.

For the breaking loads of short-link chains and stud-link chains, see Tab 4 and Tab 5, respectively.

3.2.2 Where the anchors have a mass greater than that required in [2.2], [2.3] and [2.5.1] the breaking load of the anchor chain cable shall be determined as a function of that highest anchor mass.

3.2.3 The attachments between anchor and chain shall withstand a tensile load 20% higher than the tensile strength of the corresponding chain.

3.3 Length of chain cables

3.3.1 Bow anchor chain cables

For the minimum length of bow anchor chain cables, see Tab 6.

3.3.2 Stern anchor chain cables

The length of stern anchor chain cables is not to be less than 40 m. However, where vessels need to stop facing downstream they are to be equipped with a stern anchor chain of not less than 60 m in length.

3.3.3 Steel wire ropes

In special cases, steel wire ropes may be permitted instead of anchor chain cables, for vessels intended to operate in stretches of fresh waters corresponding to **IN(1,2 ≤ x ≤ 2)**. The wire ropes are to have at least the same breaking strength as the required anchor chain cables, but shall be 20% longer.

A short length of chain cable is to be fitted between the wire rope and the anchor, having a length equal at least to the distance from the anchor in the stowed position to the winch.

Table 3 : Minimum breaking loads R of chain cables

Anchor mass (kg)	R (kN)
≤ 500	$R = 0{,}35\,P'$
> 500 and ≤ 2000	$R = \left(0,35 - \dfrac{P' - 500}{15000}\right)P'$
> 2000	$R = 0{,}25\,P'$
Note 1: P′ : Theoretical mass of each anchor determined in accordance with [2.2] and [2.3].	

Table 4 : Breaking loads, in kN, for short-link chain cables

Chain diameter (mm)	Grade SL_1		Grade SL_2		Grade SL_3	
	Proof load	Breaking load	Proof load	Breaking load	Proof load	Breaking load
6,0	6,5	13	9	18	13	26
8,0	12,0	24	17	34	24	48
10,0	18,5	37	26	52	37	74
11,0	22,5	45	32	64	45	90
12,5	29,0	58	41	82	58	116
14,5	39,0	78	55	110	78	156
16,0	47,5	95	67	134	95	190
17,5	56,5	113	80	160	113	226
19,0	67,0	134	95	190	134	268
20,5	78,0	156	111	222	156	312
22,0	90,0	180	128	256	180	360
24,0	106	212	151	302	212	424
25,5	120	240	170	340	240	480
27,0	135	270	192	384	270	540
28,5	150	300	213	426	300	600
30,0	166	332	236	472	332	664
32,0	189	378	268	536	378	756
33,0	201	402	285	570	402	804
35,0	226	452	321	642	452	904
37,0	253	506	359	718	506	1012
38,0	267	534	379	758	534	1068
40,0	296	592	420	840	592	1184

Table 5 : Breaking loads, in kN for stud-link chain cables

Chain diameter (mm)	Grade K_1		Grade K_2		Grade K_3	
	Proof load	Breaking load	Proof load	Breaking load	Proof load	Breaking load
11	36	51	51	72	72	102
12,5	46	66	66	92	92	132
14	58	82	82	115	115	165
16	75	107	107	150	150	215
17,5	89	128	128	180	180	255
19	105	150	150	210	210	300
20,5	123	175	175	244	244	349
22	140	200	200	280	280	401
24	167	237	237	332	332	476
26	194	278	278	389	389	556
28	225	321	321	449	449	642
30	257	368	368	514	514	735
32	291	417	417	583	583	833
34	328	468	468	655	655	937
36	366	523	523	732	732	1050
38	406	581	581	812	812	1160
40	448	640	640	896	896	1280
42	492	703	703	985	985	1400
44	538	769	769	1080	1080	1540
46	585	837	837	1170	1170	1680
48	635	908	908	1270	1270	1810
Note 1: Grades K_1 , K_2 and K_3 are equivalent to grades Q_1 , Q_2 and Q_3 , respectively.						

Table 6 : Minimum length of bow anchor chain cables

L_M (m)	Minimum length of chain cables (m)	
	IN	**IN(x ≤ 2)**
$L_M < 30$	$\ell = 40$	$\ell = \max(40 ; L_M + 10)$
$30 \leq L_M \leq 50$	$\ell = L_M + 10$	
$L_M > 50$	$\ell = 60$	

4 Mooring and towing equipment

4.1 Ropes

4.1.1 General

Steel wire ropes as well as fibre ropes from natural or synthetic fibres or ropes consisting of steel wires and fibre strands may be used for all ropes and cables.

During loading and unloading of tankvessels carrying inflammable liquids, steel wire ropes only are to be used for mooring purposes.

4.1.2 Mooring cables

It is recommended at least mooring cables as defined in Tab 7 and Tab 8.

Table 7 : Mooring cables

Mooring cable	Minimum length of cable (m)
1st cable	$\ell' = \min(\ell_1 ; \ell_2)$ $\ell_1 = L_M + 20$ $\ell_2 = \ell_{max}$ **(1)**
2nd cable	$\ell'' = 2/3\ \ell'$
3rd cable **(2)**	$\ell'' = 1/3\ \ell'$
(1) $\ell_{max} = 100$ m **(2)** This cable is not required on board of vessels whose L_M is less than 20 m.	

Table 8 : Minimum breaking load R_S of mooring cables

$L_M \cdot B \cdot T$	R_S, in kN
≤ 1000 m³	$R_S = 60 + \frac{L_M B T}{10}$
> 1000 m³	$R_S = 150 + \frac{L_M B T}{100}$

4.1.3 Towing cables

Self-propelled vessels and pushers that are also intended to tow shall be equipped with an at least 100 m long towing cable whose tensile strength is not less than the value determined according to Ch 7, Sec 6, [4].

Tugs are to be equipped with a number of cables that are suitable for their operation. However, the most important cable shall be at least 100 m long and have a tensile strength, in kN, not less than one third of the total power, in kW, of the power plant(s).

4.2 Bollards

4.2.1 Every vessel has to be equipped with one double bollard each on the fore and aft body on port and starboard side. In between, depending on the vessel's size, one to three single bollards have to be arranged on either side of the vessel.

For larger vessels (as from L = 70 m) it is recommended to mount a triple bollard on the fore body and two double bollards on the aft body on port and starboard side.

4.2.2 The bollards have to be led through the deck and below be attached to a horizontal plate spaced at least one bollard diameter from the deck. Said plate being of the same thickness as the bollard wall has to be connected to the side wall and adjacent beam knees. Should this be impossible, the bollards have to be constrained in a bollard seat on deck.

4.3 Supporting hull structures associated with towing and mooring

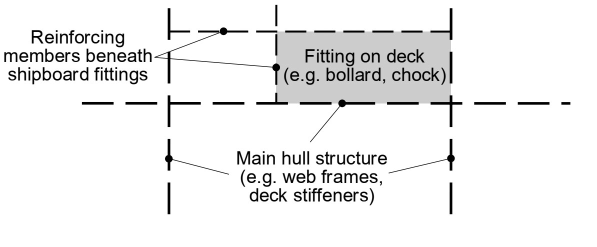
4.3.1 General

The strength and arrangement of supporting hull structures associated with towing and mooring are to comply with the present sub-article.

On board fittings, winches and capstans are to be located on stiffeners and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the towing and mooring loads.

The reinforced members beneath on board fittings are to be effectively arranged for any variation of direction (horizontally and vertically) of the mooring and towing forces acting upon the on board fittings, see Fig 1 for a sample arrangement. Proper alignment of fitting and supporting hull structure is to be ensured.

Figure 1 : Reinforced members beneath onboard fittings



4.3.2 Information to be submitted

A plan showing the towing and mooring arrangement is to be submitted to the Society for information. This plan is to define the method of using the towing and mooring lines and is to include the following information for each on board fitting:

a) location on the vessel
b) fitting type
c) safe working load
d) purpose (mooring, towing)
e) manner of applying towing and mooring lines (including line load, line angles, etc.).

4.3.3 Hull structure reinforcement

As a general rule, hull structure reinforcements in way of

mooring and towing equipment are to be examined by direct calculation, taking into account a tension in the mooring or towing line equal to the safe working load of the equipment and considering the following allowable stresses:

a) For strength assessment with beam theory or grillage analysis:
   - normal stress: $\sigma \leq R_y$
   - shear stress: $\tau \leq 0{,}6R_y$
b) For strength assessment with finite element analysis:
   - $\sqrt{\sigma^2 + 3\tau^2} \leq R_Y$

where:

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:
- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

with:

k : Material factor defined in:
- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

Note 1: Normal stress is to be considered as the sum of bending stress and axial stress, with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors being taken into account.

Note 2: When the mooring plan is not available, the equipment such as bitts and bollards (when the line may come and go from the same direction) are to be loaded up to twice their safe working loads.

4.3.4 Corrosion additions

The scantlings obtained by applying the allowable stresses as specified in [4.3.3] are net scantlings excluding any addition for corrosion.

The total corrosion addition t_c is not to be less than the following values:

- for the supporting hull structure, according to Ch 2, Sec 5, [1] for the surrounding structure (e.g. deck structures, bulwark structures).
- for pedestals and foundations on deck which are not part of a fitting according to a recognised standard, 2.0 mm.
- for shipboard fittings not selected from a recognised standard, 2.0 mm.

Note 1: In addition to the corrosion addition t_c given above, a wear down allowance t_w not less than 1.0 mm is to be included for on board fittings not selected from an recognised standard. This wear allowance is to be added to surfaces which are intended to regularly contact the line.

5 Hawse pipes and chain lockers

5.1 Arrangements

5.1.1 Hawse pipes are to be of substantial construction. Their position and slope are to be arranged so as to facilitate housing and dropping of the anchors and avoid damage to the hull during these operations. The parts on which the chains bear are to be rounded to a suitable radius.

5.1.2 The foreship of the vessels shall be built in such a way that the anchors do not stick out of the side shell.

5.1.3 All mooring units and accessories, such as riding and trip stoppers are to be securely fastened to the Surveyor's satisfaction.

5.1.4 Where two chains are used, the chain locker is to be divided into two compartments, each capable of housing the full length of one line.

5.2 Hawse pipe scantlings

5.2.1 The gross thickness of the hawse pipes is not to be less than:

- for $t_0 < 10$ mm:

  $t = \min (t_0 + 2 ; 10)$
- for $t_0 \geq 10$ mm:

  $t = t_0$

where:

t_0 : Gross thickness of adjacent shell plating, in mm.

SECTION 5 LIFTING APPLIANCES - HULL CONNECTIONS

1 General

1.1 Application

1.1.1 The present Section applies to the structural arrangement and strength of the vessel hull in way of the connections with the lifting appliances (cranes, derrick, bunker masts).

1.1.2 The fixed parts of lifting appliances and their connections to the vessel's structure are within the vessel classfication scope, even when the certification of lifting appliances is not required.

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

1.1.4 It shall be possible to lower the crane boom or the derrick structure and to secure it to the vessel during the voyage.

2 Structural arrangement

2.1 General

2.1.1 The vessel structure is to be suitably reinforced in the area of lifting appliance attachments in order to avoid excessive local stresses or possible buckling of the deck plating.

2.1.2 When inserted plates are provided in deck, side shell or bulkheads in way of crane foundation, these inserts are to have well radiused corners and are to be edge-prepared prior to welding.

3 Hull strength check

3.1 Load transmitted by the lifting appliances

3.1.1 The forces and moments transmitted by the lifting appliances to the vessel's structures, during both lifting service and navigation, are to be submitted to the Society.

3.1.2 For a lifting appliance having a safe working load F less than 50 kN, and when its deadweights are unknown, the bending moment M, in kNm, induced by the pedestal to the hull is not to be taken less than:

$M = 2,2 F x_0$

where:

x_0 : Maximum jib radius of the crane, in m.

3.1.3 For cranes having a safe working load greater than 50 kN, the bending moment and forces induced by the crane pedestal to the hull are to be as defined in NR526 Rules for the Certification of Lifting Appliances on board Ships and Offshore Units.

3.2 Strength criteria for steel and aluminium structures

3.2.1 Local reinforcements and hull structure surrounding the lifting appliance pedestal are to be checked by direct calculation according to the following:

$\sqrt{\sigma^2 + 3\tau^2} \leq 0,63 R_Y$

where:

σ : Normal stress, in N/mm², calculated considering the bending moments and the tensile and compressive forces

τ : Shear stress, in N/mm², calculated considering the torsional moment and the shear forces

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:

- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

with:

k : Material factor defined in:

- Ch 2, Sec 3, [2.3] for steel
- Ch 2, Sec 3, [3.5] for aluminium alloys

3.2.2 Corrosion additions

The scantlings obtained by applying the allowable stresses as specified in [3.2.1] are gross scantlings including corrosion additions.

The net scantlings for the surrounding hull structure is to be obtained according to the process defined in Ch 2, Sec 5, [1].

3.3 Strength criteria for structures in composite materials

3.3.1 Local reinforcements and hull structure surrounding the crane pedestal are to be checked by direct calculations, taking into account the following permissible stresses:

$SF_{CRANE} = 1,7\ SF$

$SF_{CSCRANE} = 1,7\ SF_{CS}$

where:

SF : Rules safety factor applicable to maximum stress defined in Ch 2, Sec 6, [4.3.3]

SF_{CS} : Rules safety factor applicable to combined stress defined in Ch 2, Sec 6, [4.3.3].

SECTION 6 VESSEL COUPLING

1 General

1.1 Application

1.1.1 The requirements of this Section apply to coupling arrangements and scantling of vessels assigned the range of navigation **IN**.

The coupling of vessels assigned range of a navigation **IN(x ≤ 2)** will be examined by the Society on a case by case basis.

1.1.2 Pushed barges and pushers/self-propelled vessels intended to push other vessels are to comply with [2].

Towed units and tugs/self-propelled vessels intended to tow other vessels are to comply with [3].

The requirements under [4] are given as recommendations.

2 Pushing arrangements

2.1 Hull strengthening

2.1.1 The bow of the pusher and the stern of the barge are to be reinforced in order to withstand the connection forces (see [2.4.4]).

The structural reinforcements are to be continued in aft and fore directions in order to transmit the connection forces to the hull structure of pusher and barge.

2.1.2 Pushers

Pushers are to be arranged with a pushing device, having a width not smaller than two thirds of its breadth.

2.2 Pushing transoms

2.2.1 Pushing transoms, at the stem of the pushing vessel and the stern of the barge, are to be arranged with boxes securely attached to the vessel structure by means of horizontal and vertical web plates.

Attention is to be paid that this box is not supported by elements thinner and/or a less rigid structure.

2.3 Other structures

2.3.1 Pusher fore part

The pusher fore structure is to be aligned with the barge aft structure in way of the notch or the dock bottom.

2.3.2 Barge aft part

The barge aft structure is to be aligned with the pusher fore structure in way of the notch or the dock bottom.

2.4 Coupling devices

2.4.1 Every coupling system shall guarantee the rigid coupling of all the craft in a convoy, i.e. under foreseen operating conditions the coupling device shall prevent longitudinal or transversal movement between the vessels, so that the assembly can be seen as a nautical unit.

2.4.2 The forces arising from foreseen operating conditions shall be properly absorbed and safely transmitted into the vessel's structure by the coupling system and its components.

2.4.3 The coupling devices are to be fixed on deck, which is to be locally reinforced. The dimensioning of longitudinal coupling components is to be performed on the basis of coupling forces defined by the designer.

Where the value of coupling forces is not available, it is not to be taken less than those derived from [2.4.4].

2.4.4 Coupling forces

The coupling devices of convoys and formations of vessels shall be dimensioned so as to guarantee sufficient safety levels. This condition is deemed to be fulfilled if the coupling forces determined according to (1), (2) and (3) are assumed to be the tensile strength for the dimensioning of the longitudinal coupling components.

Coupling forces, in kN, between units forming a rigid pushed convoy may be obtained using the following formulae:

- Coupling points between pusher and pushed vessel:

$$F_{SB} = \frac{T_F P_B L_S}{B_S} 10^{-3} \qquad (1)$$

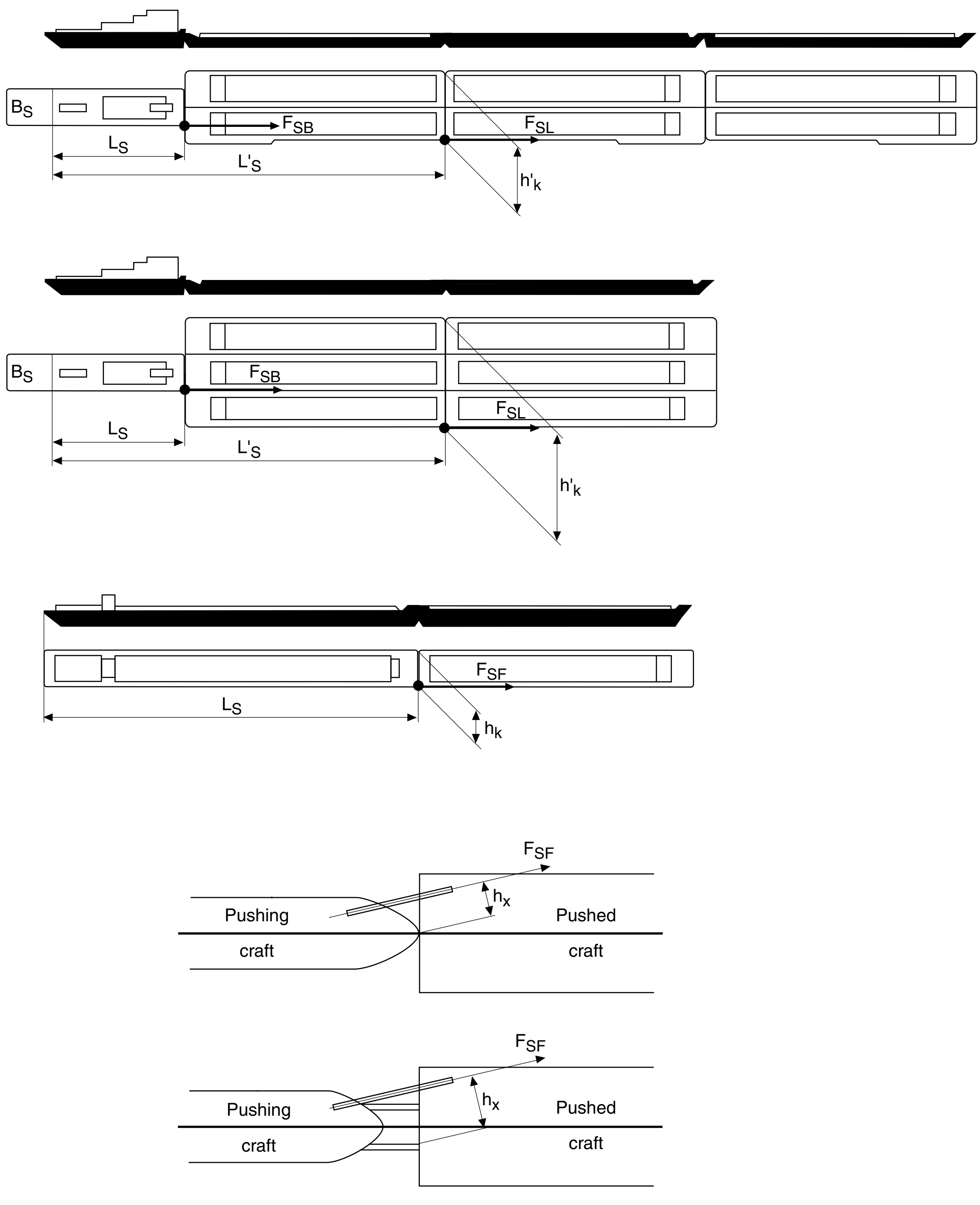
- Coupling points between pushing motor vessel and pushed vessel:

$$F_{SF} = \frac{T_F P_B L_S}{h_K} 10^{-3} \qquad (2)$$

- Coupling points between pushed vessels:

$$F_{SL} = \frac{T_F P_B L^1{}_S}{h^1{}_K} 10^{-3} \qquad (3)$$

Figure 1 : Vessel coupling arrangement



where (see also Fig 1):

F_{SB} , F_{SF} , F_{SL} : Coupling force, in kN, of the longitudinal connection

P_B : Installed propulsion power, in kW, of the pusher or pushing vessel

L_S : Distance, in m, from the stern of the pusher or pushing vessel to the coupling point

L^1_S : Distance, in m, from the stern of the pushing vessel to the coupling point between the first pushed vessel and the vessel coupled ahead of it

h_K , h^1_K : Respective lever arm, in m, of the longitudinal connection

B_S : Breadth, in m, of the pusher or pushing vessel.

T_F : Empirical factor for the conversion of installed power to thrust including adequate safety factor

- T_F = 270 kN/kW, for coupling points between pusher and pushed vessel
- T_F = 80 kN/kW, for coupling points between pushing motor vessel and pushed vessel or coupling points between pushed vessels.

A value of 1200 kN is deemed to be sufficient for the maximum coupling force for a pushing craft at the coupling point between the first pushed craft and the craft coupled ahead of it, even if formula (3) hereabove produces a higher value.

For the coupling points of all other longitudinal connections between pushed craft, the dimensioning of the coupling devices shall be based on the coupling force determined according to formula (3) hereabove.

2.4.5 For the longitudinal coupling of individual craft, at least two coupling points shall be used. Each coupling point shall be dimensioned for the coupling force determined according to [2.4.4]. If rigid coupling components are used, a single coupling point may be authorised if that point ensures secure connection of the craft.

2.4.6 Bollards

Sufficient numbers of bollards or equivalent devices shall be available and be capable of absorbing the coupling forces arising.

A safety coefficient not less than 4, considering the breaking load, is to be obtained when the bollards are subjected to the forces exerted by the cables.

Bollards supporting the cables of a convoy, are never to be applied simultaneously for mooring purposes.

The diameter of the bollards is to be not less than 15 times the diameter of the cable.

Bollards fitted on the pusher are to be at adequate distance of the bollards fitted on the pushed vessel, namely at a distance not less than 3 m.

3 Towing arrangements

3.1 General

3.1.1 Barges are to be fitted with suitable arrangements for towing, with scantlings under the responsibility of the designer.

The Society may, at the specific request of the interested parties, check the above arrangements and the associated hull strengthening; to this end, the maximum pull for which the arrangements are to be checked is to be specified on the plans.

4 Cables

4.1 General

4.1.1 The tensile strength of the cables shall be selected according to the foreseen number of windings. There shall be no more than three windings at the coupling point. Cables shall be selected according to their intended use.

4.1.2 The cables are to be joined at their end or equipped with a sleeve.

Part B
Hull Design and Construction

Chapter 8
CONSTRUCTION AND TESTING

SECTION 1 GENERAL

SECTION 2 WELDING AND WELD CONNECTIONS - STEEL HULL STRUCTURES

SECTION 3 PROTECTION OF HULL METALLIC STRUCTURES

SECTION 4 TESTING - METALLIC HULLS

SECTION 1 GENERAL

1 Application

1.1 Scope

1.1.1 The present Chapter contains the requirements concerning construction, protection and testing of hull structures made of materials covered by these Rules.

1.2 Connections of structures

1.2.1 Steel hulls

The preparation, execution and inspection of welded connections in steel hull structures are to comply with Ch 8, Sec 2.

1.2.2 Aluminium alloy hulls

The preparation, execution and inspection of welded connections in aluminium alloy hull structures are defined in NR561 Aluminium Ships.

The conditions for heterogeneous assembly between steel and aluminium alloy structures are also to be as defined in NR561 Aluminium Ships.

1.2.3 Direct calculation of fillet welds

As an alternative to the determination of the necessary fillet weld throat thicknesses according to [1.2.1] and [1.2.2], a direct calculation may be performed in accordance with Ch 2, Sec 8, [3], e.g. in order to optimize the weld thicknesses in relation to the loads.

1.2.4 Hulls made of composite material or plywood

The scantling of joint assembly for vessels built in composite material or plywood are to be as defined in NR546 Composite Ships.

1.3 Protection of hull metallic structure

1.3.1 The requirements for the protection of hull metallic structure are given in Ch 8, Sec 1.

1.4 Testing

1.4.1 Metallic hulls

The testing conditions for tanks, watertight and weathertight structures for vessels built in steel and aluminium alloy are given in Ch 8, Sec 4.

1.4.2 Hulls made of composite material or plywood

The testing conditions for tanks, watertight and weathertight structures for vessels built in composite material or plywood are defined in NR546 Composite Ships.

SECTION 2 WELDING AND WELD CONNECTIONS - STEEL HULL STRUCTURES

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the preparation, execution and inspection of welded connections in steel hull structures.

1.2 General requirements

1.2.1 The general requirements relevant to fabrication by welding and qualification of welding procedures are given in the relevant chapters of NR216 Materials and Welding, Chapter 5.

1.2.2 Weld connections are to be executed according to the reviewed plans. A detail not specifically represented in the plans is, if any, to comply with the applicable requirements.

1.2.3 It is understood that welding of the various types of steel is to be carried out by means of welding procedures approved for the purpose, even though an explicit indication to this effect may not appear on the reviewed/approved plans.

1.2.4 The quality standard adopted by the shipyard is to be submitted to the Society and applies to all constructions unless otherwise specified on a case by case basis.

1.3 Base material

1.3.1 The requirements of this Section apply for the welding of hull structural steels of the types considered in NR216 Materials and Welding or other types accepted as equivalent by the Society.

1.3.2 The service temperature is intended to be the ambient temperature, unless otherwise stated.

1.4 Welding consumables and procedures

1.4.1 Approval of welding consumables and procedures

Welding consumables and welding procedures adopted are to be approved by the Society.

The requirements for the approval of welding consumables are given in NR216 Materials and Welding, Ch 5, Sec 2.

The requirements for the approval of welding procedures are given in NR216 Materials and Welding, Ch 5, Sec 1, NR216 Materials and Welding, Ch 5, Sec 4 and NR216 Materials and Welding, Ch 5, Sec 5.

Table 1 : Consumable grades

Steel grade	Consumable minimum grade	
	Butt welding, partial and full T penetration welding	Fillet welding
A	1	1
B - D	2	
E	3	
AH32 - AH36 - DH32 - DH36	2Y	2Y
AH40	2Y40	2Y40
DH40	3Y40	

Note 1: Welding consumables approved for welding higher strength steels (Y) may be used in lieu of those approved for welding normal strength steels having the same or a lower grade; welding consumables approved in grade Y40 may be used in lieu of those approved in grade Y having the same or a lower grade.

Note 2: In the case of welded connections between two hull structural steels of different grades, as regards strength or notch toughness, welding consumables appropriate to one or the other steel are to be adopted.

1.4.2 Consumables

For welding of hull structural steels, the minimum consumable grades to be adopted are specified in Tab 1 depending on the steel grade.

Consumables used for manual or semi-automatic welding (covered electrodes, flux-cored and flux-coated wires) of higher strength hull structural steels are to be at least of hydrogen-controlled grade H15 (H). Where the carbon equivalent Ceq is not more than 0,41% and the thickness is below 30 mm, any type of approved higher strength consumables may be used at the discretion of the Society.

Especially, welding consumables with hydrogen-controlled grade H15 and H10 shall be used for welding hull steel forgings and castings of respectively ordinary strength level and higher strength level.

The condition and remarks of welding consumables manufactures have to be observed.

1.5 Personnel and equipment

1.5.1 Welders

Welders for manual welding and for semi-automatic welding processes are to be certified by the Society unless otherwise agreed for welders already certified in accordance with a recognised standard accepted by the Society.

1.5.2 Automatic welding operators

Personnel manning automatic welding machines and equipment are to be competent and sufficiently trained.

1.5.3 Organisation

The internal organisation of the Building Yard, is to be such as to ensure compliance with the requirements in [1.5.1] and [1.5.2] and to provide for assistance and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

1.5.4 NDE operators

Non-destructive tests are to be carried out by qualified personnel, certified by the Society, or by recognised bodies in compliance with appropriate standards.

The qualifications are to be appropriate to the specific applications.

1.5.5 Technical equipment and facilities

The welding equipment is to be appropriate to the adopted welding procedures, of adequate output power and such as to provide for stability of the arc in the different welding positions.

In particular, the welding equipment for special welding procedures is to be provided with adequate and duly calibrated measuring instruments, enabling easy and accurate reading, and adequate devices for easy regulation and regular feed.

Manual electrodes, wires and fluxes are to be stored in suitable locations so as to ensure their preservation in proper condition. Especially, where consumables with hydrogen-controlled grade are to be used, proper precautions are to be taken to ensure that manufacturer's instructions are followed to obtain (drying) and maintain (storage, maximum time exposed, re-backing, ...) hydrogen-controlled grade.

1.6 Documentation to be submitted

1.6.1 The structural plans to be submitted for review/approval according to Ch 1, Sec 3, are to contain the necessary data relevant to the fabrication by welding of the structures and items represented as far as class is concerned.

For important structures, the main sequences of prefabrication, assembly and welding and non-destructive examination planned are also to be represented in the plans.

1.6.2 A plan showing the location of the various steel types is to be submitted at least for outer shell, deck and bulkhead structures.

1.7 Design

1.7.1 General

For the various structural details typical of welded construction in shipbuilding and not dealt with in this Section, the rules of good practice, recognised standards and past experience are to apply as agreed by the Society.

1.7.2 Plate orientation

The plates of the shell and strength deck are generally to be arranged with their length in the fore-aft direction. Possible exceptions to the above will be considered by the Society on a case-by-case basis; tests as deemed necessary (for example, transverse impact tests) may be required by the Society.

1.7.3 Overall arrangement

Particular consideration is to be given to the overall arrangement and structural details of highly stressed parts of the hull.

Plans relevant to the special details are to be submitted.

1.7.4 Prefabrication sequences

Prefabrication sequences are to be arranged so as to facilitate positioning and assembling as far as possible.

The amount of welding to be performed on board is to be limited to a minimum and restricted to easily accessible connections.

1.7.5 Local clustering of welds, minimum spacing, socket weldments

The local clustering of welds and short distances between welds are to be avoided.

- Adjacent butt welds should be separated from each other by a distance of at least:

  50 mm + 4 t

- Fillet welds should be separated from each other and from butt welds by a distance of at least:

  30 mm + 2 t,

where t is the plate thickness, in mm.

The width of replaced or inserted plates (strips) should, however, be at least 300 mm or ten times the plate thickness, whichever is the greater.

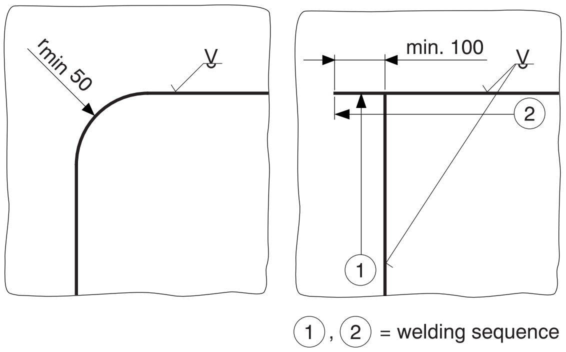
Reinforcing plates, welding flanges, mountings and similar components socket welded into plating should be of the following minimum size:

D = 120 + 3 (t – 10), without being less than 120 mm.

The corners of angular socket weldments are to be rounded to a radius of at least 50 mm unless the longitudinal butt welds are extended beyond the transverse butt weld as shown in Fig 1. The socket welding sequence shall then comprise firstly the welding of the transverse seams (1) following by cleaning of the ends of these and then the welding of the longitudinal seams (2).

The socket welding of components with radiused corners should proceed in accordance with the relevant welding sequence description.

Figure 1 : Corners of socket weldments



2 Type of connections and preparation

2.1 General

2.1.1 The type of connection and the edge preparation are to be appropriate to the welding procedure adopted, the structural elements to be connected and the stresses to which they are subjected.

2.2 Butt welding

2.2.1 General

In general, butt connections of plating are to be full penetration, welded on both sides except where special procedures or specific techniques, considered equivalent by the Society, are adopted.

Connections different from the above may be accepted by the Society on a case by case basis; in such cases, the relevant detail and workmanship specifications are to be approved.

2.2.2 Welding of plates with different thicknesses

In the case of welding of plates with a difference in gross thickness z equal to or greater than (see Fig 2):

- 3 mm if $t_1 \leq 10$ mm
- 4 mm if $t_1 > 10$ mm,

a taper having a length of not less than 4 times the difference in gross thickness is to be adopted for connections of plating perpendicular to the direction of main stresses. For connections of plating parallel to the direction of main stresses, the taper length may be reduced to 3 times the difference in gross thickness.

The transition between different component dimensions shall be smooth and gradual.

When the difference in thickness is less than the above values, it may be accommodated in the weld transition between plates.

Figure 2 : Transition between different component dimensions

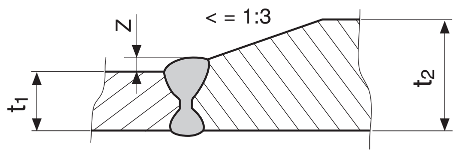
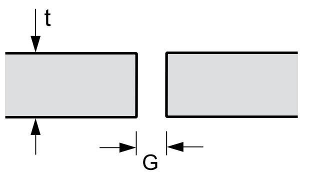
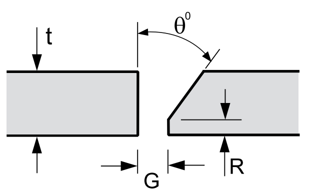
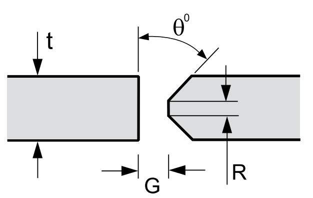
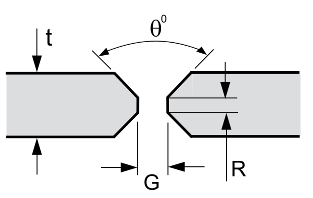
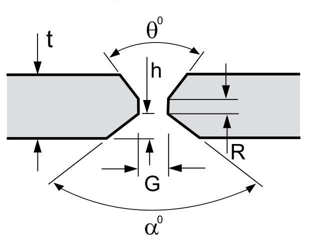


Table 2 : Typical butt weld plate edge preparation (manual welding) - See Note 1

Detail	Standard
Square butt 	$t \leq 5$ mm G = 3 mm
Single bevel butt 	$t > 5$ mm $G \leq 3$ mm $R \leq 3$ mm $50° \leq \theta \leq 70°$
Double bevel butt 	$t > 19$ mm $G \leq 3$ mm $R \leq 3$ mm $50° \leq \theta \leq 70°$
Double vee butt, uniform bevels 	$G \leq 3$ mm $R \leq 3$ mm $50° \leq \theta \leq 70°$
Double vee butt, non-uniform bevels 	$G \leq 3$ mm $R \leq 3$ mm $6 \leq h \leq t/3$ mm $\theta = 50°$ $\alpha = 90°$

Note 1: Different plate edge preparation may be accepted or approved by the Society on the basis of an appropriate welding procedure specification.

2.2.3 Butt welding edge preparation, root gap

Typical butt weld plate edge preparation for manual welding is specified in Tab 2 and Tab 3.

The acceptable root gap is to be in accordance with the adopted welding procedure and relevant bevel preparation.

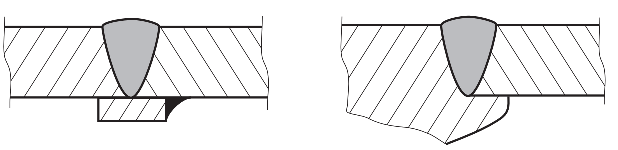
2.2.4 Butt welding on permanent backing

Butt welding on permanent backing, i.e. butt welding assembly of two plates backed by the flange or the face plate of a stiffener, may be accepted where back welding is not feasible or in specific cases deemed acceptable by the Society.

The type of bevel and the gap between the members to be assembled are to be such as to ensure a full penetration of the weld on its backing and an adequate connection to the stiffener as required.

See Fig 3.

Figure 3 : Butt welding on permanent backing



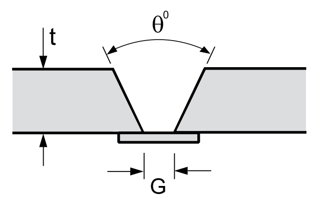
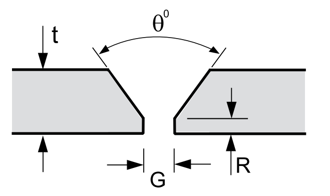
2.2.5 Section, bulbs and flat bars

When lengths of longitudinals of the shell plating and strength deck within 0,6 L amidships, or elements in general subject to high stresses, are to be connected together by butt joints, these are to be full penetration. Other solutions may be adopted if deemed acceptable by the Society on a case by case basis.

The work is to be done in accordance with an approved procedure; in particular, this requirement applies to work done on board or in conditions of difficult access to the welded connection. Special measures may be required by the Society.

Welding of bulbs without a doubler is to be performed by welders specifically certified by the Society for such type of welding.

Table 3 : Typical butt weld plate edge preparation (manual welding) - See Note 1

Detail	Standard
Single vee butt, one side welding with backing strip (temporary or permanent) 	3 ≤ G ≤ 9 mm 30° ≤ θ ≤ 45°
Single vee butt 	G ≤ 3 mm 50° ≤ θ ≤ 70° R ≤ 3 mm
Note 1: Different plate edge preparation may be accepted or approved by the Society on the basis of an appropriate welding procedure specification.	

2.3 Fillet welding

2.3.1 General

Ordinary fillet welding may be adopted for T connections of the various simple and composite structural elements, where they are subjected to low tensile stress or where they are not critical for fatigue.

Where this is not the case, partial or full T penetration welding according to [2.4] is to be adopted.

2.3.2 Fillet welding types

Fillet welding may be of the following types:

- continuous fillet welding, where the weld is constituted by a continuous fillet on each side of the abutting plate (see [2.3.3])
- intermittent fillet welding, which may be subdivided (see [2.3.4]) into:
  - chain welding
  - scallop welding
  - staggered welding.

Table 4 : Welding factors w_F and coefficient φ for the various hull structural connections

Hull area	Connection			w_F **(1)**	φ **(2) (3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
General, unless otherwise specified in the table	watertight plates	boundaries		0,35				
	webs of ordinary stiffeners	plating	at ends **(4)**	0,13				
			elsewhere	0,13	3,5	3,0	4,6	ST 260
		face plate of fabricated stiffeners	at ends **(4)**	0,13				
			elsewhere	0,13	3,5	3,0	4,6	ST 260

Hull area	Connection of	Connection to		w_F **(1)**	φ **(2)** **(3)** CH	SC	ST	p_1, in mm (see [2.3.6]) **(3)**
Bottom and double bottom	longitudinal ordinary stiffeners	bottom and inner bottom plating **(5)**		0,13	3,5	3,0	4,6	ST 260
	centre girder	keel		0,25	1,8	1,8		CH/SC 130
		inner bottom plating		0,20	2,2	2,2		CH/SC 160
	side girders	bottom and inner bottom plating		0,13	3,5	3,0	4,6	ST 260
		floors (interrupted girders)		0,20	2,2			CH 160
	floors	bottom and inner bottom plating	in general	0,13	3,5	3,0	4,6	ST 260
			at ends (20% of span) for longitudinally framed double bottom	0,25	1,8			CH 130
		inner bottom plating in way of brackets of primary supporting members		0,25	1,8			CH 130
		girders (interrupted floors)		0,20	2,2			CH 160
		side girders in way of hopper tanks		0,35				
	partial side girders	floors		0,25	1,8			CH 130
	web stiffeners	floor and girder webs		0,13	3,5	3,0	4,6	ST 260
Side and inner side	ordinary stiffeners	side and inner side plating		0,13	3,5	3,0	4,6	ST 260
	girders and web frames in double side skin ships	side and inner side plating		0,35				
Deck	strength deck	side plating		w_F = 0,45 if t ≤ 15 mm Partial penetration welding if t >15mm				
	non-watertight decks	side plating		0,20	2,2			CH 160
	ordinary stiffeners and intercostal girders	deck plating		0,13	3,5	3,0	4,6	ST 260
	hatch coamings	deck plating	in general	0,35				
			at corners of hatchways for 15% of the hatch length	0,45				
	web stiffeners	coaming webs		0,13	3,5	3,0	4,6	ST 260
Bulkheads	tank bulkhead structures	tank bottom	plating and ordinary stiffeners (plane bulkheads)	0,45				
			vertical corrugations (corrugated bulkheads)	Full penetration welding, in general				
		boundaries other than tank bottom		0,35				
	watertight bulkhead structures	boundaries		0,35				
	non-watertight bulkhead structures	boundaries	wash bulkheads	0,20	2,2	2,2		CH/SC 160
			others	0,13	3,5	3,0	4,6	ST 260
	ordinary stiffeners	bulkhead plating	in general **(5)**	0,13	3,5	3,0	4,6	ST 260
			at ends (25% of span), where no end brackets are fitted	0,35				
Fore peak **(6)**	bottom longitudinal ordinary stiffeners	bottom plating		0,20	2,2			CH 160
	floors and girders	bottom and inner bottom plating		0,25	1,8			CH 130
	side frames in panting area	side plating		0,20	2,2			CH 160
	webs of side girders in single side skin structures	side plating and face plate	A < 65 cm² **(7)**	0,25	1,8	1,8		CH/SC 130
			A ≥ 65 cm² **(7)**	See Tab 5				
After peak **(6)**	internal structures	each other		0,20				
	side ordinary stiffeners	side plating		0,20				
	floors	bottom and inner bottom plating		0,20				

Hull area	Connection			w_F **(1)**	φ **(2)** **(3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
Machinery space **(6)**	centre girder	keel and inner bottom plating	in way of main engine foundations	0,45				
			in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,25	1,8	1,8		CH/SC 130
	side girders	bottom and inner bottom plating	in way of main engine foundations	0,45				
			in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,20	2,2	2,2		CH/SC 160
	floors (except in way of main engine foundations)	bottom and inner bottom plating	in way of seating of auxiliary machinery and boilers	0,35				
			elsewhere	0,20	2,2	2,2		CH/SC 160
	floors in way of main engine foundations	bottom plating		0,35				
		foundation plates		0,45				
	floors	centre girder	single bottom	0,45				
			double bottom	0,25	1,8	1,8		CH/SC 130
Super-structures and deckhouses	external bulkheads	deck	in general	0,35				
			engine and boiler casings at corners of openings (15% of opening length)	0,45				
	internal bulkheads	deck		0,13	3,5	3,0	4,6	ST 260
	ordinary stiffeners	external and internal bulkhead plating		0,13	3,5	3,0	4,6	ST 260
Hatch covers	ordinary stiffener	plating		0,13	3,5	3,0	4,6	ST 260
Pillars	elements composing the pillar section	each other (fabricated pillars)		0,13				
	pillars	deck	pillars in compression	0,35				
			pillars in tension	See [3.7]				
Ventilators	coamings	deck		0,35				
Rudders	horizontal and vertical webs directly connected to solid parts	solid parts or rudder stock		According to Ch 7, Sec 1, [6.3] or Ch 7, Sec 1, [6.4]				
		elsewhere	for shear force greater than or equal to 45% of the maximum rudder body value	0,45				
			for shear force lower than 45% of the maximum rudder body value	0,20				
	other webs	each other		0,20		2,2		SC 160
		plating	in general	0,20		2,2		SC 160
			top and bottom plates of rudder plating	0,35				

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.

(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted and continuous welding is to be adopted.

(3) CH = chain welding, SC = scallop welding, ST = staggered welding.

(4) The web at the end of intermittently welded girders or stiffeners is to be continuously welded to the plating or the flange plate, as applicable, over a distance d at least equal to the depth h of the girder or stiffeners, with 300 mm ≥ d ≥ 75 mm. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes.

(5) In tanks intended for the carriage of ballast or fresh water, continuous welding with $w_F = 0,35$ is to be adopted.

(6) For connections not mentioned, the requirements for the central part apply.

(7) A is the face plate sectional area of the side girders, in cm^2.

Table 5 : Welding factors w_F and coefficient φ for connections of primary supporting members

Primary supporting member	Connection			w_F **(1)**	φ **(2)** **(3)**			p_1, in mm (see [2.3.6]) **(3)**
	of	to			CH	SC	ST	
General **(4)**	web, where A < 65 cm²	plating and face plate	at ends	0,20				
			elsewhere	0,15	3,0	3,0		CH/SC 210
	web, where A ≥ 65 cm²	plating		0,35				
		face plate	at ends	0,35				
			elsewhere	0,25	1,8	1,8		CH/SC 130
	end brackets	face plate		0,35				
In tanks, where A < 65 cm² **(5)**	web	plating	at ends	0,25				
			elsewhere	0,20	2,2	2,2		CH/SC 160
		face plate	at ends	0,20				
			elsewhere	0,15	3,0	3,0		CH/SC 210
	end brackets	face plate		0,35				
In tanks, where A ≥ 65 cm²	web	plating	at ends	0,45				
			elsewhere	0,35				
		face plate		0,35				
	end brackets	face plate		0,45				

(1) In connections for which $w_F \geq 0,35$, continuous fillet welding is to be adopted.
(2) For coefficient φ, see [2.3.4]. In connections for which no φ value is specified for a certain type of intermittent welding, such type is not permitted.
(3) CH = chain welding, SC = scallop welding, ST = staggered welding.
(4) For cantilever deck beams, continuous welding is to be adopted.
(5) For primary supporting members in tanks intended for the carriage of ballast or fresh water, continuous welding is to be adopted.

Note 1:
A is the face plate sectional area of the primary supporting member, in cm².

Note 2:
Ends of primary supporting members means the area extended 20% of the span from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 100 mm beyond the bracket toes.

2.3.3 Continuous fillet welding

Continuous fillet welding is to be adopted:

- for watertight connections
- for connections of brackets, lugs and scallops
- at the ends of connections for a length of at least 75 mm
- for connections of stiffeners subject to wheeled loads
- where intermittent welding is not allowed, according to [2.3.4].

Continuous fillet welding may also be adopted in lieu of intermittent welding wherever deemed suitable, and it is recommended where the spacing p, calculated according to [2.3.4], is low.

2.3.4 Intermittent welding

In water, fuel and cargo tanks, in the bottom area of fuel oil tanks and of spaces where condensed or sprayed water may accumulate and in hollow components (e.g. rudders) threatened by corrosion, only continuous or intermittent scallop welding shall be used.

Where the plating is liable to be subjected to locally concentrated loads (e.g. due to grounding or impacts when berthing) intermittent welding with scallops should not be used.

The spacing p and the length d, in mm, of an intermittent weld, shown in:

- Fig 4 for chain welding
- Fig 5 for scallop welding
- Fig 6 for staggered welding,

are to be such that:

$$p / d \leq \varphi$$

where the coefficient φ is defined in Tab 4 and Tab 5 for the different types of intermittent welding, depending on the type and location of the connection.

In general, staggered welding is not allowed for connections subjected to high alternate stresses.

One side continuous welding may be accepted instead of chain and staggered intermittent welding for connections of stiffeners in the dry spaces of deckhouses and superstructures, where not affected by external pressure, tank pressure or concentrated loads.

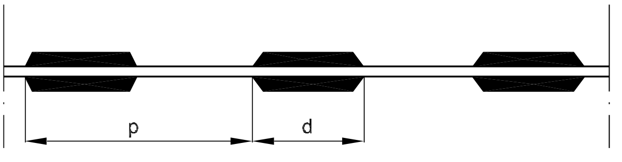
In addition, the following limitations are to be complied with:

- chain welding (see Fig 4):

  $d \geq 75$ mm

  $p - d \leq 200$ mm

Figure 4 : Intermittent chain welding



- scallop welding (see Fig 5):

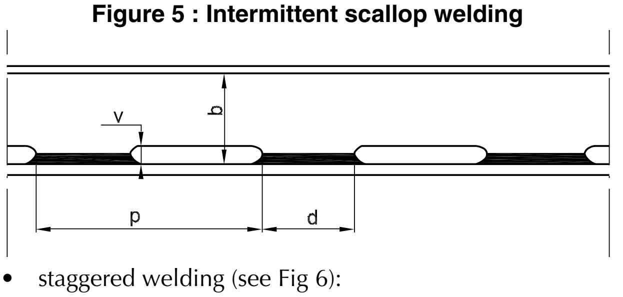
  $d \geq 75$ mm

  $p - d \leq 25$ t and $p - d \leq 150$ mm,

  where t is the lesser thickness of parts to be welded

  $v \leq 0,25$ b, without being greater than 75 mm

Figure 5 : Intermittent scallop welding



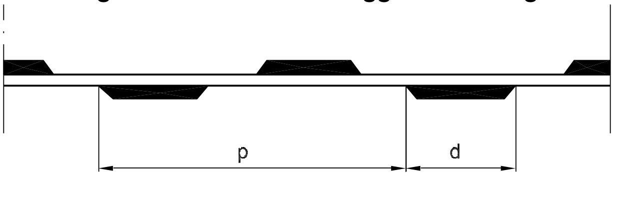
- staggered welding (see Fig 6):

  $d \geq 75$ mm

  $p - 2\ d \leq 300$ mm

  $p \leq 2\ d$ for connections subjected to high alternate stresses.

Figure 6 : Intermittent staggered welding



2.3.5 Throat thickness of fillet weld T connections

Fillet welds shall normally be made on both sides, and exceptions to this rule (as in the case of closed box girders and predominant shear stresses parallel to the weld) are subject to approval in each individual case.

The minimum throat thickness of fillet weld T connections is to be obtained, in mm, from the following formula:

$$t_T = w_F t \frac{p}{d}$$

where:

w_F : Welding factor, defined in Tab 4 for the various hull structural connections; for connections of primary supporting members belonging to single skin structures and not mentioned in Tab 4, w_F is defined in Tab 5

t : Actual gross thickness, in mm, of the structural element which constitutes the web of the T connection

p, d : Spacing and length, in mm, of an intermittent weld, defined in [2.3.4].

For continuous fillet welds, p / d is to be taken equal to 1.

Unless otherwise agreed (e.g. for the fully mechanised welding of smaller plate thicknesses in appropriate clamping jigs), the minimum fillet weld throat thickness shall be the greater of:

- $t_{T-min} = \sqrt{\dfrac{t_1 + t_2}{3}}$

and:

- 3,0 mm for $t_1 \leq 6$ mm

  3,5 mm for $t_1 > 6$ mm,

where:

t_1, t_2 : Thicknesses of connected plates with $t_1 < t_2$.

In the case of automatic or semi-automatic deep penetration weld, the throat thickness may be reduced according to [2.3.9]. Prior to start fabrication welding with deep penetration a production test has to be conducted to ensure the relevant weld quality. The kind of tests and the test scope has to be agreed with the Society.

The throat thickness may be required by the Society to be increased, depending on the results of structural analyses.

The leg length of fillet weld T connections is to be not less than 1,4 times the required throat thickness.

2.3.6 Weld dimensions in a specific case

Where intermittent fillet welding is adopted with:

- length d = 75 mm
- throat thickness t_T specified in Tab 6 depending on the thickness t defined in [2.3.5],

the weld spacing may be taken equal to the value p_1 defined in Tab 4. The values of p_1 in Tab 4 may be used when $8 \leq t \leq 16$ mm.

For thicknesses t less than 8 mm, the values of p_1 may be increased, with respect to those in Tab 4, by:

- 10 mm for chain or scallop welding
- 20 mm for staggered welding,

without exceeding the limits in [2.3.4].

For thicknesses t greater than 16 mm, the values of p_1 are to be reduced, with respect to those in Tab 4, by:

- 10 mm for chain or scallop welding
- 20 mm for staggered welding.

Table 6 : Required throat thickness

t, in mm	t_T , in mm	t, in mm	t_T , in mm
6	3,0	17	7,0
8	3,5	18	7,0
9	4,0	19	7,5
10	4,5	20	7,5
11	5,0	21	8,5
12	5,5	22	8,5
13	6,0	23	9,0
14	6,0	24	9,0
15	6,5	25	10,0
16	6,5	26	10,0

2.3.7 Throat thickness of welds between cut-outs

The throat thickness of the welds between the cut-outs in primary supporting member webs for the passage of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formula:

$$t_{TC} = t_T \frac{\varepsilon}{\lambda}$$

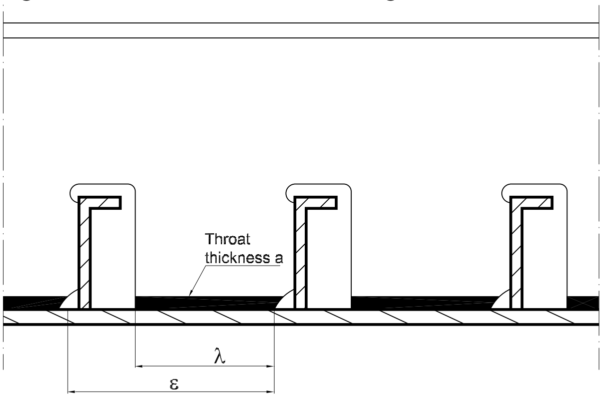
where:

t_T : Throat thickness defined in [2.3.5]

ε, λ : Dimensions, in mm, to be taken as shown in:

- Fig 7 for continuous welding
- Fig 8 for intermittent scallop welding.

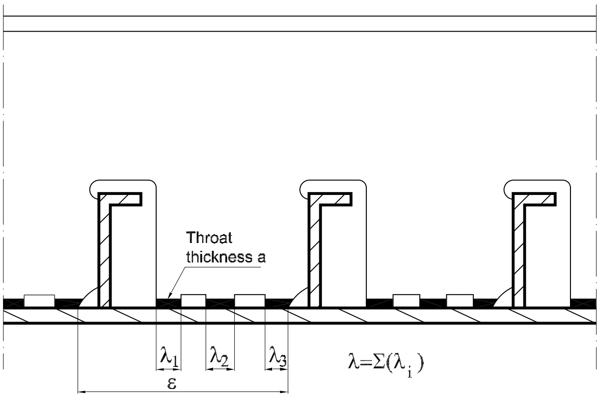
Figure 7 : Continuous fillet welding between cut-outs



2.3.8 Throat thickness of welds connecting ordinary stiffeners with primary supporting members

The throat thickness of fillet welds connecting ordinary stiffeners and collar plates, if any, to the web of primary supporting members is to be not less than 0,35 t_W, where t_W is the web gross thickness, in mm.

Figure 8 : Intermittent scallop fillet welding between cut-outs



2.3.9 Throat thickness of deep penetration fillet welding

When fillet welding is carried out with automatic welding processes, the throat thickness required in [2.3.5] may be reduced up to 15%, depending on the penetration of the weld process. The evidence of the weld penetration is subject to a welding procedure test which has to be approved by the Society. However, this reduction may not be greater than 1,5 mm.

The same reduction applies also for semi-automatic procedures where the welding is carried out in the downhand position.

2.4 Partial and full T penetration welding

2.4.1 General

Partial or full T penetration welding is to be adopted for connections subjected to high stresses for which fillet welding is considered unacceptable by the Society.

Typical edge preparations are indicated in:

- for partial penetration welds: Fig 9 and Fig 10, in which f, in mm, is to be taken between 3 mm and t / 3, and α between 45° and 60°
- for full penetration welds: Fig 11 and Fig 12, in which f, in mm, is to be taken between 0 and 3 mm, and α between 45° and 60°.

  Back gouging is generally required for full penetration welds.

Figure 9 : Partial penetration weld

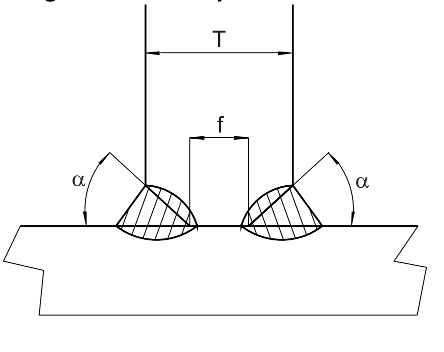


Figure 10 : Partial penetration weld

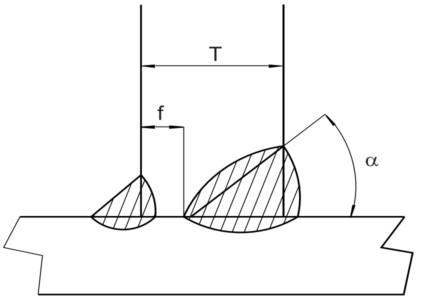


Figure 11 : Full penetration weld

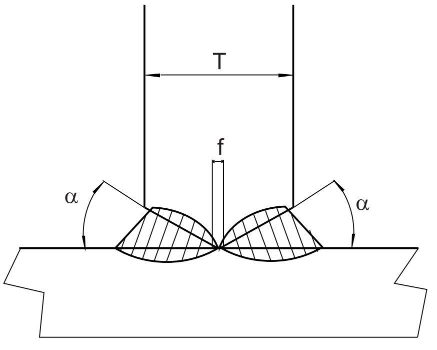
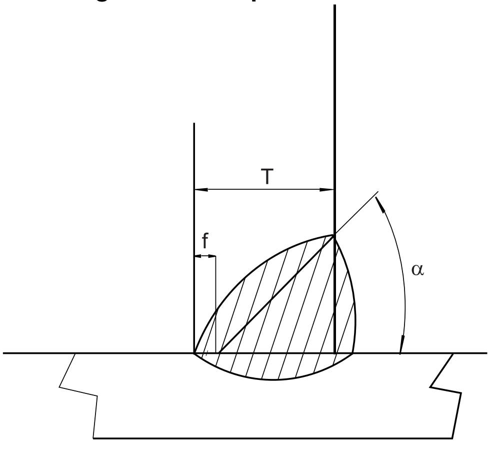


Figure 12 : Full penetration weld



2.4.2 Lamellar tearing

Precautions are to be taken in order to avoid lamellar tears, which may be associated with:

- cold cracking when performing T connections between plates of considerable thickness or high restraint
- large fillet welding and full penetration welding on higher strength steels.

Additional provisions may be required by the Society on a case by case basis.

2.5 Lap-joint welding

2.5.1 General

Lap-joint welding may be adopted for:

- peripheral connection of doublers
- internal structural elements subjected to very low stresses.

Elsewhere, lap-joint welding may be allowed by the Society on a case by case basis, if deemed necessary under specific conditions.

Continuous welding is generally to be adopted.

2.5.2 Gap

The surfaces of lap-joints are to be in sufficiently close contact.

2.5.3 Dimensions

The dimensions of the lap-joint are to be specified and are considered on a case by case basis. Typical details are given in Tab 7.

2.6 Slot welding

2.6.1 General

Slot welding may be adopted in very specific cases subject to the special agreement of the Society, e.g. for doublers according to Ch 2, Sec 4, [3.1].

In general, slot welding of doublers on the outer shell and strength deck is not permitted within 0,6L amidships. Beyond this zone, slot welding may be accepted by the Society on a case by case basis.

Slot welding is, in general, permitted only where stresses act in a predominant direction. Slot welds are, as far as possible, to be aligned in this direction.

2.6.2 Dimensions

Slot welds are to be of appropriate shape (in general oval) and dimensions, depending on the plate thickness, and may not be completely filled by the weld.

Typical dimensions of the slot weld and the throat thickness of the fillet weld are given in Tab 7.

The distance between two consecutive slot welds is to be not greater than a value which is defined on a case by case basis taking into account:

- the transverse spacing between adjacent slot weld lines
- the stresses acting in the connected plates
- the structural arrangement below the connected plates.

2.7 Plug welding

2.7.1 Plug welding may be adopted only when accepted by the Society on a case by case basis, according to specifically defined criteria. Typical details are given in Tab 7.

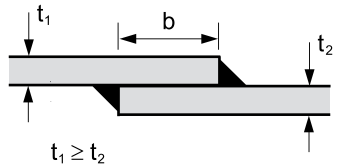
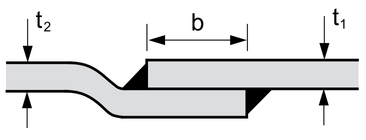
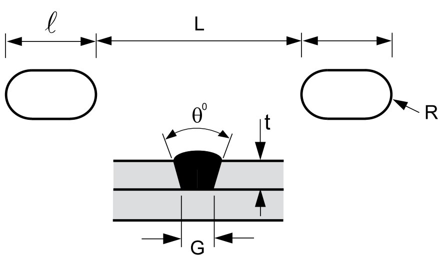
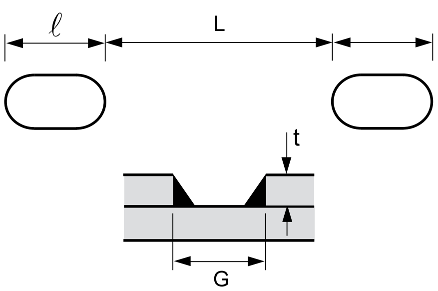
3 Specific weld connections

3.1 Corner joint welding

3.1.1 Corner joint welding, as adopted in some cases at the corners of tanks, performed with ordinary fillet welds, is permitted provided the welds are continuous and of the required size for the whole length on both sides of the joint.

3.1.2 Alternative solutions to corner joint welding may be considered by the Society on a case by case basis.

Table 7 : Typical lap joint, plug and slot welding (manual welding)

Detail	Standard	Remark
Fillet weld in lap joint  $t_1 \geq t_2$	$b = 2\ t_2 + 25$ mm	location of lap joint to be approved by the Society
Fillet weld in joggled lap joint  $t_1 \geq t_2$	$b \geq 2\ t_2 + 25$ mm	
Plug welding 	• $t \leq 12$ mm $\ell = 60$ mm $R = 6$ mm $40° \leq \theta \leq 50°$ $G = 12$ mm $L > 2\ \ell$ • 12 mm $< t \leq 25$ mm $\ell = 80$ mm $R = 0{,}5\ t$ (mm) $\theta = 30°$ $G = t$ (mm) $L > 2\ \ell$	
Slot welding 	• $t \leq 12$ mm $G = 20$ mm $\ell = 80$ mm $2\ \ell \leq L \leq 3\ \ell$, max 250 mm • $t > 12$ mm $G = 2\ t$ $\ell = 100$ mm $2\ \ell \leq L \leq 3\ \ell$, max 250 mm	

3.2 Bilge keel connection

3.2.1 The intermediate flat, through which the bilge keel is connected to the shell according to Pt D, Ch 2, Sec 12, [2.1], is to be welded as a shell doubler by continuous fillet welds.

The butt welds of the doubler and bilge keel are to be full penetration and shifted from the shell butts.

The butt welds of the bilge plating and those of the doublers are to be flush in way of crossing, respectively, with the doubler and with the bilge keel.

Butt welds of the intermediate flat are to be made to avoid direct connection with the shell plating, in order that they do not alter the shell plating, by using, for example, a copper or a ceramic backing.

3.3 Struts connecting ordinary stiffeners

3.3.1 In case of a strut connected by lap joint to the ordinary stiffener, the throat thickness of the weld is to be obtained, in mm, from the following formula:

$$t_T = \frac{\eta F}{n_W \ell_W \tau} 10^3$$

where:

F : Maximum force transmitted by the strut, in kN

η : Safety factor, to be taken equal to 2

n_W : Number of welds in way of the strut axis

ℓ_W : Length of the weld in way of the strut axis, in mm

τ : Permissible shear stress, to be taken equal to 100 N/mm².

3.4 Connection between propeller post and propeller shaft bossing

3.4.1 Fabricated propeller posts are to be welded with full penetration welding to the propeller shaft bossing.

3.5 Bar stem connections

3.5.1 The bar stem is to be welded to the bar keel generally with butt welding.

The shell plating is also to be welded directly to the bar stem with butt welding.

3.6 Deck subjected to wheeled loads

3.6.1 Double continuous fillet welding is to be adopted for the connections of ordinary stiffeners with deck plating.

3.7 Pillars connection

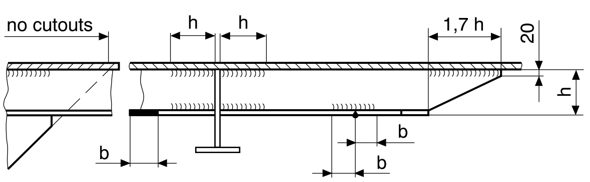
3.7.1 For pillars in tension, continuous fillet welding may be accepted provided that the tensile stress in welds does not exceed 50/k N/mm^2, where k is the greatest material factor of the welded elements and the filler metal.

For pillars subjected to higher tensile stress, full penetration welding is to be adopted.

3.8 Welds at the ends of structural members

3.8.1 As shown in Fig 13, the web at the end of intermittently welded girders or stiffeners is to be continuously welded to the plating or the flange plate, as applicable, over a distance at least equal to the depth h of the girder or stiffener, subject to a maximum of 300 mm and minimum of 75 mm.

Figure 13 : Welds at the ends of girders and stiffeners



3.8.2 The areas of bracket plates should be continuously welded over a distance at least equal to the length of the bracket plate. Scallops are to be located only beyond a line imagined as an extension of the free edge of the bracket plate.

3.8.3 Wherever possible, the free ends of stiffeners shall abut against the transverse plating or the webs of sections and girders so as to avoid stress concentrations in the plating. Failing this, the ends of the stiffeners shall be cut off obliquely and shall be continuously welded over a distance of at least 1,7 h, subject to a maximum of 300 mm.

3.8.4 Where butt joints occur in flange plates, the flange shall be continuously welded to the web on both sides of the joint over a distance at least equal to the width of the flange.

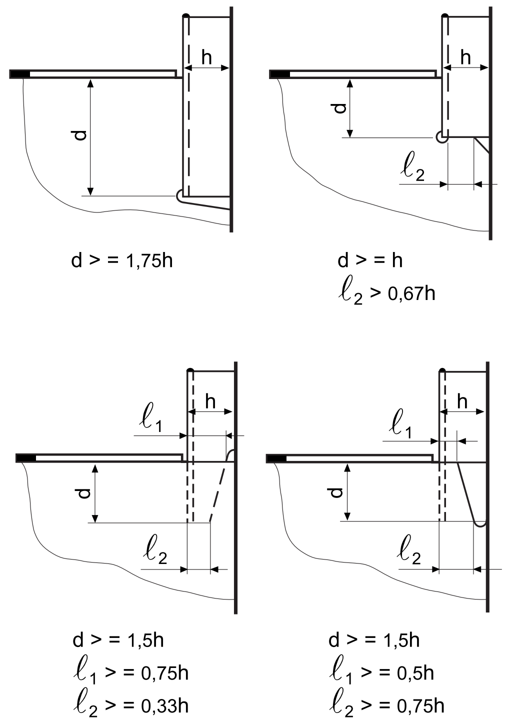
3.9 Joints between section ends and plates

3.9.1 Welded joints uniting section ends and plates (e.g. at lower ends of frames) may be made in the same plane or lapped.

Where no design calculations have been carried out or stipulated for the welded connections, the joints may be made analogously to those shown in Fig 14.

If the thickness t_1 of the section web is greater than the thickness t of the plate to be connected, the length of the joint d must be increased in the ratio t_1 / t.

Figure 14 : Joints between section ends and plates



3.9.2 Where the joint lies in the plane of the plate, it may conveniently take the form of a single-bevel butt weld with fillet. Where the joint between the plate and the section end overlaps, the fillet weld must be continuous on both sides and must meet at the ends. The necessary a dimension is to be calculated in accordance with Ch 2, Sec 8, [3.7] but need not exceed 0,6 t. The fillet weld throat thickness shall not be less than the minimum specified in [2.3.5].

3.10 Welded shaft bracket joints

3.10.1 Unless cast in one piece and provided with integrally cast welding flanges (see Fig 15), strut barrel and struts are to be connected to each other and to the shell plating in the manner shown in Fig 16.

3.10.2 In the case of single-strut shaft brackets no welding may be performed on the arm at or close to the position of constraint. Such components must be provided with integrally forged or cast welding flanges in the manner shown in Fig 15.

3.11 Rudder coupling flanges

3.11.1 Unless forged or cast steel flanges with integrally forged or cast welding flanges are used, horizontal rudder coupling flanges are to be joined to the rudder body by plates of graduated thickness and full penetration single or double-bevel welds as prescribed in [2.4] (see Fig 17).

Figure 15 : Shaft bracket with integrally cast welding flanges

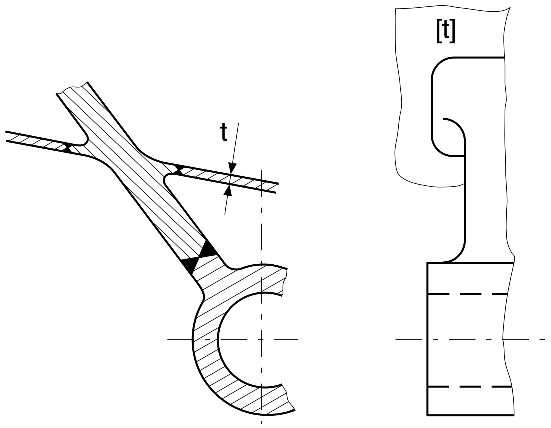
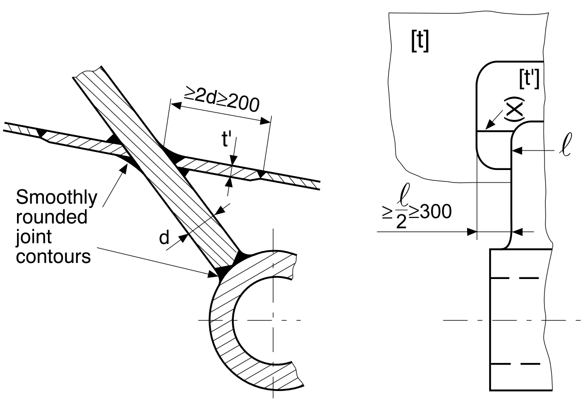


Figure 16 : Shaft bracket without integrally cast welding flanges

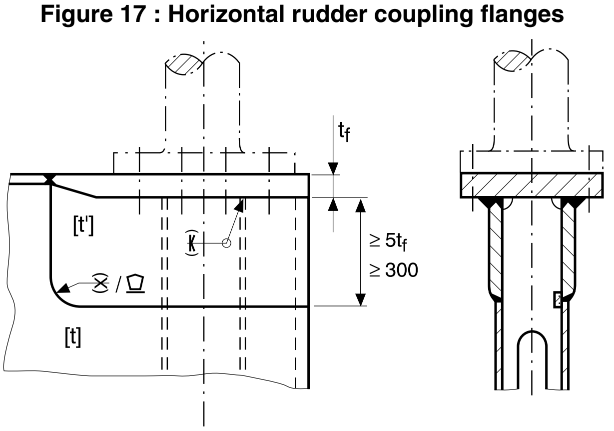


t : Shell plating thickness

t' = d/3 + 5 mm, where d < 50 mm

t' = 3 $d^{0,5}$ mm, where d ≥ 50 mm.

Figure 17 : Horizontal rudder coupling flanges



t : Rudder plating thickness, in mm

t_f : Actual flange thickness, in mm

t' = 1,25 t

3.11.2 Allowance shall be made for the reduced strength of the coupling flange in the thickness direction (see Note 1). It is recommended that a material with guaranteed properties in the thickness direction (Z grade) should be used for this purpose. In case of doubt, proof by calculation of the adequacy of the welded connection shall be produced.

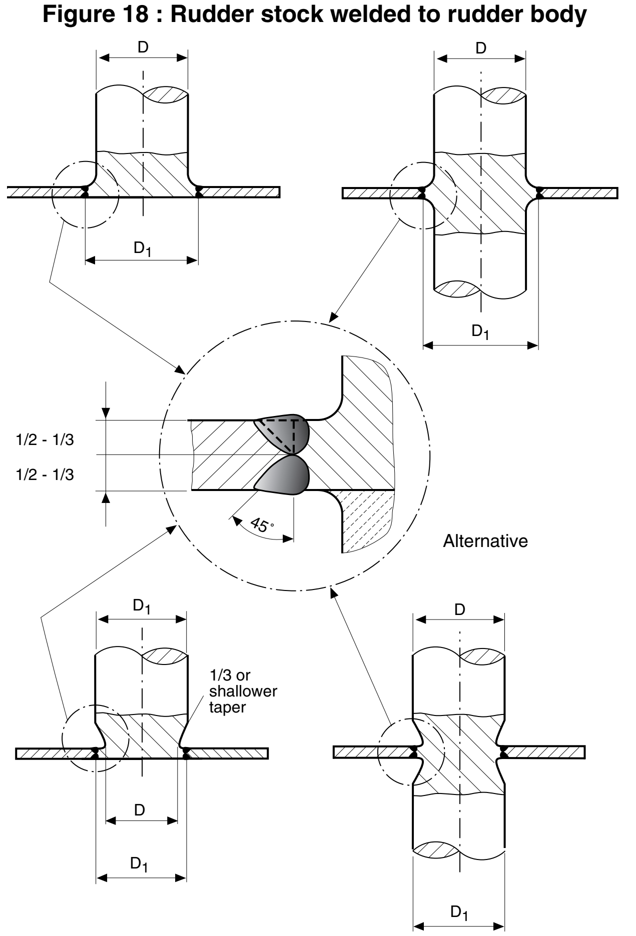
Note 1: Special characteristics peculiar to the material such as the (lower) strength values of rolled material in the thickness direction or the softening of cold hardened aluminium as a result of welding are factors which have to be taken into account when designing and dimensioning welded joints.

3.12 Welded joints between rudder stock and rudder body

3.12.1 Where rudder stocks are welded into the rudder body, a thickened collar of the type shown in Fig 18 must be provided at the upper mounting (top edge of rudder body). The welded joint between the collar and the top rib is to take the form of a full penetration single or double-bevel weld in accordance with [2.4].

The transitions from the weld to the collar are to be free from notches. The collar radii shall be kept free from welds in every case.

Figure 18 : Rudder stock welded to rudder body



D_1 = 1,1 D without being less than D + 20 mm

$D_{1\,min}$ = D + 10 mm (applies only to alternative solution),

where D is the rudder stock diameter, in mm.

3.13 Deck subjected to wheeled loads

3.13.1 Double continuous fillet welding is to be adopted for the connections of ordinary stiffeners with deck plating.

4 Workmanship

4.1 Welding procedures and consumables

4.1.1 The various welding procedures and consumables are to be used within the limits of their approval and in accordance with the conditions of use specified in the respective approval documents.

Welding may only be performed on materials whose identity and weld ability under the given fabricating conditions can be unequivocally established by reference to markings, certificates, etc. Only welding consumables and auxiliary materials tested and approved according to the Society's Rules and of a quality grade standards recognized by the Society appropriate to the base material to be welded may be used.

4.2 Welding operations

4.2.1 Weather protection

The area in which welding work is performed (particularly outside) is to be sheltered from wind, damp and cold. Where gas-shielded arc welding is carried out, special attention is to be paid to ensuring adequate protection against draughts. When working in the open under unfavourable weather conditions it is advisable to dry welding edges by heating.

4.2.2 Butt connection edge preparation

The edge preparation is to be of the required geometry and correctly performed. In particular, if edge preparation is carried out by flame, it is to be free from cracks or other detrimental notches.

Seam edges (groove faces) prepared by thermal cutting shall be finished by machining (e.g. grinding) if a detrimental effect on the welded joint as a result of the cutting operation cannot be ruled out. Welding edges of steel castings and forgings shall always be ground as a minimum requirement; roll scale or casting skin is to be removed.

4.2.3 Surface condition

The surfaces to be welded are to be free from rust, moisture and other substances, such as mill scale, slag caused by oxygen cutting, grease or paint, which may produce defects in the welds.

Effective means of cleaning are to be adopted particularly in connections with special welding procedures; flame or mechanical cleaning may be required.

The presence of a shop primer may be accepted, provided it has been approved by the Society.

Shop primers are to be approved by the Society for a specific type and thickness according to NR216 Materials and Welding.

4.2.4 Assembling and gap

The setting appliances and system to be used for positioning are to ensure adequate tightening adjustment and an appropriate gap of the parts to be welded, while allowing maximum freedom for shrinkage to prevent cracks or other defects due to excessive restraint.

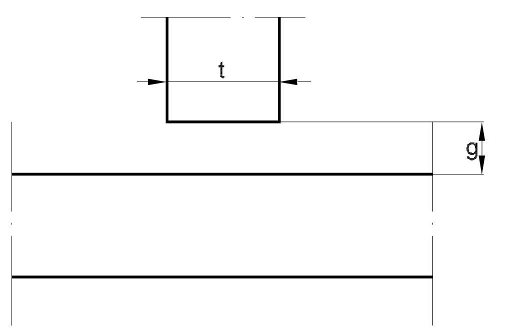
The gap between the edges is to comply with the required tolerances or, when not specified, it is to be in accordance with normal good practice.

When preparing and assembling components, care shall be taken to ensure compliance with the weld shapes and root openings (air gaps) specified in the manufacturing documents. With single and double bevel butt welds in particular, care shall be taken to make an adequate root opening to achieve sufficient root penetration. Moisture or dirt shall be carefully removed before welding.

4.2.5 Gap in fillet weld T connections

In fillet weld T connections, a gap g, as shown in Fig 19, may not be greater than 2 mm. In the case of a gap greater than 2 mm, the throat thickness shall be increased accordingly, or a single or double-bevel weld shall be made, subject to the consent of the Surveyor. Inserts and wires may not be used as fillers.

Figure 19 : Gap in fillet weld T connections



4.2.6 Plate misalignment in butt connections

The misalignment m, measured as shown in Fig 20, between plates with the same gross thickness t is to be less than 0,15 t, without being greater than 3 mm.

4.2.7 Misalignment in cruciform connections

The misalignment m in cruciform connections, measured on the median lines as shown in Fig 21, is to be less than:

- t /2, in general, where t is the gross thickness of the thinner abutting plate for steel grade A, B and D
- t /3, where t is the gross thickness of the thinner abutting plate for steel grade AH32 to DH40.

The Society may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

Figure 20 : Plate misalignment in butt connections

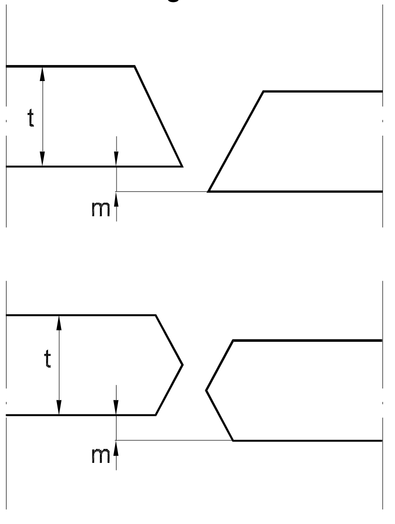
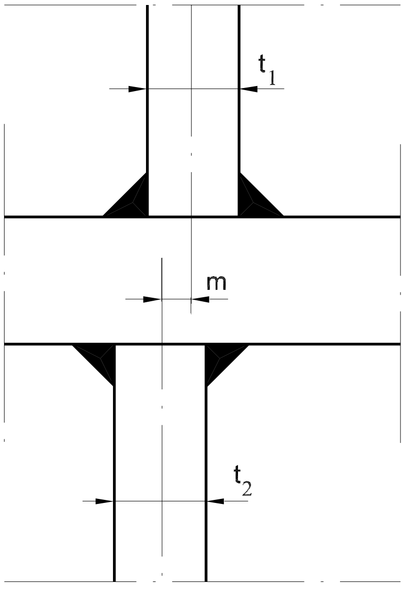


Figure 21 : Misalignment in cruciform connections



4.2.8 Assembling of aluminium alloy parts

When welding aluminium alloy parts, particular care is to be taken so as to:

- reduce as far as possible restraint from welding shrinkage, by adopting assembling and tack welding procedures suitable for this purpose
- keep possible deformations within the allowable limits.

Further specifications may be required by the Society on a case by case basis.

4.2.9 Preheating and interpass temperatures, welding in cold conditions

The need for and degree of preheating is determined by various factors, such as chemical composition, plate thickness, two or three-dimensional heat dissipation, ambient and work piece temperatures, or heat input during welding.

At low (subzero) temperatures, suitable measures shall be taken to ensure the satisfactory quality of the welds. Such measures include the shielding of components, large area preliminary warming and preheating, especially when welding with a relatively low heat input, e.g. when laying down thin fillet welds or welding thick-walled components. Wherever possible, no welding should be performed at temperatures below –10°C.

Normal-strength hull structural steels do not normally require preheating. In the case of corresponding thick-walled steel castings and forgings, gentle preheating to approximately 80 - 120°C is advisable. The necessary preheating temperatures of other materials (e.g. thick-walled higher tensile steels) have to comply with the applicable Society's Rules for Materials and Welding.

Suitable preheating, to be maintained during welding, and slow cooling may be required by the Society on a case by case basis.

The preheating and interpass temperatures are to be shown in the welding procedures which have to be approved by the Society.

4.2.10 Welding sequences

Welding sequences and direction of welding are to be determined so as to minimise deformations and prevent defects in the welded connection.

All main connections are generally to be completed before the vessel is afloat.

Departures from the above provision may be accepted by the Society on a case by case basis, taking into account any detailed information on the size and position of welds and the stresses of the zones concerned, both during vessel launching and with the vessel afloat.

4.2.11 Interpass cleaning

After each run, the slag is to be removed by means of a chipping hammer and a metal brush; the same precaution is to be taken when an interrupted weld is resumed or two welds are to be connected.

4.2.12 Stress relieving

It is recommended and in some cases it may be required that special structures subject to high stresses, having complex shapes and involving welding of elements of considerable thickness (such as rudder spades and stern frames), are prefabricated in parts of adequate size and stress-relieved in the furnace, before final assembly, at a temperature within the range 550°C ÷ 620°C, as appropriate for the type of steel.

Further specifications may be required by the Society on a case by case basis.

Welding may be performed at the cold formed sections and adjacent areas of hull structural steels and comparable structural steels provided that the minimum bending radius is not less than those specified in Tab 8.

Table 8 : Minimum bending radius of welding of cold formed sections

Plate thickness t (mm)	Minimum inner bending radius r
up to 4	1,0 t
up to 8	1,5 t
up to 12	2,0 t
up to 24	3,0 t
over 24	5,0 t

4.3 Crossing of structural elements

4.3.1 In the case of T crossing of structural elements (one element continuous, the other physically interrupted at the crossing) when it is essential to achieve structural continuity through the continuous element (continuity obtained by means of the welded connections at the crossing), particular care is to be devoted to obtaining the correspondence of the interrupted elements on both sides of the continuous element. Suitable systems for checking such correspondence are to be adopted.

5 Modifications and repairs during construction

5.1 General

5.1.1 Deviations in the joint preparation and other specified requirements, in excess of the permitted tolerances and found during construction, are to be repaired as agreed with the Society on a case by case basis.

5.2 Gap and weld deformations

5.2.1 Welding by building up of gaps exceeding the required values and repairs of weld deformations may be accepted by the Society upon special examination.

5.3 Defects

5.3.1 Defects and imperfections on the materials and welded connections found during construction are to be evaluated for possible acceptance on the basis of the applicable requirements of the Society.

Where the limits of acceptance are exceeded, the defective material and welds are to be discarded or repaired, as deemed appropriate by the Surveyor on a case by case basis.

When any serious or systematic defect is detected either in the welded connections or in the base material, the manufacturer is required to promptly inform the Surveyor and submit the repair proposal.

The Surveyor may require destructive or non-destructive examinations to be carried out for initial identification of the defects found and, in the event that repairs are undertaken, for verification of their satisfactory completion.

5.4 Repairs on structures already welded

5.4.1 In the case of repairs involving the replacement of material already welded on the hull, the procedures to be adopted are to be agreed with the Society on a case by case basis.

6 Inspections and checks

6.1 General

6.1.1 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 Building Yard suitable to check compliance with the applicable requirements, reviewed/approved plans and standards.

6.1.2 The Building yard is to make available to the Surveyor a list of the manual welders and welding operators and their respective qualifications.

The Building yard'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.

6.1.3 The Building yard is responsible for ensuring that the operating conditions, welding procedures and work schedule are in accordance with the applicable requirements, reviewed/approved plans and recognised good welding practice.

6.1.4 The Building yard is responsible for ensuring that non-destructive examination (NDE) procedures and plans are adhered to during the construction and that NDE reports are made available to the Society.

6.2 Non-destructive examination

6.2.1 Non-destructive examination techniques refer to the testing methods applicable to the detection of surface imperfections (Visual Testing, Magnetic particle Testing, Liquid penetrant Testing) or sub-surface imperfections (Ultrasonic Testing, Radiographic Testing, Time Of Flight Diffraction Testing, Phased Array Ultrasonic Testing).

6.2.2 In case of non-destructive testing carried out by an independent company from the manufacturer or shipyard, such company has to comply with the requirements set out in NR669 “Recognition of non-destructive testing suppliers”.

6.2.3 NDE of hull welds are to be performed in accordance with written procedures accepted by the Society. Such procedures are to contain appropriate details about the applied codes or standards, testing method, equipment, calibration, testing conditions and personnel qualification.

6.2.4 The NDE acceptance criteria defined by the Building yard are to be submitted to the Society and should comply with a recognized standard which has been accepted by the Society.

6.2.5 All finished welds are to be subjected to visual testing by the Building yard's qualified personnel.

6.2.6 After completion of the welding operation and workshop inspection, the structure is to be presented to the Surveyor for general visual examination at a suitable stage of fabrication.

As far as possible, the results on non-destructive examinations are to be submitted.

6.2.7 Radiographic testing is to be carried out on the welded connections of the hull in accordance with [6.3]. The results are to be made available to the Society. The surveyor may require to witness some testing preparations.

6.2.8 The Society may accept radiographic testing to be replaced by ultrasonic testing.

6.2.9 The Shipbuilder's NDE plan describing the extent, type and location of NDE is to be submitted to the Society for acceptance.

6.2.10 When the non-destructive examinations reveal the presence of unacceptable indications, the relevant connection is to be repaired to an extent and according to a procedure agreed with the Surveyor.

The repaired zone is then to be submitted to non-destructive examination, using a method deemed suitable by the Surveyor to verify that the repair is satisfactory.

Additional examinations may be required by the Surveyor on a case by case basis.

6.2.11 Ultrasonic and magnetic particle testing may also be required by the Surveyor in specific cases to check the base material.

6.3 Radiographic inspection

6.3.1 A radiographic inspection is to be carried out on the welded butts of shell plating, strength deck plating as well as of members contributing to the longitudinal strength. This inspection may also be required for the joints of members subject to heavy stresses.

The requirements [6.3.2] to [6.3.5] constitute general rules: the number of radiographs may be increased where requested by the Surveyor, mainly where visual inspection or radiographic soundings have revealed major defects, specially for butts of sheerstrake, stringer plate, bilge strake or keel plate.

Provisions alteration to these rules may be accepted by the Society when justified by the organisation of the Building Yard or of the inspection department; the inspection is then to be equivalent to that deduced from [6.3.2] to [6.3.5].

6.3.2 As far as automatic welding of the panels butt welds during the premanufacturing stage is concerned, the Building Yard is to carry out random non-destructive testing of the welds (radiographic or ultrasonic inspection) in order to ascertain the regularity and the constancy of the welding inspection.

6.3.3 In the midship area, radiographies are to be taken at the joinings of panels.

Each radiography is situated in a butt joint at a cross-shaped welding.

In a given vessel cross-section bounded by the panels, a radiography is to be made of each butt of sheerstrake, stringer, bilge and keel plate; in addition, the following radiographies are to be taken:

- bottom plating: two
- deck plating: two
- side shell plating: two each side.

For vessels where $B + D \leq 15$ m, only one radiography for each of the above items is required.

This requirement remains applicable where panel butts are shifted or where some strakes are built independently from the panels. It is recommended to take most of these radiographies at the intersections of butt and panel seams.

Still in the midship area, a radiographic inspection is to be taken, at random, of the following main members of the structure:

- butts of continuous longitudinal bulkheads
- butts of longitudinal stiffeners, deck and bottom girders contributing to the overall strength
- assembly joints of insert plates at the corners of the openings.

6.3.4 Outwards the midship area, a programme of radiographic inspection at random is to be set up by the Building Yard in agreement with the Surveyor for the major points. It is further recommended to take:

- a number of radiographies of the very thick parts and those comprising restrained joint, such as sternframes, shaft brackets, masts
- a complete set of radiographies or to increase the number of radiographies for the first joint of a series of identical joints. This recommendation is applicable not only to the assembly joints of prefabricated members completed on the slip, but also to joints completed in the workshop to prepare such prefabricated members.

6.3.5 Where a radiography is rejected and where it is decided to carry out a repair, the Building Yard is to determine the length of the defective part, then a set of inspection radiographies of the repaired joint and of adjacent parts is to be taken. Where the repair has been decided by the inspection office of the Building Yard, the film showing the initial defect is to be submitted to the Surveyor together with the film taken after repair of the joint.

SECTION 3 PROTECTION OF HULL METALLIC STRUCTURES

Symbols

t : Thickness, in mm.

1 Protection by coating

1.1 General

1.1.1 It is the responsibility of the Building Yard and the Owner to choose the coating and have it applied in accordance with the manufacturer’s requirements.

1.1.2 Information and recommendations aiming to fulfilling the requirements of this Section are developed in NI607 Guidelines for Corrosion Protection Applicable to Inland Navigation Vessels.

1.2 Structures to be protected

1.2.1 All areas endangered by corrosion are to be protected by a suitable corrosion protective coating.

1.2.2 All brackish water ballast spaces with boundaries formed by the hull envelope are to have a corrosion protective coating, epoxy or equivalent, applied in accordance with the manufacturer's requirements.

1.2.3 Corrosion protective coating is not required for internal surfaces of spaces intended for the carriage of cargo oil or fuel oil.

1.2.4 Narrow spaces are generally to be filled by an efficient protective product, particularly at the ends of the vessel where inspections and maintenance are not easily practicable due to their inaccessibility.

2 Protection against galvanic corrosion in tanks

2.1 General

2.1.1 Suitable protection measures shall take place, where the danger of galvanic corrosion exists.

2.1.2 Non-stainless steel is to be electrically insulated from stainless steel or from aluminium alloys.

2.1.3 Where stainless steel or aluminium alloys are fitted in the same tank as non-stainless steel, a protective coating is to cover both materials.

3 Cathodic protection of tanks

3.1 General

3.1.1 Ballast water tanks or other internal spaces endangered by corrosion due to brackish or harbour water may be provided with cathodic protection.

Cathodic protection may be fitted in addition to the required corrosion protective coating, if any.

3.1.2 Uncoated stainless steels are not to be protected cathodically if they are suitable for withstanding the corrosion stress.

Coated stainless steels must be cathodically protected in the submerged zone.

3.1.3 Where fitted, cathodic protection shall comply with the manufacturer’s instructions / recommendations.

4 Protection of bottom by ceiling

4.1 General

4.1.1 In single bottom vessels, ceiling is to be laid on the floors from side to side up to the upper bilge.

4.1.2 In double bottom vessels, ceiling is to be laid over the inner bottom and lateral bilges, if any.

Ceiling on the inner bottom is not required where the thickness of the inner bottom is increased in accordance with Pt D, Ch 1, Sec 2, [3.7.4] or Pt D, Ch 1, Sec 2, [4.6.4].

4.2 Arrangement

4.2.1 Planks forming ceiling over the bilges and on the inner bottom are to be easily removable to permit access for maintenance.

4.2.2 Where the double bottom is intended to carry fuel oil, ceiling on the inner bottom is to be separated from the plating by means of battens 30 mm high, in order to facilitate the drainage of oil leakages to the bilges.

4.2.3 Where the double bottom is intended to carry water, ceiling on the inner bottom may lie next to the plating, provided a suitable corrosion protection is applied beforehand.

4.2.4 The Building Yard is to take care that the attachment of ceiling does not affect the tightness of the inner bottom.

4.2.5 In single bottom vessels, ceiling is to be fastened to the reversed frames by galvanised steel bolts or any other equivalent detachable connection.

A similar connection is to be adopted for ceiling over the lateral bilges in double bottom vessels.

4.3 Scantling

4.3.1 The thickness of ceiling boards, in mm, is to be at least equal to the smaller of the following values:

- vessels intended to carry ore or concentrated loads, and not fitted with a double bottom:
  - $t = 50$
  - $t = 0{,}45\ s\ (L + 160)$
- other vessels:
  - $t = 25$
  - $t = 0{,}3\ s\ (L + 160)$

with:

s : Floor spacing, in m.

Where the floor spacing is large, the thicknesses may be considered by the Society on a case by case basis.

Under cargo hatchways, the thickness of ceiling is to be increased by 15 mm.

4.3.2 Where a side ceiling is provided, it is to be secured every 4 frame spacings to the side frames by an appropriate system. Its thickness may be taken equal to 0,7 times that of the bottom ceiling, without being less than 20 mm.

The batten spacing is not, as a rule, to exceed 0,2 m.

5 Protection of decks by wood sheathing

5.1 Deck not entirely plated

5.1.1 The wood used for sheathing is to be of good quality dry teak or pine, without sapwood or knots. The sheathing thickness, in mm, is not to be less than:

- teak: $t = (L + 55) / 3 \geq 40$
- pine: $t = (L + 100) / 3$

5.1.2 The width of the planks is not to exceed twice their thickness. Their butts are to be adequately shifted so that, if two butts occur in the same frame spacing, they are separated by at least three planks.

Planks are to be secured to every other frame by means of 12 mm bolts. On small vessels, galvanized steel screws are permitted.

5.1.3 Wooden decks are to be carefully caulked, to the satisfaction of the Surveyor.

5.2 Wood sheathed plate deck

5.2.1 As far as practicable, plate decks above passenger or crew cabins are to be sheathed with wood planks.

5.2.2 The plank thickness, in mm, is not to be less than 40 nor than:

- teak: $t = (L + 40) / 3$
- pine: $t = (L + 85) / 3$

SECTION 4 TESTING - METALLIC HULLS

1 Testing procedures of watertight compartments

1.1 Application

1.1.1 These test procedures are to confirm the watertightness of tanks and watertight boundaries, and the structural adequacy of tanks forming a part of the watertight subdivisions of vessels. These procedures may also be applied to verify the weathertightness of structures and onboard outfitting.

The tightness of all tanks and watertight boundaries of vessels during new construction and vessels relevant to major conversions or major repairs is to be confirmed by these test procedures prior to the delivery of the vessels.

Note 1: Major repair means a repair affecting structural integrity.

1.1.2 Testing procedures are to be carried out in accordance with the requirements [1.4.1] to [1.9.1].

1.1.3 All gravity tanks and other boundaries required to be watertight or weathertight are to be tested in accordance with these procedures and proven tight and structurally adequate as follows:

- gravity tanks for their tightness and structural adequacy
- watertight boundaries other than tank boundaries for their watertightness
- weathertight boundaries for their weathertightness.

Note 1: Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

1.1.4 Testing of structures not listed in Tab 2 or Tab 3 is to be specially considered by the Society.

1.2 General

1.2.1 Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work, with all the hatches, doors, windows, etc., installed and all the penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in [1.6] and Tab 2. For the timing of the application of coating and the provision of safe access to joints, see [1.7], [1.8] and Tab 4.

1.3 Definitions

1.3.1 Structural test

A structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

1.3.2 Leak test

A leak test is a test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered to be an acceptable form of leak test for certain boundaries, as indicated by footnote **(3)** of Tab 2.

1.3.3 Each type of structural and leak test is defined in Tab 1.

1.4 Structural test procedures

1.4.1 Type and time of test

Where a structural test is specified in Tab 2 and Tab 3, a hydrostatic test in accordance with [1.6.1] is acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with [1.6.2] may be accepted instead.

A hydrostatic or hydropneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat, provided the results of a leak test are confirmed to be satisfactory before the vessel is set afloat.

1.4.2 Testing schedule for new construction and major structural conversion or repair

a) tanks which are intended to hold liquids, and which form part of the watertight subdivision of the vessel, shall be tested for tightness and structural strength as indicated in Tab 2 and Tab 3

b) tank boundaries are to be tested from at least one side. The tanks for the structural test are to be selected so that all the representative structural members are tested for the expected tension and compression

c) watertight boundaries of spaces other than tanks may be exempted from the structural test, provided that the boundary watertightness of the exempted spaces is verified by leak tests and inspections. The tank structural test is to be carried out and the requirements from item a) to item b) are to be applied for ballast holds, chain lockers

d) tanks which do not form part of the watertight subdivision of the vessel, may be exempted from structural testing provided that the boundary watertightness of the exempted spaces is verified by leak tests and inspections.

1.5 Leak test procedures

1.5.1 For the leak tests specified in Tab 2, tank air tests, compressed air fillet weld tests and vacuum box tests, in accordance respectively with [1.6.3], [1.6.5] and [1.6.6], or their combinations, are acceptable. Hydrostatic or hydropneumatic tests may be also accepted as leak tests, provided [1.7], [1.8] and [1.9] are complied with. Hose tests, in accordance with [1.6.3], are also acceptable for items 14 to 17 referred to in Tab 2, taking footnote **(3)** into account.

1.5.2 Air tests of joints may be carried out at the block stage, provided that all work on the block that may affect the tightness of a joint is completed before the test. The application of the leak test for each type of welded joint is specified inTab 4. See also [1.7.1] for the application of final coatings, [1.8] for the safe access to joints, and Tab 4 for the summary.

1.6 Test methods

1.6.1 Hydrostatic test

Unless another liquid is approved, hydrostatic tests are to consist in filling the space with fresh water or river/sea water, whichever is appropriate for testing, to the level specified in Tab 2 or Tab 3. See also [1.9].

In case where a tank is intended for cargoes having a density higher than the density of the liquid used for the test, the testing pressure height is to be adjusted is to simulate the actual loading as far as practicable.

All the external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, any other related damage, and leaks.

1.6.2 Hydropneumatic test

Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, simulates the actual loading as far as practicable. The requirements and recommendations in [1.6.4] for tank air tests apply also to hydropneumatic tests. See also [1.9].

All the external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, any other related damage, and leaks.

1.6.3 Hose test

Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at $2 \cdot 10^5$ Pa during the test. The nozzle is to have a minimum inside diameter of 12 mm and to be at a perpendicular distance from the joint not exceeding 1,5 m. The water jet is to impinge upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation, or outfitting items, it may be replaced by a careful visual examination of the welded connections, supported where necessary by means such as a dye penetrant test or an ultrasonic leak test, or equivalent.

1.6.4 Tank air test

All boundary welds, erection joints and penetrations including pipe connections are to be examined in accordance with approved procedures and under a stabilized pressure differential above atmospheric pressure not less than $0,15 \cdot 10^5$ Pa, with a leak-indicating solution (such as soapy water/detergent or a proprietary solution) applied.

A U-tube having a height sufficient to hold a head of water corresponding to the required test pressure is to be arranged. The cross-sectional area of the U-tube is not to be less than that of the pipe supplying air to the tank. Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account appropriate safe precautions.

A double inspection of the tested welds is to be carried out. The first inspection is to be made immediately upon application of the leak indication solution; the second one is to be made approximately four or five minutes after, in order to detect those smaller leaks which may take time to appear.

Table 1 : Types of test

Test types	Procedure
Hydrostatic test (leak and structural)	The space to be tested is filled with a liquid to a specified head
Hydropneumatic test (leak and structural)	Combination of a hydrostatic test and an air test, the space to be tested being partially filled with liquid and pressurized with air
Hose test (leak)	Tightness check of the joint to be tested by means of a jet of water, the joint being visible from the opposite side
Air test (leak)	Tightness check by means of an air pressure differential and a leak-indicating solution. It includes tank air tests and joint air tests, such as compressed air fillet weld tests and vacuum box tests
Compressed air fillet weld test (leak)	Air test of fillet welded tee joints, by means of a leak indicating solution applied on fillet welds
Vacuum box test (leak)	A box over a joint with a leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks
Ultrasonic test (leak)	Tightness check of the sealing of closing devices such as hatch covers, by means of ultrasonic detection techniques
Penetration test (leak)	Check, by means of low surface tension liquids (i.e. dye penetrant test), that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment

Table 2 : Test requirements for tanks and boundaries

Item	Tank or boundaries to be tested	Test type	Test head or pressure	Remarks
1	Double bottom tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	
2	Double bottom voids	leak	See [1.6.4] to [1.6.6], as applicable	
3	Double side tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	
4	Double side voids	leak	See [1.6.4] to [1.6.6], as applicable	
5	Deep tanks other than those listed elsewhere in this Table	leak and structural **(1)**	The greater of: • top of the overflow • 1,0 m above top of tank **(2)**	
6	Cargo oil tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	
7	Peak tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	After peak to be tested after installation of stern tube
8	a) Fore peak spaces with equipment	leak	See [1.6.3] to [1.6.6], as applicable	
	b) Fore peak voids	leak	See [1.6.4] to [1.6.6], as applicable	
	c) Aft peak spaces with equipment	leak	See [1.6.3] to [1.6.6], as applicable	
	d) Aft peak voids	leak	See [1.6.4] to [1.6.6], as applicable	After peak to be tested after installation of stern tube
9	Cofferdams	leak	See [1.6.4] to [1.6.6], as applicable	
10	a) Watertight bulkheads	leak **(6)**	See [1.6.3] to [1.6.6], as applicable **(5)**	
	b) Superstructure end bulkheads	leak	See [1.6.3] to [1.6.6], as applicable	
11	Watertight doors below freeboard or bulkhead deck	leak **(4)** **(5)**	See [1.6.3] to [1.6.6], as applicable	
12	Double plate rudder blades	leak	See [1.6.4] to [1.6.6], as applicable	
13	Shaft tunnels clear of deep tanks	leak **(3)**	See [1.6.3] to [1.6.6], as applicable	
14	Shell doors	leak **(3)**	See [1.6.3] to [1.6.6], as applicable	
15	Weathertight hatch covers and closing appliances	leak **(3)** **(5)**	See [1.6.3] to [1.6.6], as applicable	Hatch covers closed by tarpaulins and battens excluded
16	Chain lockers	leak and structural	Head of water up to top of chain pipe	
17	Ballast ducts	leak and structural **(1)**	The greater of: • ballast pump maximum pressure • setting of any pressure relief valve	
18	Fuel oil tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	

(1) See [1.4.2], item b).
(2) The top of a tank is the deck forming the top of the tank, excluding any hatchways.
(3) Hose test may be also considered as a medium of the leak test. See [1.3.2].
(4) Where watertightness of watertight doors has not been confirmed by a prototype test, a hydrostatic test (filling of the watertight spaces with water) is to be carried out.
(5) As an alternative to the hose test, other testing methods listed in [1.6.7] to [1.6.9] may be acceptable, subject to adequacy of such testing methods being verified. For watertight bulkheads (item 10 a)), alternatives to the hose test may be used only where the hose test is not practicable.
(6) A structural test (see [1.4.2]) is also to be carried out for a representative cargo hold in case of cargo holds intended for in-port ballasting. The filling level required for the structural test of such cargo holds is to be the maximum loading that will occur in-port, as indicated in the loading manual.

Table 3 : Additional test requirements for special service vessels/tanks

Item	Type of vessel/tank	Structure to be tested	Type of test	Test head or pressure	Remarks
1	Liquefied gas carriers	Integral tanks	leak and structural	See Ch 3, Sec 4, Tab 15	
		Independent pressure tanks	structural	See Pt C, Ch 1, Sec 3, [7.3]	
		Independent gravity tanks	See applicable NR467, Pt D, Ch 9, Sec 4	See applicable NR467, Pt D, Ch 9, Sec 4	
		Hull structure supporting membrane or semi-membrane tanks			
2	Edible liquid tanks	Independent tanks	leak and structural **(1)**	The greater of: • top of the overflow • 1,0 m above top of tank **(2)**	
3	Chemical carriers	Integral or independent cargo tanks	leak and structural **(1)**	See Ch 3, Sec 4, Tab 15	An appropriate additional head is to be considered where a cargo tank is designed for the carriage of cargoes with specific gravities greater than 1,0

(1) See [1.4.2], item b).
(2) Top of tank is deck forming the top of the tank excluding any hatchways.

1.6.5 Compressed air fillet weld test

In this air test, compressed air is injected from one end of a fillet welded joint, and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least $0,15\cdot10^5$ Pa can be verified at each end of any passage within the portion being tested.

Note 1: Where a leak test is required for fabrication involving partial penetration welds, a compressed air test is also to be carried out in the same manner as to fillet weld where the root face is large, i.e. 6-8 mm.

1.6.6 Vacuum box test

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak-indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of $0,20\cdot10^5$ to $0,26\cdot10^5$ Pa inside the box.

1.6.7 Ultrasonic test

An ultrasonic echo transmitter is to be arranged on the inside of a compartment, and a receiver on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver, in order to detect an ultrasonic leak indication. Any leakage in the sealing of the compartment is indicated at a location where sound is detectable by the receiver.

1.6.8 Penetration test

For the test of butt welds or other weld joints, a low surface tension liquid is applied on one side of a compartment boundary or a structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

1.6.9 Other test

Other methods of testing may be considered by the Society upon submission of full particulars prior to the commencement of the tests.

1.7 Application of coating

1.7.1 Final coating

For butt joints welded by means of an automatic process, the final coating may be applied at any time before completion of a leak test of the spaces bounded by the joints, provided that the welds have been visually inspected with care, to the satisfaction of the Surveyor.

The Surveyors reserve the right to require a leak test prior to the application of a final coating over automatic erection butt welds.

For all the other joints, the final coating is to be applied after the completion of the joint leak test. See also Tab 4.

1.7.2 Temporary coating

Any temporary coating which may conceal defects or leaks is to be applied at the same time as for a final coating (see [1.7.1]). This requirement does not apply to shop primers.

1.8 Safe access to joints

1.8.1 For leak tests, a safe access to all joints under examination is to be provided. See also Tab 4.

1.9 Hydrostatic or hydropneumatic tightness test

1.9.1 In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, the examined boundaries are to be dew-free, otherwise small leaks are not visible.

2 Miscellaneous

2.1 Watertight decks, trunks, etc.

2.1.1 After completion, a hose or flooding test is to be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators.

2.2 Steering nozzles

2.2.1 Upon completion of manufacture, the nozzle is to be subjected to a leak test.

Table 4 : Application of leak test, coating, and provision of safe access for the different types of welded joints

Type of welded joints		Leak test	Coating **(1)**		Safe access **(2)**	
			Before leak test	After leak test but before structural test	Leak test	Structural test
Butt	Automatic	not required	allowed **(3)**	not applicable	not required	not required
	Manual or semi-automatic **(4)**	required	not allowed	allowed	required	not required
Fillet	Boundary including penetrations	required	not allowed	allowed	required	not required

(1) Coating refers to internal (tank/hold) coating, where applied, and external (shell/deck) painting. It does not refer to shop primer.
(2) Temporary means of access for verification of the leak test.
(3) The condition applies provided that the welds have been visually inspected with care, to the satisfaction of the Surveyor.
(4) Flux Core Arc Welding (FCAW) semi-automatic butt welds need not be tested, provided careful visual inspections show continuous and uniform weld profile shape, free from repairs, and the results of NDE show no significant defects.

Shaping a World of Trust

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Rules for the Classification of Inland Navigation Vessels

PART C – Machinery, Electricity and Fire

Chapters 1 – 2 – 3 – 4

NR 217.C1 DT R06 E June 2021

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Bureau Veritas Marine & Offshore

General Conditions

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 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.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of the above listed being relieved from any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 Only the Society is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards ("Applicable Referential"), in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification (or Certification as defined in clause 2.2) is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules and/or to Applicable Referential for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules (available online on veristar.com), guidance notes and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the Rules and/or the Applicable Referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, and/or to the Applicable Referential, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate nor on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisement made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involves, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interest equal to twelve (12) months LIBOR plus two (2) per-cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to resolve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 The Services shall be automatically and immediately terminated in the event the Client can no longer establish any form of interest in the Unit (e.g. sale, scrapping).

9.3 The Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, or immediately in the event of termination under clause 9.2, subject to compliance with clause 4.1 and 6 above.

9.4 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, will be treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, other than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed in accordance with and governed by the laws of England and Wales.

15.2 Any dispute shall be finally settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

15.3 Notwithstanding clause 15.2, disputes relating to the payment of the Society's invoices may be submitted by the Society to the *Tribunal de Commerce de Nanterre*, France, or to any other competent local Court, at the Society's entire discretion.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics and, when applicable, Business Partner Code of Conduct both available at https://group.bureauveritas.com/group/corporate-social-responsibility/operational-excellence.

RULES FOR INLAND NAVIGATION VESSELS

Part C
Machinery, Electricity and Fire

Chapters **1 2 3 4**

Chapter 1	**MACHINERY AND SYSTEMS**
Chapter 2	**ELECTRICAL INSTALLATIONS**
Chapter 3	**AUTOMATION**
Chapter 4	**FIRE PROTECTION, DETECTION AND EXTINCTION**

June 2021

These Rules apply to inland navigation vessels for which contracts for construction are signed on or after June 1st, 2021.

The English version of these Rules takes precedence over editions in other languages.

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Part C
Machinery, Electricity and Fire

Chapter 1
MACHINERY AND SYSTEMS

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SECTION 15 TESTS ON BOARD

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Application

1.1.1 Part C, Chapter 1 applies to the design, construction, installation, tests and trials of main propulsion and essential auxiliary machinery systems and associated equipment, boilers and pressure vessels and piping systems installed on board classed vessels, as indicated in each Section of this Chapter, as far as class is concerned.

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in Part D, for the assignment of the type and service notations and additional class notations.

1.3 Documentation to be submitted

1.3.1 The drawings and documents requested in the relevant Sections of this Chapter are to be submitted to the Society for review.

1.4 Machinery space of category A

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

- internal combustion machinery used for main propulsion, or
- internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or
- any oil fired boiler or fuel oil unit, or
- gas generators, incinerators, waste disposal units, etc., which use oil fired equipment

1.5 Machinery spaces

1.5.1 Machinery spaces are all machinery spaces of Category A and all other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.6 Essential services

1.6.1 Essential services are defined in Pt A, Ch 1, Sec 1, [1.3].

2 Design and construction

2.1 General

2.1.1 The machinery, boilers and other pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

2.2 Materials, welding and testing

2.2.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of NR216 Materials and Welding and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding the requirements given in [2.2.2] apply.

2.2.2 Welded machinery components

Welding processes are to be approved and welders certified by the Society in accordance with NR216 Materials and Welding.

References to welding procedures adopted are to be clearly indicated on the plans submitted for review.

Joints transmitting loads are to be either:

- full penetration butt-joints welded on both sides, except when an equivalent procedure is approved, or
- full penetration T- or cruciform joints.

For joints between plates having a difference in thickness greater than 3 mm, a taper having a length of not less than 4 times the difference in thickness is required. Depending on the type of stress to which the joint is subjected, a taper equal to three times the difference in thickness may be accepted.

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0,7 times the thickness of the thinner plate on both sides.

In the case of welded structures including cast pieces, the latter are to be cast with appropriate extensions to permit connection, through butt-welded joints, to the surrounding structures, and to allow any radiographic and ultrasonic examinations to be easily carried out.

Where required, preheating and stress relieving treatments are to be performed according to the welding procedure specification.

2.2.3 Non-destructive testing suppliers

In case of non-destructive testing carried out by an independent company from the manufacturer or shipyard, such company has to comply with the requirements set out in NR669 Recognition of non-destructive testing suppliers.

2.3 Vibrations

2.3.1 Special consideration (see Ch 1, Sec 9) is to be given to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

2.4 Operation in inclined position

2.4.1 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the vessel are, as fitted in the vessel, to be designed to operate when the vessel is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Tab 1.

Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged alongships. If this is not possible, the manufacturer is to be informed at the time the machinery is ordered.

Table 1 : Permanent inclination of vessel

Installations, components	Angle of inclination (degrees) **(1)**	
	Athwartship	Fore and aft
Main and auxiliary machinery **(2)**	12	5

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) Higher angle values may be required depending on vessel operating conditions

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +40 (+45 in tropical zone) **(1)**
On machinery components, boilers In spaces subject to higher or lower temperatures	according to specific local conditions
On exposed decks	between −20 and +40 (+45 in tropical zone)

WATER TEMPERATURE	
Coolant	Temperature (°C)
River water or, if applicable, river water at charge air coolant inlet	up to +25 in general up to +32 in tropical zone

(1) Different temperatures may be accepted by the Society in the case of vessels intended for restricted service.

2.5 Ambient conditions

2.5.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 2, unless otherwise specified in each Section of this Chapter.

2.6 Power of machinery

2.6.1 Unless otherwise stated in each Section of this Chapter, where scantlings of components are based on power, the values to be used are determined as follows:

- for main propulsion machinery, the power/rotational speed for which classification is requested
- for auxiliary machinery, the power/rotational speed which is available in service.

2.7 Astern power

2.7.1 Sufficient power for going astern is to be provided to secure proper control of the vessel in all normal circumstances.

In order to maintain sufficient manoeuvrability and secure control of the vessel in all normal circumstances, the main propulsion machinery is to be capable of reversing the direction of thrust so as to bring the vessel to rest from the maximum service speed. The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the ahead revolutions.

For main propulsion systems with reversing gears or controllable pitch propellers, running astern is not to lead to an overload of propulsion machinery.

During the river trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also Ch 1, Sec 15, [3.2]).

2.8 Safety devices

2.8.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2.8.2 Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided, where practicable, to protect against such excessive pressure.

2.8.3 Main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shut-off arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

The Society may permit provisions for overriding automatic shut-off devices.

2.9 Fuels

2.9.1 Fuel oils

Fuel oils used for engines and boilers are, in general, to have a flash point (determined using the closed cup test) of not less than 55°C.

2.9.2 Natural gas

Natural gas may be used as fuel for boilers or propulsion engines for installation specially approved in the scope of service features **Dualfuel** or **Gasfuel** as defined in Pt A, Ch 1, Sec 3, [1.3.5] and subject to the corresponding requirements.

3 Arrangement and installation on board

3.1 General

3.1.1 Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

3.2 Floors

3.2.1 Floor plating and gratings in machinery spaces are to be metallic, divided into easily removable panels.

The floor plating of normal passageways in machinery spaces shall be made of steel.

3.3 Bolting down

3.3.1 Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure a perfect fit.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain a perfect levelling and general alignment between the propulsion engines and their shafting.

3.3.2 Chocking resins are to be type approved.

3.4 Safety devices on moving parts

3.4.1 Suitable protective devices are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid injuries to personnel.

3.5 Gauges

3.5.1 All gauges are to be grouped, as far as possible, near each manoeuvring position; in any event, they are to be clearly visible.

3.6 Ventilation in machinery spaces

3.6.1 Machinery spaces are to be sufficiently ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions, including heavy weather, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions.

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

3.7 Hot surfaces and fire protection

3.7.1 Surfaces, having temperature exceeding 60°C, with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material (see Ch 4, Sec 1, [2.14] for definition) or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

Fire protection, detection and extinction is to comply with the requirements of Part C, Chapter 4.

3.8 Machinery remote control, alarms and safety systems

3.8.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, see Ch 1, Sec 2, [2.7] and Pt D, Ch 2, Sec 8, for additional class notation **AUT-UMS.**

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter.

Where such tests cannot be performed in the workshop, the Society may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being tested or with particular features of the on board installation. In such cases, the Surveyor is to be informed in advance and the tests are to be carried out in accordance with the requirements of NR216 Materials and Welding relative to incomplete tests.

All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time as detailed in the other Sections of this Chapter.

4.2 Tests on board

4.2.1 Trials on board of machinery are detailed in Ch 1, Sec 15.

SECTION 2 DIESEL ENGINES

1 General

1.1 Application

1.1.1 Diesel engines listed below are to be designed, constructed, installed, tested and certified in accordance with the requirements of this Section, under the supervision and to the satisfaction of the Society's Surveyors:

a) main propulsion engines, when the power exceeds 220 kW per engine

b) engines driving electric generators, including emergency generators, when they develop a power of 110 kW and over

c) engines driving other auxiliaries essential for safety and navigation and cargo pumps in tankers, when they develop a power of 110 kW and over.

All other engines are to be designed and constructed according to sound marine practice, with the equipment required in [2.3.2], and delivered with the relevant works' certificate (see 216 Materials and Welding, Ch 1, Sec 1, [4.2.3]).

In addition to the requirements of this Section, those given in Ch 1, Sec 1 apply.

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to the Society the documents listed in Tab 1 for engine type approval.

Plans listed under items 2 and 3 in Tab 1 are also to contain details of the lubricating oil sump in order to demonstrate compliance with Ch 1, Sec 1, [2.4].

Where changes are made to an engine type for which the documents listed in Tab 1 have already been examined or approved, the engine Manufacturer is to resubmit to the Society for consideration and review only those documents concerning the engine parts which have undergone substantial changes.

If the engines are manufactured by a licensee, the licensee is to submit, for each engine type, a list of all the drawings specified in Tab 1, indicating for each drawing the relevant number and revision status from both licensor and licensee.

Where the licensee proposes design modifications to components, the associated documents are to be submitted by the licensee to the Society for review or for information purposes. In the case of significant modifications, the licensee is to provide the Society with a statement confirming the licensor's acceptance of the changes. In all cases, the licensee is to provide the Surveyor entrusted to carry out the testing, with a complete set of the documents specified in Tab 1.

Table 1 : Documentation to be submitted

No.	I/A **(1)**	Document	Document details
1	I	Engine particulars and data for calculation of crankshafts as per NR467, Pt C, Ch 1, App 1	–
2	I	Engine transverse cross-section	Max inclination angles, oil surface lines, oil suction strum position
3	I	Engine longitudinal section	Max inclination angles, oil surface lines, oil suction strum position
4	I / A	Bedplate or crankcase, cast or welded. For welded bedplates or cranks, welding details and instructions	Design of welded joints, electrodes used, welding sequence, heat treatment, non-destructive examinations
5	A	Thrust bearing assembly **(2)**	–
6	I / A	Thrust bearing bedplate, cast or welded. For welded bedplates or cranks, welding details and instructions **(3)**	Design of welded joints, electrodes used, welding sequence, heat treatment, non-destructive examinations
7	I / A	Frame/column, cast or welded with welding details and instructions **(4)**	Design of welded joints, electrodes used, welding sequence, heat treatment, non-destructive examinations
8	I	Tie rod	–
9	I	Cylinder cover, assembly	–
10	I	Cylinder jacket or engine block **(5)**	–
11	I	Cylinder liner **(5)**	–
12	A	Crankshaft, details, for each cylinder number	–
13	A	Crankshaft, assembly, for each cylinder number	–

No.	I/A (1)	Document	Document details
14	A	Thrust shaft or intermediate shaft (if integral with engine)	–
15	A	Coupling bolts	–
16	A	Counterweights (if not integral with crankshaft), with associated fastening bolts	Bolt fastening instructions
17	I	Connecting rod	–
18	I	Connecting rod, assembly **(5)**	Bolt fastening instructions
19	I	Crosshead, assembly **(5)**	–
20	I	Piston rod, assembly **(5)**	–
21	I	Piston, assembly	–
22	I	Camshaft drive, assembly	–
23	A	Material specifications of main parts of engine, with detailed information on: - non-destructive tests, and - pressure tests **(6)**	Required for items 4, 7, 8, 9, 10, 11, 12, 15, 18, 21, including acceptable defects and repair procedures. Required for items 4, 7, 9, 10, 11, 21 and for injection pumps and exhaust manifold
24	A	Arrangement of foundation bolts (for main engines only)	–
25	A	Schematic layout or other equivalent documents for starting air system on the engine **(7)**	–
26	A	Schematic layout or other equivalent documents for fuel oil system on the engine **(7)**	–
27	A	Schematic layout or other equivalent documents for lubricating oil system on the engine **(7)**	–
28	A	Schematic layout or other equivalent documents for cooling water system on the engine **(7)**	–
29	A	Schematic diagram of engine control and safety system on the engine **(7)**	List, specification and layout of sensors, automatic controls and other control and safety devices
30	A	Schematic layout or other equivalent documents of hydraulic system (for valve lift) on the engine	–
31	I	Shielding and insulation of exhaust pipes, assembly	–
32	A	Shielding of high pressure fuel pipes, assembly	Recovery and leak detection devices
33	A	Crankcase explosion relief valves **(8)**	Volume of crankcase and other spaces (camshaft drive, scavenge, etc.)
34	I	Operation and service manuals **(9)**	–
35	A	Type test program and type test report	–
36	A	High pressure parts for fuel oil injection system **(10)**	–

(1) A = to be submitted for review
I = to be submitted for information.
Where two indications I / A are given, the first refers to cast design and the second to welded design.

(2) To be submitted only if the thrust bearing is integral with the engine and not integrated in the engine bedplate.

(3) The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.

(4) Only for one cylinder.

(5) To be submitted only if sufficient details are not shown on the engine transverse and longitudinal cross-sections.

(6) For comparison with NR216 Materials and Welding, NDT and pressure testing as applicable.

(7) Dimensions and materials of pipes, capacity and head of pumps and compressors and any additional functional information are to be included. The layout of the entire system is also required, if this is part of the goods to be supplied by the engine Manufacturer. Where engines incorporate electronic control systems a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of an electronic control system will not result in the loss of essential services for the operation of the engine and that operation or the engine will not be lost or degraded beyond an acceptable performance criteria or the engine.

(8) Required only for engines with cylinder bore of 200 mm and above or crankcase gross volume of 0,6 m^3 and above.

(9) Operation and service manuals are to contain maintenance requirements (servicing and repair) including derails of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.

(10) The documentation to contain specification of pressures, pipe dimensions and materials.

1.3 Definitions

1.3.1 Engine type

In general, the type of an engine is defined by the following characteristics:

- the cylinder diameter
- the piston stroke
- the method of injection (direct or indirect injection)
- the kind of fuel (liquid, gaseous or dual-fuel)
- the working cycle (4-stroke, 2-stroke)
- the gas exchange (naturally aspirated or supercharged)
- the maximum continuous power per cylinder at the corresponding speed and/or brake mean effective pressure corresponding to the above-mentioned maximum continuous power
- the method of pressure charging (pulsating system or constant pressure system)
- the charging air cooling system (with or without intercooler, number of stages, etc.)
- the cylinder arrangement (in-line or V-type).

1.3.2 Engine power

The maximum continuous power is the maximum power at ambient reference conditions (see [1.3.3]) which the engine is capable of delivering continuously, at nominal maximum speed, in the period of time between two consecutive overhauls.

Power, speed and the period of time between two consecutive overhauls are to be stated by the Manufacturer and agreed by the Society.

The rated power is the maximum power at ambient reference conditions (see [1.3.3]) which the engine is capable of delivering as set after works trials (fuel stop power) at the maximum speed allowed by the governor.

The rated power for engines driving electric generators is the nominal power, taken at the net of overload, at ambient reference conditions (see [1.3.3]), which the engine is capable of delivering as set after the works trials (see [4]).

1.3.3 Ambient reference conditions

The power of engines as per [1.1.1] a), b) and c) is to be referred to the following conditions:

- barometric pressure = 1 bar
- relative humidity = 60%
- ambient air temperature = 40°C in general, and 45°C in tropical zone
- river water temperature (and temperature at inlet of river water cooled charge air cooler) = 25°C in general, and 32°C in tropical zone.

The engine Manufacturer is not expected to provide the above ambient conditions at a test bed. The rating is to be adjusted according to a recognised standard accepted by the Society.

1.3.4 Same type of engines

Two diesel engines are considered to be of the same type when they do not substantially differ in design and construction characteristics, such as those listed in the engine type definition as per [1.3.1], it being taken for granted that the documentation concerning the essential engine components listed in [1.2] and associated materials employed has been submitted, examined and, where necessary, approved by the Society.

1.3.5 Substantive modifications or major modifications or major changes

Design modifications, which lead to alterations in the stress levels, operational behaviour, fatigue life or an effect on other components or characteristics of importance such as emissions.

1.3.6 Low-Speed Engines means diesel engines having a rated speed of less than 300 rpm.

Medium-Speed Engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

High-Speed Engines means diesel engines having a rated speed of 1400 rpm and above.

2 Design and construction

2.1 Materials and welding

2.1.1 Crankshaft materials

In general, crankshafts are to be of forged steel having a tensile strength not less than 400 N/mm^2 and not greater than 1000 N/mm^2.

The use of forged steels of higher tensile strength is subject to special consideration by the Society in each case.

The Society, at its discretion and subject to special conditions (such as restrictions in vessel navigation), may accept crankshafts made of cast carbon steel, cast alloyed steel of appropriate quality and manufactured by a suitable procedure having a tensile strength as follows:

a) between 400 N/mm^2 and 560 /mm^2 for cast carbon steel

b) between 400 N/mm^2 and 700 N/mm^2 for cast alloyed steel.

The Society, at its discretion and subject to special conditions (such as restrictions in vessel navigation), may also accept crankshafts made of cast iron for mass produced engines of a nominal power not exceeding 110 kW with a significative in-service behaviour either in marine or industry. The cast iron is to be of “SG” type (spheroidal graphite) of appropriate quality and manufactured by a suitable procedure.

2.1.2 Welded frames and foundations

Steels used in the fabrication of welded frames and bedplates are to comply with the requirements of NR216 Materials and Welding.

Welding is to be in accordance with the requirements of Ch 1, Sec 1, [2.2].

2.2 Crankshaft

2.2.1 Check of the scantling

The check of crankshaft strength is to be carried out in accordance with NR467, Pt C, Ch 1, App 1.

2.3 Crankcase

2.3.1 Crankcase construction and crankcase doors are to be of sufficient strength to withstand anticipated crankcase pressures that may arise during a crankcase explosion taking into account the installation of required explosion relief valves. Crankcase doors are to be fastened sufficiently securely for them not be readily displaced by a crankcase explosion.

2.3.2 Crankcase arrangements and fittings are to comply with applicable requirements of NR467, Part C, Chapter 1.

2.4 Systems

2.4.1 General

In addition to the requirements of the present Sub-article, those given in Ch 1, Sec 10 are to be satisfied.

Flexible hoses in the fuel and lubricating oil system are to be limited to the minimum and are to be type approved.

2.4.2 Fuel oil system

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

In fuel oil systems for propulsion machinery, filters are to be fitted and arranged so that an uninterrupted supply of filtered fuel oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Ch 1, Sec 10.

a) All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a shielded piping system capable of containing fuel from a high pressure line failure.

   A shielded pipe incorporates an outer pipe into which the high pressure fuel pipe is placed forming a permanent assembly.

   The shielded piping system is to include a means for collection of leakages and arrangements are to be provided for an alarm to be given in the event of a fuel line failure.

   If flexible hoses are used for shielding purposes, these are to be approved by the Society.

   When in fuel oil return piping the pulsation of pressure with peak to peak values exceeds 20 bar, shielding of this piping is also required as above

b) For vessels classed for restricted navigation, the requirements under a) may be relaxed at the Society's discretion.

2.4.3 Lubricating oil system

Efficient filters are to be fitted in the lubricating oil system when the oil is circulated under pressure.

In such lubricating oil systems for propulsion machinery, filters are to be arranged so that an uninterrupted supply of filtered lubricating oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Ch 1, Sec 10.

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

The relief valves may be omitted provided that the filters can withstand the maximum pressure that the pump may develop.

Where necessary, the lubricating oil is to be cooled by means of suitable coolers.

2.4.4 Charge air system

a) Requirements relevant to design, construction, arrangement, installation, tests and certification of exhaust gas turbochargers are to comply with Ch 1, Sec 14.

b) When two-stroke propulsion engines are supercharged by exhaust gas turbochargers which operate on the impulse system, provision is to be made to prevent broken piston rings entering turbocharger casings and causing damage to blades and nozzle rings.

2.5 Starting air system

2.5.1 The requirements given in [3.1] apply.

2.6 Control and safety devices

2.6.1 Governors of main and auxiliary engines

Each engine, except the auxiliary engines for driving electric generators for which [2.6.4] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed the rated speed by more than 15%.

2.6.2 Overspeed protective devices of main and auxiliary engines

In addition to the speed governor, each:

- main propulsion engine having a rated power of 220 kW and above, which can be declutched or which drives a controllable pitch propeller, and
- auxiliary engine having a rated power of 220 kW and above, except those for driving electric generators, for which [2.6.4] item f) applies

is to be fitted with a separate overspeed protective device so adjusted that the engine cannot exceed the rated speed n by more than 20%; arrangements are to be made to test the overspeed protective device.

Equivalent arrangements may be accepted subject to special consideration by the Society in each case.

The overspeed protective device, including its driving mechanism or speed sensor, is to be independent of the governor.

2.6.3 Use of electronic governors

a) Type approval

   Electronic governors and their actuators are to be type approved by the Society.

b) Electronic governors for main propulsion engines

   If an electronic governor is fitted to ensure continuous speed control or resumption of control after a fault, an additional separate governor is to be provided unless the engine has a manually operated fuel admission control system suitable for its control.

   A fault in the governor system is not to lead to sudden major changes in propulsion power or direction of propeller rotation.

Alarms are to be fitted to indicate faults in the governor system.

The acceptance of electronic governors not in compliance with the above requirements will be considered by the Society on a case by case basis, when fitted on vessels with two or more main propulsion engines.

the power distribution system is designed such that the declared maximum step loading is not exceeded the maximum step load is declared and demonstrated

c) Electronic governors forming part of a remote control system

When electronic speed governors of main internal combustion engines form part of a remote control system, they are to comply with the following conditions:

- If lack of power to the governor may cause major and sudden changes in the present speed and direction of thrust of the propeller, back up power supply is to be provided;
- Local control of the engines is always to be possible even in the case of failure in any part of the automatic or remote control systems. To this purpose, from the local control position it is to be possible to disconnect the remote signal, bearing in mind that the speed control according to [2.6.1] is not available unless an additional separate governor is provided for such local mode of control.

d) Electronic governors for auxiliary engines driving electric generators

In the event of a fault in the electronic governor system the fuel admission is to be set to “zero”.

Alarms are to be fitted to indicate faults in the governor system.

The acceptance of electronic governors fitted on engines driving emergency generators will be considered by the Society on a case by case basis.

2.6.4 Governors for auxiliary engines driving electric generators

a) Prime movers for driving generators of the main and emergency sources of electrical power are to be fitted with a speed governor which will prevent transient frequency variations in the electrical network in excess of ±10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

In the case when a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause intervention of the overspeed device as required in item f).

b) At all loads between no load and rated power, the permanent speed variation is not to be more than 5% of the rated speed.

c) Prime movers are to be selected in such a way that they meet the load demand within the vessel’s mains and, when running at no load, can satisfy the requirement in item a) above if suddenly loaded to 50% of the rated power of the generator, followed by the remaining 50% after an interval sufficient to restore speed to steady state. Steady state conditions (see Note 1) are to be achieved in not more than 5 s (see Note 1).

d) Application of the electrical load in more than 2 load steps can only be allowed if the conditions within the vessel’s mains permit the use of those auxiliary engines which can only be loaded in more than 2 load steps (see Fig 1 for guidance on 4-stroke diesel engines expected maximum possible sudden power increase) and provided that this is already allowed for in the designing stage.

This is to be verified in the form of system specifications to be approved and to be demonstrated at vessel’s trials. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after blackout and to the sequence in which it is connected.

This also applies to generators to be operated in parallel and where the power is to be transferred from one generator to another, in the event that any one generator is to be switched off.

e) Emergency generator sets must satisfy the governor conditions as per items a) and b) when:

- their total consumer load is applied suddenly, or
- their total consumer load is applied in steps, subject to:
  - the total load is supplied within 45 seconds since power failure on the main switchboard
  - the maximum step load is declared and demonstrated
  - the power distribution system is designed such that the declared maximum step loading is not exceeded the maximum step load is declared and demonstrated
  - the compliance of time delays and loading sequence with the above is to be demonstrated at vessel’s trials

f) In addition to the speed governor, auxiliary engines of rated power equal to or greater than 220 kW driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

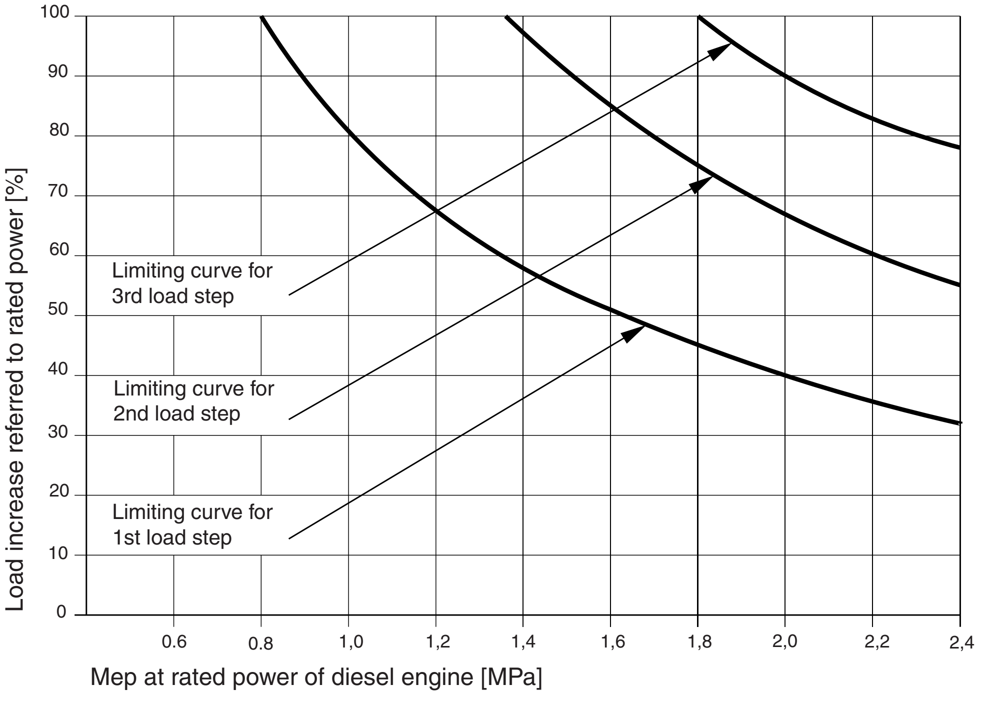
This device is to automatically shut down the engine.

g) For alternating current generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

For alternating current generating sets intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

Note 1: Steady state conditions are those at which the envelope of speed variation does not exceed ± 1% of the declared speed at the new power.

Figure 1 : Limiting curves for loading 4-stroke diesel engines step by step from no load to rated power as a function of the brake mean effective pressure (Mep)



2.7 Control and monitoring

2.7.1 General

Diesel engines are to be equipped with monitoring equipment in compliance with Ch 3, Sec 2.

In addition, vessels assigned **AUT-UMS** additional notation are to comply with the requirements of Pt D, Ch 2, Sec 8.

The alarms are to be visual and audible.

The indicators are to be fitted at a normally attended position (on the engine or at the local control station).

2.7.2 Control station - Definition

A control station is a group of control and monitoring devices by means of which an operator can control and verify the performance of equipment.

2.7.3 Main engines room control station

As a minimum requirement, the engine room control station is to be equipped with the following main engine indicators, which are to be clearly and logically arranged:

- engine speed indicator
- lubricating oil pressure at engine inlet
- cylinder cooling water pressure
- starting air pressure
- charge air pressure
- control air pressure at engine inlet
- shaft revolution indicator.

Indicators are to be provided for the following on the control station and/or directly on the engine:

- lubricating oil temperature
- coolant temperature
- fuel temperature at engine inlet only for engines running on heavy fuel oil
- exhaust gas temperature, wherever the dimensions permit, at each cylinder outlet and at the turbocharger inlet/outlet.

In the case of geared transmissions or controllable pitch propellers, the scope of the control equipment is to be extended accordingly.

On the pressure gauges the permissible pressures, and on the tachometers any critical speed ranges, are to be indicated in red.

A machinery alarm system is to be installed for the pressures and temperatures specified above, with the exception of the charge air pressure, the control air pressure and the exhaust gas temperature.

2.7.4 Main engines control from the wheelhouse

The vessel's control stand is to be fitted with indicators, easily visible to the operator, showing the starting and manoeuvring air pressure as well as the direction of rotation and revolutions of the propeller shaft.

In addition, the alarm system required under last paragraph of [2.7.3] is to signal faults on the bridge. Faults may be signalled in accordance with Ch 1, Sec 1, [3.8]. An indicator in the engine room and on the bridge shall show that the alarm system is operative.

2.7.5 auxiliary engines

Instruments or equivalent devices mounted in a logical manner on the engine shall indicate at least:

- engine speed
- lubricating oil pressure
- cooling water pressure
- cooling water temperature.

In addition, engines of over 50 kW power are to be equipped with an engine alarm system responding to the lubricating oil pressure and to the pressure or flow rate of the cooling water or a failure of the cooling fan, as applicable.

3 Arrangement and installation

3.1 Starting arrangements

3.1.1 Mechanical air starting

a) Air starting the main and auxiliary engines is to be arranged in compliance with Ch 1, Sec 10, [17.3.1].

b) The total capacity of air compressors and air receivers is to be in compliance with Ch 1, Sec 10, [17.3.2] and Ch 1, Sec 10, [17.3.3].

c) The main starting air arrangements for main propulsion or auxiliary diesel engines are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes. To this end, the following safety devices are to be fitted:

   - An isolating non-return valve, or equivalent, at the starting air supply connection to each engine
   - A bursting disc or flame arrester:
     - in way of the starting valve of each cylinder, for direct reversing engines having a main starting air manifold
     - at least at the supply inlet to the starting air manifold, for non-reversing engines.

   The bursting disc or flame arrester above may be omitted for engines having a bore not exceeding 230 mm.

   Other protective devices will be specially considered by the Society.

   The requirements of this item c) do not apply to engines started by pneumatic motors.

d) Compressed air receivers are to comply with the requirements of Ch 1, Sec 3. Compressed air piping and associated air compressors are to comply with the requirements of Ch 1, Sec 10.

3.1.2 Electrical starting

a) Where main internal combustion engines are arranged for electrical starting, at least two separate batteries are to be fitted.

   The arrangement is to be such that the batteries cannot be connected in parallel.

   Each battery is to be capable of starting the main engine when in cold and ready to start condition.

   The combined capacity of batteries is to be sufficient to provide within 30 min, without recharging, the number of starts required in [3.1.1] b) in the event of air starting.

b) Electrical starting arrangements for auxiliary engines are to have two separate storage batteries or may be supplied by two separate circuits from main engine storage batteries when these are provided. In the case of a single auxiliary engine, one battery is acceptable. The combined capacity of the batteries is to be sufficient for at least three starts for each engine.

c) The starting batteries are only to be used for starting and for the engine's alarm and monitoring. Provision is to be made to maintain the stored energy at all times.

d) For rating of each charging device, see Ch 2, Sec 7, [7].

3.2 Turning gear

3.2.1 Each engine is to be provided with hand-operated turning gear; where deemed necessary, the turning gear is to be both hand and mechanically-operated.

The turning gear engagement is to inhibit starting operations.

3.3 Trays

3.3.1 Trays fitted with means of drainage are to be provided in way of the lower part of the crankcase and, in general, in way of the parts of the engine, where oil is likely to spill in order to collect the fuel oil or lubricating oil dripping from the engine.

3.4 Exhaust gas system

3.4.1 In addition to the requirements given in Ch 1, Sec 10, [18], the exhaust system is to be efficiently cooled or insulated in such a way that the surface temperature does not exceed 220°C (see also Ch 1, Sec 1, [3.7]).

4 Type tests, material tests, workshop inspection and testing, certification

4.1 General

4.1.1 Type testing, material and non-destructive tests for engine components, factory acceptance test and certification for diesel engines are to be in compliance with NR467, Pt C, Ch 1, Sec 2, [4].

SECTION 3 PRESSURE EQUIPMENT

1 General

1.1 Principles

1.1.1 Scope of the Rules

The boilers and other pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and are to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

So these Rules apply to pressure equipment (see Note 1) for the following requirements:

- be safe in sight of pressure risk
- be safe in sight of other risks, moving parts, hot surfaces
- ensure capability of essential services.

Note 1: Pressure equipment means pressure vessels, piping (see Ch 1, Sec 10), safety accessories and pressure accessories.

1.1.2 Overpressure risk

Where boilers and other pressure vessels or any parts thereof may be subject to dangerous overpressure, means are to be provided where practicable to protect against such excessive pressure.

1.1.3 Tests

All boilers and other pressure vessels including their associated fittings which are under internal pressure are to be subjected to appropriate tests including a pressure test before being put into service for the first time (see also [7]).

1.2 Application

1.2.1 Pressure vessels covered by the Rules

The requirements of this Section apply to:

- all fired or unfired pressures vessels of metallic construction, including the associated fittings and mountings with maximum allowable pressure greater than 0,5 bar above atmospheric pressure with the exception of those indicated in [1.2.2]
- all boilers and other steam generators, including the associated fittings and mountings with maximum allowable pressure greater than 0,5 bar above atmospheric pressure with the exception of those indicated in [1.2.2].

1.2.2 Pressure vessels not covered by the Rules

Among others the following boilers and pressure vessels are not covered by the Rules and are to be considered on a case by case basis:

a) boilers with design pressure $p > 10$ MPa

b) pressure vessel intended for radioactive material

c) equipment comprising casings or machinery where the dimensioning, choice of material and manufacturing rules are based primarily on requirements for sufficient strength, rigidity and stability to meet the static and dynamic operational effects or other operational characteristics and for which pressure is not a significant design factor. Such equipment may include:
   - engines including turbines and internal combustion engines
   - steam engines, gas/steam turbines, turbo-generators, compressors, pumps and actuating devices

d) small pressure vessels included in self-contained domestic equipment.

1.3 Definitions

1.3.1 Pressure vessel

Pressure vessel means a housing designed and built to contain fluids under pressure including its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber.

1.3.2 Fired pressure vessel

Fired pressure vessel is a pressure vessel which is completely or partially exposed to fire from burners or combustion gases or otherwise heated pressure vessel with a risk of overheating.

a) Boiler

   Boiler is one or more fired pressure vessels and associated piping systems used for generating steam or hot water at a temperature above 120°C.

   Any equipment directly connected to the boiler, such as economisers, superheaters and safety valves, is considered as part of the boiler, if it is not separated from the steam generator by means of any isolating valve. Piping connected to the boiler is considered as part of the boiler upstream of the isolating valve and as part of the associated piping system downstream of the isolating valve.

b) Thermal oil heater

   Thermal oil heater is one or more fired pressure vessels and associated piping systems in which organic liquids (thermal oils) are heated. When heated by electricity thermal oil heater is considered as an unfired pressure vessel.

1.3.3 Unfired pressure vessel

Any pressure vessel which is not a fired pressure vessel is an unfired pressure vessel.

a) Heat exchanger

   A heat exchanger is an unfired pressure vessel used to heat or cool a fluid with an another fluid. In general heat exchangers are composed of a number of adjacent chambers, the two fluids flowing separately in adjacent chambers. One or more chambers may consist of bundles of tubes.

b) Steam generator

   A steam generator is a heat exchanger and associated piping used for generating steam. In general in these Rules, the requirements for boilers are also applicable for steam generators, unless otherwise indicated.

1.3.4 Safety accessories

Safety accessories means devices designed to protect pressure equipment against the allowable limits being exceeded. Such devices include:

- devices for direct pressure limitation, such as safety valves, bursting disc safety devices, buckling rods, controlled safety pressure relief systems, and
- limiting devices, which either activate the means for correction or provide for shutdown or shutdown and lockout, such as pressure switches or temperature switches or fluid level switches and safety related measurement control and regulation devices.

1.3.5 Design pressure

The design pressure is the pressure used by the manufacturer to determine the scantlings of the vessel. This pressure cannot be taken less than the maximum working pressure and is to be limited by the set pressure of the safety valve, as prescribed by the applicable Rules. Pressure is indicated as gauge pressure above atmospheric pressure, vacuum is indicated as negative pressure.

1.3.6 Design temperature

a) Design temperature is the actual metal temperature of the applicable part under the expected operating conditions, as modified in Tab 1. This temperature is to be stated by the manufacturer and is to take in account of the effect of any temperature fluctuations which may occur during the service.

b) The design temperature is not to be less than the temperatures stated in Tab 1, unless specially agreed between the manufacturer and the Society on a case by case basis.

1.3.7 Volume

Volume V means the internal volume of a chamber, including the volume of nozzles to the first connection or weld and excluding the volume of permanent internal parts.

1.3.8 Boiler heating surface

Boiler heating surface is the area of the part of the boiler through which the heat is supplied to the medium, on the side exposed to fire or hot gases.

1.3.9 Maximum steam output

Maximum steam output is the maximum quantity of steam than can be produced continuously by the boiler or steam generator operating under the design steam conditions.

1.3.10 Toxic and corrosive substances

Toxic and corrosive substances are those which are listed in the ADN "European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways)", as amended.

1.3.11 Liquid and gaseous substances

a) Liquid substances are liquids having a vapour pressure at the maximum allowable temperature of not more than 0,5 bar above normal atmospheric pressure.

b) Gaseous substances are gases, liquefied gases, gases dissolved under pressure, vapours and also those liquids whose vapour pressure at the maximum allowable temperature is greater than 0,5 bar above normal atmospheric pressure.

1.3.12 Ductile material

For the purpose of this Section, ductile material is a material having an elongation over 12%.

Table 1 : Minimum design temperature

Type of vessel	Minimum design temperature
Pressure parts of pressure vessels and boilers not heated by hot gases or adequately protected by insulation	Maximum temperature of the internal fluid
Pressure vessel heated by hot gases	25°C in excess of the temperature of the internal fluid
Water tubes of boilers mainly subjected to convection heat	25°C in excess of the temperature of the saturated steam
Water tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to convection heat	35°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Economiser tubes	35°C in excess of the temperature of the internal fluid
For combustion chambers of the type used in wet-back boilers	50°C in excess of the temperature of the internal fluid
For furnaces, fire-boxes, rear tube plates of dry-back boilers and other pressure parts subjected to similar rate of heat transfer	90°C in excess of the temperature of the internal fluid

1.4 Classes

1.4.1 Significant parameters

Pressure vessels are classed in three class in consideration of the:

- type of equipment: pressure vessel or steam generator
- state (gaseous or liquid) of the intended fluid contents
- substances listed or not in ADN
- design pressure p, in MPa
- design temperature T, in °C
- actual thickness of the vessel tA, in mm
- volume V, in litres.

1.4.2 Pressure vessel classification

Pressure vessels are classed as indicated in Tab 2.

1.4.3 Implication of class

The class of a pressure vessel has, among others, implication in:

- design
- material allowance
- welding design
- efficiency of joints
- examination and non-destructive tests
- thermal stress relieving.

See Tab 10.

1.5 Applicable Rules

1.5.1 General

Boilers and pressure vessels are to be designed, constructed, installed and tested in accordance with the applicable requirements of this Section.

1.5.2 Alternative standards

Other national and international standards such as AD-Merkbläter, ASME, CODAP, British Standards or harmonized European Standards may be considered as an alternative to the requirements of this Section.

1.5.3 Statutory regulations

As regards their construction and installation, pressure equipment is also required to comply with applicable statutory regulations of the flag state Authority.

1.5.4 Provisions applicable to oil firing equipment

For rule requirements applicable to oil firing equipment, see Ch 1, Sec 4.

1.6 Documentation to be submitted

1.6.1 General

Documents mentioned in the present sub-article are to be submitted for class 1 and class 2 and not for class 3, unless the equipment is considered as critical.

1.6.2 Boilers and steam generators

The plans listed in Tab 3 are to be submitted.

The drawings listed in Tab 3 are to contain the:

- constructional details of all pressure parts, such as shells, headers, tubes, tube plates, nozzles
- strengthening members, such as stays, brackets, opening reinforcements and covers
- installation arrangements, such as saddles and anchoring system,

as well as the information and data indicated in Tab 4.

1.6.3 Pressure vessels

The plans listed in Tab 5 are to be submitted.

The drawings listed in Tab 5 are to contain the constructional details of:

- pressure parts, such as shells, headers, tubes, tube plates, nozzles, opening reinforcements and covers
- strengthening members, such as stays, brackets and reinforcements.

Table 2 : Pressure vessel classification

Equipment	Class 1	Class 2	Class 3
Steam generators or boilers	$p > 3{,}2$ and $V > 2$ or $p\,V > 20$ and $V > 2$	if not class 1 or class 3	$p\,V \leq 5$ or $V \leq 2$
Pressure vessels for toxic substances	all	–	–
Pressure vessels for corrosive substances	$p > 20$ or $p\,V > 20$ or $T > 350$	if not in class 1	–
Pressure vessels for gaseous substances	$p > 100$ or $p\,V > 300$	$V > 1$ and $p\,V > 100$ and not in class 1	all pressure vessels which are not class 1 or class 2
Pressure vessels for liquid substances	$V > 10$ and $p\,V > 1000$ and $p > 50$	$V \leq 10$ and $p > 100$ or $1 < p \leq 50$ and $p\,V > 1000$	all pressure vessels and heat exchangers which are not class 1 or class 2
Pressure vessels for thermal oil	$p > 1{,}6$ or $T > 300$	if not class 1 or class 3	$p \leq 0{,}7$ and $T \leq 150$
Pressure vessels for fuel oil, lubricating oil or flammable hydraulic oil	$p > 1{,}6$ or $T > 150$	if not class 1 or class 3	$p \leq 0{,}7$ and $T \leq 60$
Whatever type of equipment	$t_A > 40$	$15 < t_A \leq 40$	–
Note 1: Whenever the class is defined by more than one characteristic, the equipment is to be considered belonging to the highest class of its characteristics, independently of the values of the other characteristics.			

Table 3 : Drawings to be submitted for boilers and steam generators

No	A/I	Item
1	I	General arrangement plan, including valves and fittings
2	A	Material specifications
3	A	Sectional assembly
4	A	Evaporating parts
5	A	Superheater
6	A	De-superheater
7	A	Economiser
8	A	Air heater
9	A	Tubes and tube plates
10	A	Nozzles and fittings
11	A	Safety valves and their arrangement
12	A	Boiler seating
13	I	Fuel oil burning arrangement
14	I	Forced draught system
15	I	Refractor or insulation arrangement
16	A	Boiler instrumentation, monitoring and control system
17	A	Type of safety valves and their lift, discharge rate and setting
18	A	Welding details, including at least: • typical weld joint design • welding procedure specifications • post-weld heat treatment
Note 1: A = to be submitted for review I = to be submitted for information.		

Table 4 : Information and data to be submitted for boilers and steam generators

No	Item
1	Design pressure and temperature
2	Pressure and temperature of the superheated steam
3	Pressure and temperature of the saturated steam
4	Maximum steam production per hour
5	Evaporating surface of the tube bundles and water-walls
6	Heating surface of the economiser, superheater and air-heater
7	Surface of the furnace
8	Volume of the combustion chamber
9	Temperature and pressure of the feed water
10	Type of fuel to be used and fuel consumption at full steam production
11	Number and capacity of burners

Table 5 : Drawings, information and data to be submitted for pressure vessels and heat exchangers

No	A/I	Item
1	I	General arrangement plan, including nozzles and fittings
2	A	Sectional assembly
3	A	Safety valves (if any) and their arrangement
4	A	Material specifications
5	A	Welding details, including at least: • typical weld joint design • welding procedure specifications • post-weld heat treatments
6	I	Design data, including at least design pressure and design temperatures (as applicable)
7	A	For seamless (extruded) pressure vessels, the manufacturing process, including: • a description of the manufacturing process with indication of the production controls normally carried out in the manufacturer's works • details of the materials to be used (specification, yield point, tensile strength, impact strength, heat treatment) • details of the stamped marking to be applied
8	I	Type of fluid or fluids contained
Note 1: A = to be submitted for review I = to be submitted for information.		

2 Design and construction - Scantlings of pressure parts

2.1 General

2.1.1 Application

a) In general, the formulae in the present Article do not take into account additional stresses imposed by effects other than pressure, such as stresses deriving from the static and dynamic weight of the pressure vessel and its content, external loads from connecting equipment and foundations, etc. For the purpose of the Rules, these additional loads may be neglected, provided it can reasonably be presumed that the actual average stresses of the vessel, considering all these additional loads, would not increase more than 10% with respect to the stresses calculated by the formulae in this Article.

b) Where it is necessary to take into account additional stresses, such as dynamic loads, the Society reserves the right to ask for additional requirements on a case by case basis.

2.1.2 Alternative requirements

When pressure parts are of an irregular shape, such as to make it impossible to check the scantlings by applying the formulae of this Article, the review is to be based on other means, such as burst and/or deformation tests on a prototype or by another method agreed upon between the manufacturer and the Society.

2.2 Materials

2.2.1 Materials for high temperatures

a) Materials for pressure parts having a design temperature exceeding the ambient temperature are to be selected by the Manufacturer and to have mechanical and metallurgical properties adequate for the design temperature. Their allowable stress limits are to be determined as a function of the temperature, as per [2.3.2].

b) When the design temperature of pressure parts exceeds 400°C, alloy steels are to be used. Other materials are subject of special consideration by the Society.

2.2.2 Materials for low temperatures

Materials for pressure parts having a design temperature below the ambient temperature are to have notch toughness properties suitable for the design temperature.

2.2.3 Cast iron

Grey cast iron is not to be used for:

a) class 1 and class 2 pressure vessels

b) class 3 pressure vessels with design pressure $p > 1,6$ MPa or product $p \cdot V > 1000$, where V is the internal volume of the pressure vessel in litres

c) Bolted covers and closures of pressure vessels having a design pressure $p > 1$ MPa, except for covers intended for boiler shells, for which [3.2.4] applies.

Spheroidal cast iron may be used subject to the agreement of the Society following special consideration. However, it is not to be used for parts, having a design temperature exceeding 350°C.

2.2.4 Valves and fittings for boilers

a) Ductile materials are to be used for valves and fittings intended to be mounted on boilers. The material is to have mechanical and metallurgical characteristics suitable for the design temperature and for the thermal and other loads imposed during the operation.

b) Grey cast iron is not to be used for valves and fittings which are subject to dynamic loads, such as safety valves and blow-down valves, and in general for fittings and accessories having design pressure p exceeding 0,3 MPa and design temperature T exceeding 220°C.

c) Spheroidal cast iron is not to be used for parts having a design temperature T exceeding 350°C.

d) Bronze is not to be used for parts having design temperature T exceeding 220°C for normal bronzes and 260°C for bronzes suitable for high temperatures. Copper and aluminium brass are not to be used for fittings with design temperature T above 200°C and copper-nickel fittings with design temperature T exceeding 300°C.

2.2.5 Alternative materials

In the case of boilers or pressure vessels constructed in accordance with one of the standards considered acceptable by the Society as per [1.5], the material specifications are to be in compliance with the requirements of the standard used.

2.3 Permissible stresses

2.3.1 The permissible stresses K, in N/mm², for steels, to be used in the formulae of this Article, may be determined from Tab 6, Tab 7, Tab 8 and Tab 9 where R_m is the ultimate strength of the material, in N/mm². For intermediate values of the temperature, the value of K is to be obtained by linear interpolation.

Table 6 : Permissible stresses K for carbon steels intended for boilers and thermal oil heaters

Carbon steel	Carbon steel thickness	Permissible stresses K for temperature T (°C):							
		≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm² Grade HA	t ≤ 15 mm	133	109	107	105	94	77	73	72
	15 mm < t ≤ 40 mm	128	106	105	101	90	77	73	72
	40 mm < t ≤ 60 mm	122	101	99	95	88	77	73	72
R_m = 360 N/mm² Grades HB, HD	t ≤ 15 mm	133	127	116	103	79	79	72	69
	15 mm < t ≤ 40 mm	133	122	114	102	79	79	72	69
	40 mm < t ≤ 60 mm	133	112	107	99	79	79	72	69
R_m = 410 N/mm² Grade HA	t ≤ 15 mm	152	132	130	126	112	94	89	86
	15 mm < t ≤ 40 mm	147	131	124	119	107	94	89	86
	40 mm < t ≤ 60 mm	141	120	117	113	105	94	89	86
R_m = 410 N/mm² Grades HB, HD	t ≤ 15 mm	152	147	135	121	107	95	88	84
	15 mm < t ≤ 40 mm	152	142	133	120	107	95	88	84
	40 mm < t ≤ 60 mm	152	134	127	117	107	95	88	84
R_m = 460 N/mm² Grades HB, HD	t ≤ 15 mm	170	164	154	139	124	111	104	99
	15 mm < t ≤ 40 mm	169	162	151	137	124	111	104	99
	40 mm < t ≤ 60 mm	162	157	147	136	124	111	104	99
R_m = 510 N/mm² Grades HB, HD	t ≤ 60 mm	170	170	169	159	147	134	125	112

Table 7 : Permissible stresses K for carbon steels intended for other pressure vessels

Carbon steel	Carbon steel thickness	Permissible stresses K for temperature T (°C):							
		≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm^2 Grade HA	t ≤ 15 mm	133	117	115	112	100	83	78	77
	15 mm < t ≤ 40 mm	133	114	113	108	96	83	78	77
	40 mm < t ≤ 60 mm	130	108	105	101	94	83	78	77
R_m = 360 N/mm^2 Grades HB, HD	t ≤ 15 mm	133	133	123	110	97	85	77	73
	15 mm < t ≤ 40 mm	133	131	122	109	97	85	77	73
	40 mm < t ≤ 60 mm	133	119	115	106	97	85	77	73
R_m = 410 N/mm^2 Grade HA	t ≤ 15 mm	152	141	139	134	120	100	95	92
	15 mm < t ≤40 mm	152	134	132	127	114	100	95	92
	40 mm < t ≤ 60 mm	150	128	121	112	112	100	95	92
R_m = 410 N/mm^2 Grades HB, HD	t ≤ 15 mm	152	152	144	129	114	101	94	89
	15 mm < t ≤ 40 mm	152	152	142	128	114	101	94	89
	40 mm < t ≤ 60 mm	152	143	139	125	114	101	94	89
R_m = 460 N/mm^2 Grades HB, HD	t ≤ 15 mm	170	170	165	149	132	118	111	105
	15 mm < t ≤ 40 mm	170	170	161	147	132	118	111	105
	40 mm < t ≤ 60 mm	170	167	157	145	132	118	111	105
R_m = 510 N/mm^2 Grades HB, HD	t ≤ 60 mm	189	189	180	170	157	143	133	120

Table 8 : Permissible stresses K for alloy steels intended for boilers and thermal oil heaters

Alloy steel	Alloy steel thickness	Permissible stresses K for temperature T (°C):														
		≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	153	143	134	125	106	100	94	91	89	87	36			
1Cr 0,5Mo	t ≤ 60 mm	167	167	157	144	137	128	119	112	106	104	103	55	31	19	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	170	167	157	147	144	137	131	125	119	115	112	61	41	30	22
2,25Cr 1Mo **(2)**	t ≤ 60 mm	170	167	164	161	159	147	141	130	128	125	122	61	41	30	22

(1) Normalised and tempered
(2) Normalised and tempered or quenched and tempered.

Table 9 : Permissible stresses K for alloy steels intended for other pressure vessels

Alloy steel	Alloy steel thickness	Permissible stresses K for temperature T (°C):														
		≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	159	153	143	133	113	107	100	97	95	93	38			
1Cr 0,5Mo	t ≤ 60 mm	167	167	167	154	146	137	127	119	113	111	110	59	33	20	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	183	174	167	157	154	146	140	133	127	123	119	65	44	32	23
2,25Cr 1Mo **(2)**	t ≤ 60 mm	174	174	174	172	170	157	150	139	137	133	130	65	44	32	23

(1) Normalised and tempered
(2) Normalised and tempered or quenched and tempered.

2.3.2 Direct determination of permissible stress

The permissible stresses K, where not otherwise specified, may be taken as indicated below:

a) Steel:

$$K = \min\left(\frac{R_{m,20}}{2{,}7}, \frac{R_{S,MIN,T}}{A}, \frac{S_A}{A}\right)$$

b) Spheroidal cast iron:

$$K = \min\left(\frac{R_{m,20}}{4{,}8}, \frac{R_{S,MIN,T}}{3}\right)$$

c) Grey cast iron:

$$K = \frac{R_{m,20}}{10}$$

d) Copper alloys:

$$K = \frac{R_{m,T}}{4}$$

e) Aluminium and aluminium alloys:

$$K = \min\left(\frac{R_{m,T}}{4}, \frac{R_{e,H}}{1,5}\right)$$

where:

$R_{m,\,20}$: Minimum tensile strength at ambient temperature (20°C), in N/mm^2

$R_{S,\,MIN,\,T}$: Minimum between R_{eH} and $R_{p0,2}$ at the design temperature T, in N/mm^2

S_A : Average stress to produce creep rupture in 100000 hours, in N/mm^2, at the design temperature T

A : Safety factor taken as follows, when reliability of $R_{S,\,MIN,\,T}$ and S_A values are proved to the Society's satisfaction:

- 1,6 for boilers and other steam generators
- 1,5 for other pressure vessels
- specially considered by the Society if average stress to produce creep rupture in more than 100000 hours is used instead of S_A.

In the case of steel castings, the permissible stress K, calculated as above, is to be decreased by 20%. Where steel castings are subjected to non-destructive tests, a smaller reduction up to 10% may be taken into consideration by the Society

$R_{m,\,T}$: Minimum tensile strength at the design temperature T, in N/mm^2

R_{eH} : Minimum yield stress, in N/mm^2.

2.3.3 Additional conditions

- In special cases, the Society reserves the right to apply values of K lower than those specified in [2.3.2], in particular for lifting appliance devices and steering gear devices.
- In the case of boilers or other steam generators, K is not to exceed 170 N/mm^2.
- For materials other than those listed in [2.3.2], the permissible stress K is to be agreed with the Society on a case by case basis.

2.4 Scantling of pressure vessels

2.4.1 The scantling of pressure parts of pressure vessels is to be performed in compliance with NR467, Pt C, Ch 1, Sec 3, [2].

3 Design and construction - Equipment

3.1 All pressure vessels

3.1.1 Drainage

a) Each air pressure vessel is to be fitted with a drainage device allowing the evacuation of any oil or water accumulated in the vessel.

b) Drainage devices are also to be fitted on other vessels, in particular steam vessels, in which condensation water is likely to accumulate.

3.2 Boilers and steam generators

3.2.1 Safety valve arrangement

a) Every steam boiler and every steam generator with a total heating surface of 50 m^2 and above is to be provided with not less than two spring loaded safety valves of adequate capacity. For steam boilers and steam generators having heating surface less than 50 m2, only one safety valve need be fitted.

b) Where a superheater is an integral part of the boiler, at least one safety valve is to be located on the steam drum and at least one at the superheater outlet. The valves fitted at the superheater outlet may be considered as part of the boiler safety valves required in item a), provided that their capacity does not account for more than 25% of the total capacity required in [3.2.2], unless specially considered by the Society.

c) Where fitted, superheaters which may be shut-off from the boiler are to be provided with at least one safety valve; such valve(s) cannot be considered as part of the boiler safety valves required in item a).

d) In the case of boilers fitted with a separate steam accumulator, safety valves may be fitted on the accumulator if no shut-off is provided between it and the boiler and if the connecting pipe is of a size sufficient to allow the whole steam production to pass through, without increasing the boiler pressure more than 10% above the design pressure.

3.2.2 Relieving capacity of safety valves

a) The relieving capacity of each safety valve is to be determined in compliance with NR467 Pt C, Ch 1, Sec 3, [3.2.2].

b) When the safety valves are fitted at the superheater outlet. Their relieving capacity is to be such that, during the discharge of safety valves, a sufficient quantity of steam is circulated through the superheater to avoid damage.

c) The orifice diameter in way of the safety valves seat is not to be less than 40 mm. Where only one safety valve need be fitted, the orifice minimum diameter is not to be less than 50 mm. Valves of large relieving capacity with 15 mm minimum diameter may be accepted for boilers with steam production not exceeding 2000 kg/h.

d) Independently of the above requirements, the aggregate capacity of the safety valves is to be such as to discharge all the steam that can be generated without causing a transient pressure rise of more than 10% over the design pressure.

3.2.3 Miscellaneous safety valve requirements

a) Safety valves operated by pilot valves

The arrangement on the superheater of large relieving capacity safety valves, operated by pilot valves fitted in the saturated steam drum, is to be specially considered by the Society.

b) Safety valve setting

- safety valves are to be set under steam in the presence of the Surveyor to a pressure not higher than 1,03 times the design pressure
- safety valves are to be so constructed that their setting may not be increased in service and their spring may not be expelled in the event of failure. In addition, safety valves are to be provided with simple means of lifting the plug from its seat from a safe position in the boiler or engine room
- where safety valves are provided with means for regulating their relieving capacity, they are to be so fitted that their setting cannot be modified when the valves are removed for surveys.

c) Safety valve fitting on boiler

- the safety valves of a boiler are to be directly connected to the boiler and separated from other valve bodies
- where it is not possible to fit the safety valves directly on the superheater headers, they are to be mounted on a strong nozzle fitted as close as practicable to the superheater outlet. The cross-sectional area for passage of steam through restricted orifices of the nozzles is not to be less than 1/2 the aggregate area of the valves, calculated according to [3.2.2] a)
- safety valve bodies are to be fitted with drain pipes of a diameter not less than 20 mm for double valves, and not less than 12 mm for single valves, leading to the bilge or to the hot well. Valves or cocks are not to be fitted on drain pipes.

d) Exhaust pipes

- the minimum cross-sectional area of the exhaust pipes of safety valves which have not been experimentally tested is not to be less than C times the aggregate area A (see [3.2.2], a) for definition of C and A)
- the cross-sectional area of the exhaust manifold of safety valves is to be not less than the sum of the areas of the individual exhaust pipes connected to it
- silencers fitted on exhaust manifolds are to have a free passage area not less than that of the manifolds
- the strength of exhaust manifolds and pipes and associated silencers is to be such that they can withstand the maximum pressure to which they may be subjected, which is to be assumed not less than 1/4 of the safety valve setting pressure
- in the case that the discharges from two or more valves are led to the same exhaust manifold, provision is to be made to avoid the back pressure from the valve which is discharging influencing the other valves
- exhaust manifolds are to be led to the open and are to be adequately supported and fitted with suitable expansion joints or other means so that their weight does not place an unacceptable load on the safety valve bodies.

e) Steam generator heated by steam

Steam heated steam generators are also to be protected against possible damage resulting from failure of the heating coils. In this case, the area of safety valves calculated as stated in [3.2.2] may need to be increased to the satisfaction of the Society, unless suitable devices limiting the flow of steam in the heating coils are provided.

3.2.4 Other requirements

Access arrangement

a) Boilers are to be provided with openings in sufficient number and size to permit internal examination, cleaning and maintenance operations. In general, all pressure vessels which are part of a boiler with inside diameter exceeding 1200 mm, and those with inside diameter exceeding 800 mm and length exceeding 2000 mm, are to be provided with access manholes.

b) Manholes are to be provided in suitable locations in the shells, headers, domes, and steam and water drums, as applicable. The “net” (actual hole) dimension of elliptical or similar manholes is to be not less than 300 mm x 400 mm. The “net” diameter of circular manholes (actual hole) cannot be less than 400 mm. The edges of manholes are to be adequately strengthened to provide compensation for vessel openings.

c) In pressure vessels which are part of a boiler and are not covered by the requirement in item a) above, or where an access manhole cannot be fitted, at least the following openings are to be provided, as far as practicable:

- head holes, minimum dimensions:

  220 mm x 320 mm (320 mm diameter if circular)
- handholes, minimum dimensions: 87 mm x 103 mm
- sight holes, minimum diameter: 50 mm.

d) Sight holes may only be provided when the arrangement of manholes, head holes, or handholes is impracticable.

e) Covers for manholes and other openings are to be made of ductile steel, dished or welded steel plates or other approved design. Grey cast iron may be used only for small openings, such as handholes and sight holes, provided the design pressure p does not exceed 1 MPa and the design temperature T does not exceed 220°C.

f) Covers are to be of self-closing internal type. Small opening covers of other type may be accepted by the Society on a case by case basis.

g) Covers of the internal type are to have a spigot passing through the opening. The clearance between the spigot and the edge of the opening is to be uniform for the whole periphery of the opening and is not to exceed 1,5 mm.

h) Closing devices of internal type covers, having dimensions not exceeding 180 mm x 230 mm, may be fitted with a single fastening bolt or stud. Larger closing devices are to be fitted with at least two bolts or studs.

i) Covers are to be designed so as to prevent the dislocation of the required gasket by the internal pressure. Only continuous ring gaskets may be used for packing.

Fittings

a) In general, cocks and valves are to be designed in accordance with the requirements in Ch 1, Sec 10.

b) Cocks, valves and other fittings are to be connected directly or as close as possible to the boiler shell.

c) Cocks and valves for boilers are to be arranged in such a way that it can be easily seen when they are open or closed and so that their closing is obtained by a clockwise rotation of the actuating mechanism.

Boiler burners

Burners are to be arranged so that they cannot be withdrawn unless the fuel supply to the burners is cut off.

Allowable water levels

a) In general, for water tube boilers the lowest permissible water level is just above the top row of tubes when the water is cold. Where the boiler is designed not to have fully submerged tubes, when the water is cold, the lowest allowable level indicated by the manufacturer is to be indicated on the drawings and submitted to the Society for consideration.

b) For fire tube boilers with combustion chamber integral with the boiler, the minimum allowable level is to be at least 50 mm above the highest part of the combustion chamber.

c) For vertical fire tube boilers the minimum allowable level is 1/2 of the length of the tubes above the lower tube sheet.

Steam outlets

a) Each boiler steam outlet, if not serving safety valves, integral superheaters and other appliances which are to have permanent steam supply during boiler operation, is to be fitted with an isolating valve secured either directly to the boiler shell or to a standpipe of substantial thickness, as short as possible, and secured directly to the boiler shell.

b) The number of auxiliary steam outlets is to be reduced to a minimum for each boiler.

c) Where several boilers supply steam to common mains, the arrangement of valves is to be such that it is possible to positively isolate each boiler for inspection and maintenance. In addition, for water tube boilers, non-return devices are to be fitted on the steam outlets of each boiler.

d) Where steam is used for essential auxiliaries (such as whistles, steam operated steering gears, steam operated electric generators, etc.) and when several boilers are fitted on board, it is to be possible to supply steam to these auxiliaries with any one of these boilers out of operation.

e) Each steam stop valve exceeding 150 mm nominal diameter is to be fitted with a bypass valve.

Feed check valves

a) Each fired boiler supplying steam to essential services is to be fitted with at least two feed check valves connected to two separate feed lines. For unfired steam generators a single feed check valve may be allowed.

b) Feed check valves are to be secured directly to the boiler or to an integral economiser. Water inlets are to be separated. Where, however, feed check valves are secured to an economiser, a single water inlet may be allowed provided that each feed line can be isolated without stopping the supply of feed water to the boiler.

c) Where the economisers may be bypassed and cut off from the boiler, they are to be fitted with pressure-limiting type valves, unless the arrangement is such that excessive pressure cannot occur in the economiser when cut off.

d) Feed check valves are to be fitted with control devices operable from the stokehold floor or from another appropriate location. In addition, for water tube boilers, at least one of the feed check valves is to be arranged so as to permit automatic control of the water level in the boiler.

e) Provision is to be made to prevent the feed water from getting in direct contact with the heated surfaces inside the boiler and to reduce, as far as possible and necessary, the thermal stresses in the walls.

Drains

Each superheater, whether or not integral with the boiler, is to be fitted with cocks or valves so arranged that it is possible to drain it completely.

Water sample

a) Every boiler is to be provided with means to supervise and control the quality of the feed water. Suitable arrangements are to be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

b) For this purpose, boilers are to be fitted with at least one water sample cock or valve. This device is not to be connected to the water level standpipes.

c) Suitable inlets for water additives are to be provided in each boiler.

Marking of boilers

a) Each boiler is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):
   - the design pressure
   - the design temperature
   - the test pressure and the date of the test.

b) Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.

c) For lagged vessels, these markings are also to appear on a similar plate fitted above the lagging.

3.3 Thermal oil heaters and thermal oil installation

3.3.1 General

a) The following requirements apply to thermal oil heaters in which organic liquids (thermal oils) are heated by oil fired burners, exhaust gases or electricity to temperatures below their initial boiling point at atmospheric pressure.

b) Thermal oils are only to be used within the limits set by the manufacturer.

c) Means are to be provided for manual operation. However, at least the temperature control device on the oil side and flow monitoring are to remain operative even in manual operation.

d) Means are to be provided to take samples of thermal oil.

3.3.2 Thermal oil heater design

a) Heaters are to be so constructed that neither the surfaces nor the thermal oil becomes excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

b) The surfaces which come into contact with the thermal oil are to be designed for the design pressure, subject to the minimum pressure of 1 MPa.

c) Copper and copper alloys are not permitted.

d) Heaters heated by exhaust gas are to be provided with inspection openings at the exhaust gas intake and outlet.

e) Oil fired heaters are to be provided with inspection openings for examination of the combustion chamber. The opening for the burner may be considered as an inspection opening, provided its size is sufficient for this purpose.

f) Heaters are to be fitted with means enabling them to be completely drained.

g) Thermal oil heaters heated by exhaust gas are to be fitted with a permanent system for extinguishing and cooling in the event of fire, for instance a pressure water spraying system.

3.3.3 Safety valves of thermal oil heaters

Each heater is to be equipped with at least one safety valve having a discharge capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During discharge the pressure may not increase above 10% over the design pressure.

3.3.4 Pressure vessels of thermal oil heaters

The design pressure of all vessels which are part of a thermal oil system, including those open to the atmosphere, is to be taken not less than 0,2 MPa.

3.3.5 Equipment of the expansion, storage and drain tanks

For the equipment to be installed on expansion, storage and drain tanks, see Ch 1, Sec 10, [13].

3.3.6 Marking

Each thermal oil heater and other pressure vessels which are part of a thermal oil installation are to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

- Heaters
  - maximum allowable heating power
  - design pressure
  - maximum allowable discharge temperature
  - minimum flow rate
  - liquid capacity
- Vessels
  - design pressure
  - design temperature
  - capacity.

3.4 Special types of pressure vessels

3.4.1 Seamless pressure vessels (bottles)

Each bottle is to be marked with the following information:

- name or trade name of the manufacturer
- serial number
- type of gas
- capacity
- test pressure
- empty weight
- test stamp.

3.4.2 Steam condensers

a) The water chambers and steam spaces are to be fitted with doors for inspection and cleaning.

b) Where necessary, suitable diaphragms are to be fitted for supporting tubes.

c) Condenser tubes are to be removable.

d) High speed steam flow, where present, is to be prevented from directly striking the tubes by means of suitable baffles.

e) Suitable precautions are to be taken in order to avoid corrosion on the circulating water side and to provide an efficient grounding.

3.5 Thermal oil heaters and thermal oil installation

3.5.1 General

a) The following requirements apply to thermal oil heaters in which organic liquids (thermal oils) are heated by oil fired burners, exhaust gases or electricity to temperatures below their initial boiling point at atmospheric pressure.

b) Thermal oils are only to be used within the limits set by the manufacturer.

c) Means are to be provided for manual operation. However, at least the temperature control device on the oil side and flow monitoring are to remain operative even in manual operation.

d) Means are to be provided to take samples of thermal oil.

3.5.2 Thermal oil heater design

a) Heaters are to be so constructed that neither the surfaces nor the thermal oil becomes excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

b) The surfaces which come into contact with the thermal oil are to be designed for the design pressure, subject to the minimum pressure of 1 MPa.

c) Copper and copper alloys are not permitted.

d) Heaters heated by exhaust gas are to be provided with inspection openings at the exhaust gas intake and outlet.

e) Oil fired heaters are to be provided with inspection openings for examination of the combustion chamber. The opening for the burner may be considered as an inspection opening, provided its size is sufficient for this purpose.

f) Heaters are to be fitted with means enabling them to be completely drained.

g) Thermal oil heaters heated by exhaust gas are to be fitted with a permanent system for extinguishing and cooling in the event of fire, for instance a pressure water spraying system.

3.5.3 Safety valves of thermal oil heaters

Each heater is to be equipped with at least one safety valve having a discharge capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During discharge the pressure may not increase above 10% over the design pressure.

3.5.4 Pressure vessels of thermal oil heaters

The design pressure of all vessels which are part of a thermal oil system, including those open to the atmosphere, is to be taken not less than 0,2 MPa.

3.5.5 Equipment of the expansion, storage and drain tanks

For the equipment to be installed on expansion, storage and drain tanks, see Ch 1, Sec 10, [13].

3.5.6 Marking

Each thermal oil heater and other pressure vessels which are part of a thermal oil installation are to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

- Heaters
  - maximum allowable heating power
  - design pressure
  - maximum allowable discharge temperature
  - minimum flow rate
  - liquid capacity
- Vessels
  - design pressure
  - design temperature
  - capacity.

3.6 Other pressure vessels

3.6.1 Safety valves arrangement

a) General:

- pressure vessels which are part of a system are to be provided with safety valves, or equivalent devices, if they are liable to be isolated from the system safety devices. This provision is also to be made in all cases in which the vessel pressure can rise, for any reason, above the design pressure
- in particular, air pressure vessels which can be isolated from the safety valves ensuring their protection in normal service are to be fitted with another safety device, such as a rupture disc or a fusible plug, in order to ensure their discharge in case of fire. This device is to discharge to the open
- safety devices ensuring protection of pressure vessels in normal service are to be rated to operate before the pressure exceeds the maximum working pressure by more than 5%
- where two or more pressure vessels are interconnected by a piping system of adequate size so that no branch of piping may be shut off, it is sufficient to provide them with one safety valve and one pressure gauge only.

b) Heat exchangers

Special attention is to be paid to the protection against overpressure of vessels, such as heat exchangers, which have parts that are designed for a pressure which is below that to which they might be subjected in the case of rupture of the tubular bundles or coils contained therein and that have been designed for a higher pressure.

3.6.2 Other requirements

a) Access arrangement

The access requirements for boilers stated in [3.2.4] are also applicable for other pressure vessels.

b) Corrosion protection

Vessels and equipment containing media that might lead to accelerated corrosion are to be suitably protected.

c) Marking:

- each pressure vessel is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):
  - the design pressure
  - the design temperature
  - the test pressure and the date of the test
- markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service
- for smaller pressure vessels the indication of the design pressure only may be sufficient.

4 Design and construction - Fabrication and welding

4.1 General principles

4.1.1 Base materials

a) These requirements apply to boilers and pressure vessels made of steel of weldable quality.

b) Fabrication and welding of vessels made of other materials are to be the subject of special consideration.

4.1.2 Welding

a) Weldings are to be performed in accordance with welding procedures approved by the Society.

b) Manual and semi-automatic welding is to be performed by welders qualified by the Society.

c) The conditions under which the welding procedures, welding equipment and welders operate are to correspond to those specified in the relevant approvals or qualifications.

d) Both ordinary and special electric arc welding processes are covered in the following requirements.

4.1.3 Cutting of plates

a) Plates are to be cut by flame cutting, mechanical machining or a combination of both processes. For plates having a thickness less than 25 mm, cold shearing is admitted provided that the sheared edge is removed by machining or grinding for a distance of at least one quarter of the plate thickness with a minimum of 3 mm.

b) For flame cutting of alloy steel plates, preheating is to be carried out if necessary.

c) The edges of cut plates are to be examined for laminations, cracks or any other defect detrimental to their use.

4.1.4 Forming of plates

a) The forming processes are to be such as not to impair the quality of the material. The Society reserves the right to require the execution of tests to demonstrate the suitability of the processes adopted. Forming by hammering is not allowed.

b) Unless otherwise justified, cold formed shells are to undergo an appropriate heat treatment if the ratio of internal diameter after forming to plate thickness is less than 20. This heat treatment may be carried out after welding.

c) Before or after welding, hot formed plates are to be normalised or subjected to another treatment suitable for their steel grade, if hot forming has not been carried out within an adequate temperature range.

d) Plates which have been previously butt-welded may be formed under the following conditions:
   - Hot forming

     After forming, the welded joints are to be subjected to X-ray examination or equivalent. In addition, mechanical tests of a sample weld subjected to the same heat treatment are to be carried out.
   - Cold forming

     Cold forming is only allowed for plates having a thickness not exceeding:
     - 20 mm for steels having minimum ultimate tensile strength R_m between 360 N/mm^2 and 410 N/mm^2
     - 15 mm for steels having R_m between 460 N/mm^2 and 510 N/mm^2 as well as for steels 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo.

     Cold forming is not allowed for steels 1Cr0,5Mo and 2,25Cr1Mo.
   - Weld reinforcements are to be carefully ground smooth prior to forming.
   - A proper heat treatment is to be carried out after forming, if the ratio of internal diameter to thickness is less than 36, for steels: 460 N/mm^2, 510 N/mm^2, 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo.
   - After forming, the joints are to be subjected to X-ray examination or equivalent and to a magnetic particle or liquid penetrant test.

4.2 Fabrication and welding

4.2.1 The design and procedure for fabrication and welding are to comply with NR467, Pt C, Ch 1, Sec 3, [4].

5 Design and construction - Control and monitoring

5.1 Boiler control and monitoring system

5.1.1 Local control and monitoring

Means to effectively operate, control and monitor the operation of oil fired boilers and their associated auxiliaries are to be provided locally. The functional condition of the fuel, feed water and steam systems and the boiler operational status are to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.1.2 Emergency shut-off

Means are to be provided to shut down boiler forced draft or induced draft fans and fuel oil service pumps from outside the space where they are located, in the event that a fire in that space makes their local shut-off impossible.

5.1.3 Water level indicators

a) Each boiler is to be fitted with at least two separate means for indicating the water level. One of these means is to be a level indicator with transparent element. The other may be either an additional level indicator with transparent element or an equivalent device. Level indicators are to be of an approved type.

b) The transparent element of level indicators is to be made of glass, mica or other appropriate material.

c) Level indicators are to be located so that the water level is readily visible at all times. The lower part of the transparent element is not to be below the safety water level defined by the builder.

d) Level indicators are to be fitted either with normally closed isolating cocks, operable from a position free from any danger in case of rupture of the transparent element or with self-closing valves restricting the steam release in case of rupture of this element.

5.1.4 Pressure control devices

a) Each boiler is to be fitted with a steam pressure gauge so arranged that its indications are easily visible from the stokehold floor. A steam pressure gauge is also to be provided for superheaters which can be shut off from the boiler they serve.

b) Pressure gauges are to be graduated in units of effective pressure and are to include a prominent legible mark for the pressure that is not to be exceeded in normal service.

c) Each pressure gauge is to be fitted with an isolating cock.

d) Double front boilers are to have a steam pressure gauge arranged in each front.

5.1.5 Temperature control devices

Each boiler fitted with a superheater is to have an indicator or recorder for the steam temperature at the superheater outlet.

5.1.6 Automatic shut-off of oil fired boilers

a) Each burner is to be fitted with a flame scanner designed to automatically shut off the fuel supply to the burner in the event of flame failure. In the case of failure of the flame scanner, the fuel to the burner is to be shut off automatically.

b) A low water condition is to automatically shut off the fuel supply to the burners. The shut-off is to operate before the water level reaches a level so low as to affect the safety of the boiler and no longer be visible in the gauge glass. Means are to be provided to minimise the risk of shut-off provoked by the effect of roll and pitch and/or transients. This shut-off system need not be installed in auxiliary boilers which are under local supervision and are not intended for automatic operation.

c) Forced draft failure is to automatically shut off the fuel supply to the burners.

d) Loss of boiler control power is to automatically shut off the fuel supply to the burners.

5.1.7 Alarms

Any actuation of the fuel-oil shut-off listed in [5.1.6] is to operate a visual and audible alarm.

5.2 Pressure vessel instrumentation

5.2.1

a) Pressure vessels are to be fitted with the necessary devices for checking pressure, temperature and level, where it is deemed necessary.

b) In particular, each air pressure vessel is to be fitted with a local manometer.

5.3 Thermal oil heater control and monitoring

5.3.1 Local control and monitoring

Suitable means to effectively operate, control and monitor the operation of oil fired thermal oil heaters and their associated auxiliaries are to be provided locally. The functional condition of the fuel, thermal oil circulation, forced draft and flue gas systems is to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.3.2 Flow control and monitoring

a) A flow indicator of the thermal oil is to be provided.

b) The flow detection is to be representative of the flow in each heated element.

c) The flow detection is not to be based on a measurement of the pressure-drop through the heating element.

d) Oil fired or exhaust gas heaters are to be provided with a flow monitor limit-switch. If the flow rate falls below a minimum value the firing system is to be switched off and interlocked.

5.3.3 Manual control

At least the temperature control device on the oil side and flow monitoring are to remain operative in manual operation.

5.3.4 Leakage monitoring

Oil tanks are to be equipped with a leakage detector which, when actuated, shuts down and interlocks the thermal oil firing system. If the oil fired heater is on stand-by, the starting of the burner is to be blocked if the leakage detector is actuated.

5.4 Control and monitoring requirements

5.4.1 For control and monitoring requirements of steam boilers and oil fired thermal oil heaters, see Ch 3, Sec 2.

6 Arrangement and installation

6.1 Foundations

6.1.1 For boilers and pressure vessels bolting down to their foundations, see Ch 1, Sec 1, [3.3.1]. Where necessary, they are also to be secured to the adjacent hull structures by suitable ties.

Where chocks are required to be fitted between the boilers and their foundations, they are to be of cast iron or steel.

6.2 Boilers

6.2.1 Thermal expansion

Means are to be provided to compensate thermal expansion of boilers.

6.2.2 Minimum distance of boilers from vertical bulkheads and fuel tanks

a) The distance between boilers and vertical bulkheads is to be not less than the minimum distance necessary to provide access for inspection and maintenance of the structure adjacent to the boiler.

b) In addition to the requirement in a), the distance of boilers from fuel oil tanks is to be such as to prevent the possibility that the temperature of the tank bulkhead may approach the flash point of the oil.

c) In any event, the distance between a boiler and a vertical bulkhead is not to be less than 450 mm.

6.2.3 Minimum distance of boilers from double bottom

a) Where double bottoms in way of boilers may be used to carry fuel oil, the distance between the top of the double bottom and the lower metal parts of the boilers is not to be less than:
   - 600 mm, for cylindrical boilers
   - 750 mm, for water tube boilers.

b) The minimum distance of vertical tube boilers from double bottoms not intended to carry oil may be 200 mm.

6.2.4 Minimum distance of boilers from ceilings

a) A space sufficient for adequate heat dissipation is to be provided on the top of boilers.

b) Oil tanks are not permitted to be installed in spaces above boilers.

6.2.5 Installation of boilers on engine room flats

Where boilers are installed on an engine room flat and are not separated from the remaining space by means of a watertight bulkhead, a coaming of at least 200 mm in height is to be provided on the flat. The area surrounded by the coaming may be drained into the bilge.

6.2.6 Drip trays and gutterways

Boilers are to be fitted with drip trays and gutterways in way of burners so arranged as to prevent spilling of oil into the bilge.

6.2.7 Hot surfaces

Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Ch 1, Sec 1, [3.7.1].

6.2.8 Registers fitted in the smoke stacks of oil fired boilers

Where registers are fitted in smoke stacks, they are not to obstruct more than two thirds of the cross-sectional area of gas passage when closed. In addition, they are to be provided with means for locking them in open position when the boiler is in operation and for indicating their position and degree of opening.

6.3 Pressure vessels

6.3.1 Safety devices on multiple pressure vessels

Where two or more pressure vessels are interconnected by a piping system of adequate size so that no branch of piping may be shut off, it is sufficient to provide them with one safety valve and one pressure gauge only.

6.4 Thermal oil heaters

6.4.1 In general, the requirements of [6.2] for boilers are also applicable to thermal oil heaters.

7 Material test, workshop inspection and testing, certification

7.1 Material testing

7.1.1 General

Materials, including welding consumables, for the constructions of boilers and pressure vessels are to be certified by the material manufacturer in accordance with the appropriate material specification.

7.1.2 Boilers, other steam generators, and oil fired and exhaust gas thermal oil heaters

In addition to the requirement in [7.1.1], testing of materials intended for the construction of pressure parts of boilers, other steam generators, oil fired thermal oil heaters and exhaust gas thermal oil heaters is to be witnessed by the Surveyor.

7.1.3 Class 1 pressure vessels and heat exchangers

In addition to the requirement in [7.1.1], testing of materials intended for the construction of class 1 pressure parts of pressure vessels and heat exchangers is to be witnessed by the Surveyor.

This requirement may be waived at the Society’s discretion for mass produced small pressure vessels (such as accumulators for valve controls, gas bottles, etc.).

7.2 Workshop inspections

7.2.1 Boilers and individually produced class 1 and class 2 pressure vessels

The construction, fitting and testing of boilers and individually produced class 1 and class 2 pressure vessels are to be attended by the Surveyor, at the builder's facility.

7.2.2 Mass produced pressure vessels

Construction of mass produced pressure vessels which are type approved by the Society need not be attended by the Surveyor.

7.3 Hydrostatic tests

7.3.1 General

Hydrostatic tests of all class 1, 2 and 3 pressure vessels are to be witnessed by the Surveyor with the exception of mass produced pressure vessels which are built under the conditions stated in [7.2.2].

7.3.2 Testing pressure

a) Upon completion, pressure parts of boilers and pressure vessels are to be subjected to a hydraulic test under a pressure p_t defined as a function of the design pressure p:

- $p_t = 1{,}5\ p$ where $p \leq 4$ MPa
- $p_t = 1{,}4\ p + 0{,}4$ where 4 MPa < p ≤ 25 Mpa
- $P_t = p + 10{,}4$ where p > 25 MPa

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

c) If the design temperature exceeds 300°C, the test pressure p_t is to be as determined by the following formula:

$$p_t = 1{,}5 \cdot \frac{K_{100}}{K} \cdot p$$

where:

p : Design pressure, in MPa

K_{100} : Permissible stress at 100°C, in N/mm^2

K : Permissible stress at the design temperature, in N/mm^2.

d) Consideration is to be given to the reduction of the test pressure below the values stated above where it is necessary to avoid excessive stress. In any event, the general membrane stress is not to exceed 90% of the yield stress at the test temperature.

e) Economisers which cannot be shut off from the boiler in any working condition are to be submitted to a hydraulic test under the same conditions as the boilers.

f) Economisers which can be shut off from the boiler are to be submitted to a hydraulic test at a pressure determined as a function of their actual design pressure p.

7.3.3 Hydraulic test of boiler and pressure vessel accessories

a) Boilers and pressure vessel accessories are to be tested at a pressure p_t which is not less than 1,5 times the design pressure p of the vessels to which they are attached.

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

7.3.4 Hydraulic test procedure

a) The hydraulic test specified in [7.3.1] is to be carried out after all openings have been cut out and after execution of all welding work and of the heat treatment, if any. The vessel to be tested is to be presented without lagging, paint or any other lining and the pressure is to be maintained long enough for the Surveyor to proceed with a complete examination.

b) Hydraulic tests of boilers are to be carried out either after installation on board, or at the manufacturer's plant. Where a boiler is hydrotested before installation on board, the Surveyor may, if deemed necessary, request to proceed with a second hydraulic test on board under a pressure at least equal to 1,1 p. For this test, the boiler may be fitted with its lagging. However, the Surveyor may require this lagging to be partially or entirely removed as necessary.

c) For water tube boilers, the hydraulic test may also be carried out separately for different parts of the boiler upon their completion and after heat treatment. For drums and headers, this test may be carried out before drilling the tube holes, but after welding of all appendices and heat treatment. When all parts of the boiler have been separately tested and following assembly the boiler is to undergo a hydraulic test under a pressure of 1,25 p.

7.3.5 Hydraulic tests of condensers

Condensers are to be subjected to a hydrostatic test at the following test pressures:

- steam space: 0,1 MPa
- water space: maximum pressure which may be developed by the pump with closed discharge valve increased by 0,07 MPa. However, the test pressure is not to be less than 0,2 MPa. When the characteristics of the pump are not known, the hydrostatic test is to be carried out at a pressure not less than 0,35 MPa.

7.4 Certification

7.4.1 Certification of boilers and individually produced pressure vessels

Boilers and individually produced pressure vessels of classes 1, 2 and 3 are to be certified by the Society in accordance with the procedures stated in Part A, according to Tab 10.

7.4.2 Mass produced pressure vessels

Small mass produced pressure vessels of classes 1, 2 and 3 may be accepted provided they are type approved by the Society in accordance with the procedures stated in Part A, according to Tab 10.

Table 10 : Pressure vessel certification

Class	Drawing / Calculation		Material testing		Hydraulic test	
	Manufacturer	The Society	Manufacturer	The Society	Manufacturer	The Society
1	X	review	X	witness + workshop inspection	X	witness
2	X	review	X	review	X	witness
3	X	–	X	review	X	witness

Note 1: Certificates of the Manufacturer and the Society to be issued for all cases for pressure vessels covered by the Rules of the Society.

SECTION 4 OIL FIRING EQUIPMENT

1 General

1.1

1.1.1 Scope

The oil firing equipment of automatically and semi-automatically controlled main and auxiliary boilers and thermal oil heaters is subject to the rule requirements in [2].

The oil burners of hot water generators, oil-fired heaters and small heating appliances which are located in the engine room or in spaces containing equipment important to the operation of the machinery are subject to the rule requirements specified under [3].

In addition, the following general requirements of this Section are mandatory for all installations and appliances.

1.1.2 Documents for review / approval

A sectional drawing of each type of burner together with a description of its mode of operation and circuit diagrams of the electrical control system are to be submitted to the Society for review / approval. Equipment covered by [3] is generally not subject to verification of drawings.

1.1.3 Approved fuels

See Ch 1, Sec 1, [2.9]

1.1.4 Control and monitoring

For control and monitoring requirements, see Ch 1, Sec 3, [5.4].

1.1.5 Boiler equipment and burner arrangement

Oil burners are to be designed, fitted and adjusted in such a manner as to prevent flames from causing damage to the boiler surfaces or tubes which border on the combustion space. Boiler parts which might otherwise suffer damage are to be protected by refractory lining.

The firing system shall be so arranged as to prevent flames from blowing back into the boiler or engine room and shall allow unburnt fuel to be safely drained.

Observation holes and openings in the burner registers for the insertion of ignition torches are to be arranged and closed off by sliding or rotating flaps in such a way that any danger to the operators from flame blowbacks is avoided.

The functioning of explosion doors or rupture disks may not endanger personnel or important items of equipment in the boiler room.

Fuel leaking from potential leak points is to be safely collected in oiltight trays and drained away.

1.1.6 Simultaneous operation of oil burning equipment and internal combustion machinery

The operation of oil burning equipment in spaces containing other items of plant with a high air consumption, e.g. internal combustion engines or air compressors, must not be impaired by variations in the air pressure.

2 Oil firing equipment for boilers and thermal oil heaters

2.1 Preheating of fuel oil

2.1.1 For the preheating of fuel oil any source may be used provided that it can be cut off immediately if the need arises and provided that it can be adequately controlled when in operation. Preheating with open flame is not allowed.

Where fuel oil is heated exclusively by thermal energy from the boiler, it must be possible to heat the boiler from cold with fuel needing no preheating.

After the oil firing equipment has been shut down, the heat retained in the preheater shall not cause an excessive temperature rise in the fuel oil.

The preheating temperature is to be selected so as to avoid foaming or the formation of vapour from water contained in the fuel oil. Also, it may not give rise to harmful effects due to oil vaporization and the carbonization of the heating surfaces.

Temperature or viscosity control must be automatic. For monitoring purposes, a thermometer or viscosimeter is to be fitted to the fuel oil pressure line in front of the burners. Should the oil temperature or viscosity deviate above or below the permitted limits, this must be signalled by an alarm system.

When a change is made from heavy to light oil, the latter may not be passed through the heater or be excessively heated.

The dimensional and constructional design of pressurized fuel oil preheaters is subject to the rules set out in Ch 1, Sec 3, [2].

Besides a temperature controller, electrically heated continuous-flow heaters are to be equipped with a safety thermal cutout.

2.2 Pumps, pipelines, valves and fittings

2.2.1 Fuel oil service pumps may be connected only to the fuel system.

Pipelines must be permanently installed and joined by oiltight welds, oiltight threaded connections of approved design or with flanged joints. Flexible pipes may be used only immediately in front of the burner or to enable the burner to swivel. They must be installed with adequate bending radii and must be protected against undue heating.

For non-metallic flexible pipes and expansion compensators, see Ch 1, Sec 10, [2.6].

Suitable devices, e.g. relief valves, must be fitted to prevent any excessive pressure increase in the fuel oil pump or pressurized fuel lines.

By means of a hand-operated, quick-closing device it must be possible to isolate the fuel supply to the burners from the pressurized fuel lines.

2.3 Safety equipment

2.3.1 Interlocks or control systems must be provided to ensure that safety functions are performed in the correct sequence when the burners are started up or shut down.

Each installation must be equipped with an automatic quick-closing device. This must not release the oil supply to the burners on start-up and must interrupt the oil supply during operation if one of the following faults occurs:

- failure of the required pressure of the atomizing medium (steam and compressed-air atomizers)

  failure of the oil pressure needed for atomization (pressure atomizers), or

  insufficient rotary speed of spinning cup (rotary atomizers)
- failure of combustion air supply
- actuation of limit switches (e.g. for water level or temperature)
- actuation of flame monitor
- failure of control power supply
- failure of induced-draught fan or insufficient opening of exhaust gas register
- burner retracted or pivoted out of position.

Each installation must be shut down automatically and secured if:

- a flame does not develop within the safety period following start-up (see [2.4])
- the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or
- limit switches are actuated.

Oil firing equipment with electrically operated components must also be capable of being shut down by an emergency switch located outside the space in which the equipment is installed.

2.4 Design and construction of burners

2.4.1 For the purpose of these Rules, the following definitions apply:

a) Fully automatic oil burners

   Fully automatic oil burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls so that the ignition, flame monitoring and burner start-up and shutdown are effected as a function of the controlled variable without the intervention of operating personnel.

b) Semi-automatic oil burners

   Semi-automatic oil burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls. Burner start-up is initiated manually. Shutdown may be initiated manually. Burner shutdown is not followed by automatic re-ignition.

c) Manually operated oil burners

   Manually operated oil burners are burners where every ignition sequence is initiated and carried through by hand. The burner is automatically monitored and shut down by the flame monitor and, where required by the safety system, by limiters. Re-starting can only be carried out directly at the burner and by hand.

d) Safety period

   The safety period is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.

The type and design of the burner and its atomizing and air turbulence equipment must ensure virtually complete combustion.

Oil burners must be so designed and constructed that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter must also be protected to prevent the entry of drip water.

Oil burners are to be so constructed that they can be retracted or pivoted out of the operating position only when the fuel oil supply has been cut off. The high-voltage ignition system must be automatically disconnected when this occurs. A catch is to be provided to hold the burner in the swung out position.

Steam atomizers must be fitted with appliances to prevent fuel oil entering the steam system.

Where dampers or similar devices are fitted in the air supply duct, care must be taken to ensure that air for purging the combustion space is always available unless the oil supply is positively interrupted.

Where an installation comprises several burners supplied with combustion air by a common fan, each burner must be fitted with a shutoff device (e.g. a flap). Means must be provided for retaining the shutoff device in position and its position must be indicated.

Every burner must be equipped with an igniter. The ignition operation is to be initiated immediately following purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and blower impeller) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

Every burner is to be equipped with a safety device for flame monitoring. This appliance must comply with the following safety periods on burner start-up or when the flame is extinguished in operation:

- on start-up 5 seconds
- in operation 1 second.

Where this is justified, longer safety periods may be permitted for burners with an oil throughput of up to 30 kg/h. Steps must be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniter (e.g. pilot burners).

2.5 Purging of combustion chamber and flues, exhaust gas ducting

2.5.1 The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. On manually operated equipment, a warning sign is to be mounted to this effect.

A threefold renewal of the total air volume of the combustion spaces and the flue gas ducts up to the funnel inlet is considered sufficient. Normally purging shall be performed with the total flow of combustion air for at least 15 seconds. It shall, however, in any case be performed with at least 50% of the volume of combustion air needed for the maximum rating of the burner system.

By-passes and dead corners in the exhaust gas ducting are to be avoided.

Dampers in uptakes and funnels should be avoided. Any dampers which may be fitted must be so installed that no oil supply is possible when the cross-section of the purge line is reduced below a certain minimum value. The position of the damper must be indicated at the boiler control platform.

Where an induced-draught fan is fitted, an interlocking system must prevent start-up of the burner equipment before the fan has started. A corresponding interlocking system is also to be provided for any covers which may be fitted to the funnel opening.

2.6 Electrical equipment

2.6.1 Electrical controls, safety appliances and their types of enclosure must comply with the provisions of Part C, Chapter 2, Rules for Electrical Installations.

Safety appliances and flame monitors must be self-monitoring and must be connected in such a way as to prevent the supply of oil in the event of a break in the circuitry of the automatic oil burning system.

2.7 Emergency operation

2.7.1 Should the automatic control and monitoring systems malfunction, the safety appliances may be by-passed only by means of a key-operated switch. An effort should be made to ensure that safety functions, e.g. limiter responses, can be individually by-passed.

The flame monitoring system must remain operative even during emergency operation.

2.8 Testing

2.8.1 The fitted installation is to be subjected to operational testing including, in particular, determination of the purging time required prior to burner start-up. Satisfactory combustion at all load settings and the reliable operation of the safety equipment are to be checked. Following installation, the pressurized fuel oil system is to be subjected to a pressure and tightness test; see Ch 1, Sec 10, [20].

3 Oil burners for hot water generators oil fired heaters and small heating appliances

3.1 Atomizer burners

3.1.1 Fully and semi-automatic atomizer burners must meet the requirements of recognized standards or must be recognized as equivalent. Adequate purging by means of a fan must be ensured prior to each ignition effected by the controls. In general, a purging period of at least 5 seconds may be deemed sufficient. Where the flue gas ducting is unfavorable, the purging time is to be extended accordingly.

Electrical components and their type of enclosure must comply with Part C, Chapter 2, Rules for Electrical Installations. High-voltage igniters must be adequately protected against unauthorized interference.

Where dampers or similar devices are mounted in the air supply line, care must be taken to ensure that air is available in all circumstances for purging the combustion space.

Pivoted oil burners must be so constructed that they can be swivelled out only after the fuel oil has been cut off. The high-voltage ignition equipment must likewise be disconnected when this happens.

The plant must also be capable of being shut down by means of an emergency switch located outside the space in which the plant is installed.

3.2 Evaporation burners

3.2.1 The burner design (e.g. dish or pot-type burner) must ensure that the combustion of the fuel oil is as complete as possible at all load settings. At the maximum oil level and with all possible angles of inclination of the vessel (see Ch 1, Sec 1), no fuel oil may spill from the combustion vessel or its air holes. Parts of the equipment important for the operation, monitoring and cleaning of the plant must be readily accessible.

Burners must be fitted with regulators ensuring a virtually constant flow of fuel oil at the selected setting. A safety device is required to prevent the oil in the combustion vessel from rising above the maximum permitted level. The regulators must function reliably despite all movements and inclinations of the vessel.

Burners are normally to be equipped with a blower to ensure a sufficient supply of combustion air. Should the blower fail, the oil feed must be cut off automatically. Heating equipment with burners not supplied by a blower may only be installed and operated in the spaces mentioned in [1.1] provided a supply of air adequate to maintain trouble-free combustion is guaranteed.

3.3 Oil fired burners

3.3.1 Oil-fired heaters having an evaporation burner without blower may be installed in the spaces mentioned in [1.1] only if their thermal capacity does not exceed 42000 kJ/h. They may only be operated, however, if items of equipment with a high air consumption such as internal combustion engines or air compressors do not draw air from the same space. Compliance is to be ensured by an appropriate directive in the operating instructions and by a warning sign fixed to such heaters. Attention is also to be drawn to the danger of blowbacks when the burner is reignited in the hot heater.

Oil-fired heaters must comply with the requirements of recognized standards and be tested and approved accordingly, or must be recognized as equivalent. Control and safety equipment must ensure the safe and reliable operation of the burner despite all movements and inclinations of the vessel.

Smoke tubes and uptakes must have a cross-section at least equal to that of the flue pipe on the heater and must follow as direct a path as possible. Horizontal flue spans are to be avoided. Funnel (stack) outlets are to be fitted with safety appliances (e.g. Meidinger discs) to prevent downdraughts.

3.4 Small oil-fired heaters for heating air

3.4.1 Depending on their mode of operation, the requirements set out in [3.1] to [3.3] apply in analogous manner to these units.

Equipment which does not entirely meet the requirements of the standards mentioned can be allowed provided that its functional safety is assured by other means, e.g. by the explosion-proofing of the combustion chamber and exhaust ducts.

Heating ducts are to be competently installed in accordance with the manufacturer's installation and operating instructions, and reductions in cross-section, throttling points and sharp bends are to be avoided so as not to incur the danger of the equipment overheating. A thermostatic control must shut the appliance down in the event of overheating.

SECTION 5 WINDLASSES

1 General

1.1 Scope

1.1.1 The requirements of this Section apply to bow anchor windlasses, stern anchor windlasses and wire rope windlasses. For anchors, chains and ropes, see Rules for Equipment in Pt B, Ch 7, Sec 4.

1.2 Compliance requirements

1.2.1 The design, construction and testing of windlasses are to comply with the applicable requirements of the Rule Note NR626 Anchor windlass considering the windlass brake capacity defined in [1.4].

1.3 Type of drive

1.3.1 Windlasses are normally to be driven by an engine which is independent of other deck machinery. The piping systems of hydraulic windlass engines may be connected to other hydraulic systems provided that this is permissible for the latter.

Manual operation as the main driving power can be allowed for anchors with a weight up to 250 kg.

1.4 Brake capacity

1.4.1 Based on mooring line arrangements with brakes engaged and cable lifter disengaged, the capacity HL (Holding Load), in kN, of the windlass brake is to be sufficient to withstand the following loads without any permanent deformation of the stressed parts and without brake slip:

- 0,8 times the breaking load BL of the chain, if not combined with a chain stopper
- 0,45 times the breaking load BL of the chain, if combined with a chain stopper.

2 Materials

2.1 Approved materials

2.1.1 The provisions contained in NR216 Materials and Welding are to be applied as appropriate to the choice of materials.

2.2 Testing of materials

2.2.1 The material of components which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, brake bands, brake spindles, brake bolts, tension strap) must possess mechanical characteristics in conformity with NR216 Materials and Welding. Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in NR216 Materials and Welding.

In the case of hydraulic systems, the material used for pipes as well as for pressure vessels is also to be tested.

3 Arrangement

3.1 Overload protection

3.1.1 For protection of the mechanical parts in the case of the windlass jamming, an overload protection (e.g. slip coupling, relief valve) is to be fitted to limit the maximum torque of the drive engine. The setting of the overload protection is to be specified (e.g. in the operating instructions).

3.2 Clutches

3.2.1 Windlasses are to be fitted with disengageable clutches between the cable lifter and the drive shaft. In an emergency case, hydraulic or electrically operated clutches must be capable of being disengaged by hand.

3.3 Connection with deck

3.3.1 The windlass, the foundation and the stoppers have to be connected efficiently and safely to the deck.

4 Powering equipment

4.1 Electrical systems

4.1.1 Electrical systems, when employed for driving windlasses, are to comply with Part C, Chapter 2.

4.2 Hydraulic systems

4.2.1 Hydraulic systems, when employed for driving windlasses, are to comply with Ch 1, Sec 10, [14].

4.2.2 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

The lowest permissible oil level is to be monitored.

Filters for cleaning the operating fluid are to be located in the piping system.

SECTION 6 GEARING

1 General

1.1 Application

1.1.1 Unless otherwise specified, the requirements of this Section apply to:

- reduction and/or reverse gears intended for propulsion plants with a transmitted power of 220 kW and above
- other reduction and step-up gears with a transmitted power of 110 kW and above.

Additional requirements for gears fitted to vessels having additional class notation **Ice** are given in Pt D, Ch 2, Sec 1.

1.2 Documentation to be submitted

1.2.1 Documents

Before starting construction, all plans, specifications and calculations listed in Tab 1 are to be submitted to the Society.

1.2.2 Data

The data listed in Table 2 to Table 4 of NR467, Pt C, Ch 1, Sec 6 are to be submitted with the documents required in [1.2.1].

Table 1 : Documents to be submitted for gearing

Item No.	Status of the review **(1)**	Description of the document **(2)**
1	A	Constructional drawings of shafts and flanges
2	A	Constructional drawings of pinions and wheels, including: a) specification and details of hardening procedure: • core and surface mechanical characteristics • diagram of the depth of the hardened layer as a function of hardness values b) specification and details of the finishing procedure: • finishing method of tooth flanks (hobbing, shaving, lapping, grinding, shot-peening) • surface roughness for tooth flank and root fillet • tooth flank corrections (helix modification, crowning, tip-relief, end-relief), if any • grade of accuracy according to ISO 1328-1 1997
3	A	Shrinkage calculation for shrunk-on pinions, wheels rims and/or hubs with indication of the minimum and maximum shrinkage allowances
4	A	Calculation of load capacity of the gears
5	A / I **(3)**	Constructional drawings of casings
6	A	Functional diagram of the lubricating system, with indication of: • specified grade of lubricating oil • expected oil temperature in service • kinematic viscosity of the oil
7	A	Functional diagram of control, monitoring and safety systems
8	I	Longitudinal and transverse cross-sectional assembly of the gearing, with indication of the type of clutch
9	I	Data form for calculation of gears
10	I	Detailed justification of material quality used for gearing calculation (ML, MQ, or ME according to ISO 6336-5)

(1) Submission of the drawings may be requested:
- for review, shown as "A" in the Table
- for information, shown as "I" in the Table.

(2) Constructional drawings are to be accompanied by the specification of the materials employed including the chemical composition, heat treatment and mechanical properties and, where applicable, the welding details, welding procedure and stress relieving procedure.

(3) "A" for welded casing, "I" otherwise.

2 Design of gears - Determination of the load capacity

2.1 General

2.1.1 The determination of the load capacity is to be performed in compliance with:

- NR467, Pt C, Ch 1, Sec 6, [2], for cylindrical gears
- NR467, Pt C, Ch 1, Sec 6, [3], for bevel gears.

3 Design and construction - except tooth load capacity

3.1 Materials

3.1.1 General

a) Forged, rolled and cast materials used in the manufacturing of shafts, couplings, pinions and wheels are to comply with the requirements of NR216 Materials and Welding.

b) Materials other than steels will be given special consideration by the Society.

3.1.2 Steels for pinions and wheel rims

a) Steels intended for pinions and wheels are to be selected considering their compatibility in service. In particular, for through-hardened pinion / wheel pairs, the hardness of the pinion teeth is to exceed that of the corresponding wheel. For this purpose, the minimum tensile strength of the pinion material is to exceed that of the wheel by at least 15%.

b) The minimum tensile strength of the core is not to be less than:

- 750 N/mm² for case-hardened teeth
- 800 N/mm² for induction-hardened or nitrided teeth.

3.2 Teeth

3.2.1 Manufacturing accuracy

a) Mean roughness (peak-to-valley) of shaved or ground teeth is not to exceed 4 μm.

b) Wheels are to be cut by cutters with a method suitable for the expected type and quality. Whenever necessary, the cutting is to be carried out in a temperature-controlled environment.

3.2.2 Tooth root

Teeth are to be well faired and rounded at the root. The fillet radius at the root of the teeth, within a plane normal to the teeth, is to be not less than 0,25 times the normal module (m_n).

Profile-grinding of gear teeth is to be performed in such a way that no notches are left in the fillet.

3.2.3 Tooth tips and ends

a) All sharp edges on the tips and ends of gear teeth are to be removed after cutting and finishing of teeth.

b) Where the ratio b/d exceeds 0,3, the ends of pinion and wheel are to be chamfered to an angle between 45 and 60 degrees. The chamfering depth is to be at least equal to 1,5 m_n.

3.2.4 Surface treatment

a) The hardened layer on surface-hardened gear teeth is to be uniform and extended over the whole tooth flank and fillet.

b) Where the pinions and the toothed portions of the wheels are case-hardened and tempered, the teeth flanks are to be ground while the bottom lands of the teeth remain only case-hardened. The superficial hardness of the case-hardened zone is to be at least equal to 56 C Rockwell units.

c) Where the pinions and the toothed portions of the wheels are nitrided, the hardened layer is to comply with Tab 2.

d) The use of other processes of superficial hardening of the teeth, such as flame hardening, will be given special consideration, in particular as regards the values to be adopted for the endurance limit for contact stress (herzian pressure) $\sigma_{H,lim}$ and the endurance limit for tooth root bending stress σ_{FE}.

Table 2 : Characteristics of the hardened layer for nitrided gears

Type of steel	Minimum thickness of hardened layer, in mm **(1)**	Minimum hardness (HV)
Nitrided steel	0,6	500 (at 0,25 mm depth)
Other steels	0,3	450 (surface)
(1) Depth of the hardened layer where the hardness is reduced to the core hardness. When the grinding of nitrided teeth is performed, the depth of the hardened layer to be taken into account is the depth after grinding.		

3.3 Wheels and pinions

3.3.1 General

Wheel bodies are to be so designed that radial deflections and distortions under load are prevented, so as to ensure a satisfactory meshing of teeth.

3.3.2 Welding

a) Where welding is employed for the construction of wheels, the welding procedure is to be submitted to the Society for approval. Welding processes and their qualification are to comply with NR216 Materials and Welding.

b) Stress relieving treatment is to be performed after welding.

c) Examination of the welded joints is to be performed by means of magnetic particle or dye penetrant tests to the satisfaction of the Surveyor. Suitable arrangements are to be made to permit the examination of the internal side of the welded joints.

3.3.3 Shrink-fits

a) The shrink-fit assembly of:

- rim and wheel body, and
- wheel body and shaft,

is to be designed with a safety factor against slippage of not less than 2,8 c where:

c : Coefficient equal to:

- 1,0 for gears driven by turbines or electric motors
- 1,0 for gears driven by diesel engines through a hydraulic, electromagnetic or high elasticity coupling
- 1,2 in the other cases.

Note 1: The manufacturer is to ensure that the maximum torque transmitted during the clutch engagement does not exceed the nominal torque by more than 20%.

b) The shrink-fit assembly is to take into account the thermal expansion differential between the shrunk-on parts in the service conditions.

3.3.4 Bolting

Where rims and hubs are joined together through bolted side plates or flanges, the assembly is to be secured by:

- tight fit bolts, or
- bolts and tight fit pins.

The nuts are to be suitably locked by means other than welding.

3.4 Shafts and bearings

3.4.1 General

Shafts and their connections, in particular flange couplings and shrink-fits connections, are to comply with the provisions of Ch 1, Sec 7.

3.4.2 Pinion and wheel shafts

The minimum diameter of pinion and gear wheel shafts is not to be less than the value d_S, in mm, given by the following formula:

$$d_S=\left\{\left[\left(10{,}2+\frac{28000}{R_{S,min}}\right)T\right]^2+\left[\frac{170000}{412+R_{s,min}}M\right]^2\right\}^{\frac{1}{6}}\left(\frac{1}{1-K_d^{\,4}}\right)^{\frac{1}{3}}$$

where:

$R_{S,min}$: Minimum yield strength of the shaft material, in N/mm²

T : Nominal torque transmitted by the shaft, in Nm

M : Bending moment on the shaft, in Nm

K_d : Coefficient having the following values:

- for solid shafts: $K_d = 0$
- for hollow shafts, K_d is equal to the ratio of the hole diameter to the outer shaft diameter.

  Where $K_d \le 0{,}3$, K_d may be taken equal to 0.

Note 1: The values of d_S, T and M refer to the cross-section of the shaft concerned.

As an alternative to the above formula, the Society may accept direct strength calculations considering static and fatigue stresses occurring simultaneously and assuming safety factors for the material employed of at least:

- 1,5 in respect of the yield strength
- 2,0 in respect of the alternating bending fatigue limit.

3.4.3 Quill shafts

The minimum diameter of quill shafts subject to torque only is not to be less than the value d_{QS}, in mm, given by the following formula:

$$d_{QS} = \left[\left(7{,}65+\frac{27000}{R_{S,min}}\right)\cdot\frac{T}{1-K_d^{\,4}}\right]^{\frac{1}{3}}$$

with:

$R_{S,min}$, K_d: As defined in [3.4.2].

3.4.4 Bearings

a) Thrust bearings and their supports are to be so designed as to avoid detrimental deflections under load.

b) Life duration of bearings is not to be less than 40 000 hours. Shorter durations may be accepted on the basis of the actual load time distribution, and subject to the agreement of the owner.

3.5 Casings

3.5.1 General

Manufacturers are to build gear casings of sufficient stiffness such that misalignment, external loads and thermal effects in all service conditions do not adversely affect the overall tooth contact.

3.5.2 Welded casings

a) Carbon content of steels used for the construction of welded casings is to comply with the provisions of NR216 Materials and Welding.

b) The welded joints are to be so arranged that welding and inspection can be performed satisfactorily. They are to be of the full penetration type.

c) Welded casings are to be stress-relieved after welding.

3.5.3 Openings

Access or inspection openings of sufficient size are to be provided to permit the examination of the teeth and the structure of the wheels.

3.6 Lubrication

3.6.1 General

a) Manufacturers are to take care of the following points:

- reliable lubrication of gear meshes and bearings is ensured:
  - over the whole speed range, including starting, stopping and, where applicable, manoeuvring
  - for all angles stated in Ch 1, Sec 1, [2.4]
- in multi-propellers plants not fitted with shaft brakes, provision is to be made to ensure lubrication of gears likely to be affected by windmilling.

b) Lubrication by means other than oil circulation under pressure will be given special consideration.

3.6.2 Pumps

a) Gears intended for propulsion or other essential services are to be provided with:
   - one main lubricating pump, capable of maintaining a sufficient lubrication of the gearbox in the whole speed range, and
   - one standby pump independently driven of at least the same capacity.

b) In the case of:
   - gears having a transmitted power not exceeding 375 kW, or
   - multi-engines plants,

   one of the pumps mentioned in a) may be a spare pump ready to be connected to the reduction gear lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

3.6.3 Filtration

a) Forced lubrication systems are to be fitted with a device which efficiently filters the oil in the circuit.

b) When fitted to gears intended for propulsion machinery or machinery driving electric propulsion generators, such filters are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

4 Installation

4.1 General

4.1.1 Manufacturers and building yards are to take care directly that stiffness of gear seating and alignment conditions of gears are such as not to adversely affect the overall tooth contact and the bearing loads under all operating conditions of the vessel.

4.2 Fitting of gears

4.2.1 Means such as stoppers or fitted bolts are to be arranged in the case of gears subject to propeller thrust. However, where the thrust is transmitted by friction and the relevant safety factor is not less than 2, such means may be omitted.

5 Certification, inspection and testing

5.1 General

5.1.1

a) Inspection and testing of shafts and their connections (flange couplings, hubs, bolts, pins) are to be carried out in accordance with the provisions of Ch 1, Sec 7, [4].

b) For inspection of welded joints of wheels, refer to [3.2.2].

5.2 Workshop inspection and testing

5.2.1 Testing of materials

Chemical composition and mechanical properties are to be tested in accordance with the applicable requirements of NR216 Materials and Welding, Ch 2, Sec 3 for the following items:

- pinions and wheel bodies
- rims
- plates and other elements intended for propulsion gear casings of welded construction.

5.2.2 Testing of pinion and wheel forgings

a) Mechanical tests of pinions and wheels are to be carried out in accordance with:
   - NR216 Materials and Welding, Ch 2, Sec 3, [5.6] for normalised and tempered or quenched and tempered forgings
   - NR216 Materials and Welding, Ch 2, Sec 3, [5.7] for surface-hardened forgings.

b) Non-destructive examination of pinion and wheel forgings is to be performed in accordance with NR216 Materials and Welding, Ch 2, Sec 3, [5.8].

5.2.3 Balancing test

Rotating components, in particular gear wheel and pinion shaft assemblies with the coupling part attached, are to undergo a static balancing test.

Where $n^2 \cdot d \geq 1,5 \cdot 10^9$, gear wheel and pinion shaft assemblies are also to undergo a dynamic balancing test.

5.2.4 Verification of cutting accuracy

Examination of the accuracy of tooth cutting is to be performed in the presence of the Surveyor. Records of measurements of errors, tolerances and clearances of teeth are to be submitted at the request of the Surveyor.

5.2.5 Meshing test

a) A tooth meshing test is to be performed in the presence of the Surveyor. This test is to be carried out at a load sufficient to ensure tooth contact, with the journals located in the bearings according to the normal running conditions. Before the test, the tooth surface is to be coated with a thin layer of suitable coloured compound.

b) The results of such test are to demonstrate that the tooth contact is adequately distributed on the length of the teeth. Strong contact marks at the end of the teeth are not acceptable.

c) A permanent record of the tooth contact is to be made for the purpose of subsequent checking of alignment following installation on board.

d) For type approved cylindrical gears, with a power not greater than 375 kW and a cast casing, the above required workshop meshing test could be waived at the Surveyor satisfaction.

5.2.6 Hydrostatic tests

a) Hydraulic or pneumatic clutches are to be hydrostatically tested before assembly to 1,5 times the maximum working pressure of the pumps.

b) Pressure piping, pumps casings, valves and other fittings are to be hydrostatically tested in accordance with the requirements of Ch 1, Sec 10, [20].

SECTION 7 MAIN PROPULSION SHAFTING

1 General

1.1 Application

This Section applies to shafts, couplings, clutches and other shafting components transmitting power for main propulsion. In addition, main propulsion machinery components are to comply with the requirements listed in Tab 1.

Table 1 : Rule requirements for main propulsion components

Item		Reference
Power transmission equipment	Diesel engines	Ch 1, Sec 2
	Propellers	Ch 1, Sec 8
	Gear	Ch 1, Sec 6
	Thrusters	Ch 1, Sec 12
Shaft line analysis	Shaft alignment	[3.3]
	Torsional vibration	Ch 1, Sec 9
Additional requirements	Navigation in ice	Pt D, Ch 2, Sec 1

Table 2 : Documents for review

No.	Document (drawings, calculations, etc.)
1	Shafting arrangement **(1)**
2	Thrust shaft
3	Intermediate shafts
4	Propeller shaft
5	Shaft liners, relevant manufacture and welding procedures, if any
6	Couplings and coupling bolts
7	Flexible couplings **(2)**
8	Sterntube
9	Details of sterntube glands
10	Oil piping diagram for oil lubricated propeller shaft bearings
11	Shaft alignment calculation, see also [3.3]

(1) This drawing is to show the entire shafting, from the main engine coupling flange to the propeller. The location of the thrust block, and the location and number of shafting bearings (type of material and length) are also to be shown.

(2) The Manufacturer of the elastic coupling is also to submit all data necessary to enable the stresses to be evaluated.

1.2 Documents for review

1.2.1 The Manufacturer is to submit to the Society the documents listed in Tab 2 for review.

Plans of power transmitting parts and shaft liners listed in Tab 2 are to include the relevant material specifications.

2 Design and construction

2.1 Materials

2.1.1 General

The use of other materials or steels having values of tensile strength exceeding the limits given in [2.1.2], [2.1.3] and [2.1.4] will be considered by the Society in each case.

2.1.2 Shaft materials

Where shafts may experience vibratory stresses close permissible stresses for transient operation (see Ch 1, Sec 9), the materials are to have a specified minimum ultimate tensile strength R_m of 500 N/mm^2. Otherwise materials having a specified minimum ultimate tensile strength R_m of 400 N/mm^2 may be used.

For use in the following formulae in this Section, R_m is limited as follows:

- for carbon and carbon manganese steels, R_m is not exceed 760 N/mm^2
- for alloy steels, R_m is not to exceed 800 N/mm^2
- for propeller shafts, R_m is not to exceed 600 N/mm^2 (for carbon, carbon manganese and alloy steels).

Where materials with greater specified or actual tensile strengths than the limitations given above are used, reduced shaft dimensions are not acceptable when derived from the formulae given in this Section.

2.1.3 Couplings, flexible couplings, hydraulic couplings

Non-solid forged couplings and stiff parts of elastic couplings subjected to torque are to be of forged or cast steel, or nodular cast iron.

Rotating parts of hydraulic couplings may be of grey cast iron, provided that the peripheral speed does not exceed 40m/s.

2.1.4 Coupling bolts

Coupling bolts are to be of forged, rolled or drawn steel.

In general, the value of the tensile strength of the bolt material R_{mB} is to comply with the following requirements:

- $R_m \leq R_{mB} \leq 1{,}7\ R_m$
- $R_{mB} \leq 1000$ N/mm^2.

2.1.5 Shaft liners

Liners are to be of metallic corrosion resistant material complying with the applicable requirements of NR216 Materials and Welding and with the approved specification, if any; in the case of liners fabricated in welded lengths, the material is to be recognised as suitable for welding.

In general, they are to be manufactured from castings.

For small shafts, the use of liners manufactured from pipes instead of castings may be considered.

Where shafts are protected against contact with riverwater not by metal liners but by other protective coatings, the coating procedure is to be approved by the Society.

2.1.6 Sterntubes

Sterntubes are to comply with the requirements of Pt B, Ch 6, Sec 2, [4.5].

2.2 Shafts - Scantling

2.2.1 General

The provisions of this sub-article apply to propulsion shafts such as an intermediate and propeller shafts of traditional straight forged design and which are driven by rotating machines such as diesel engines, turbines or electric motors.

For shafts that are integral to equipment, such as for gear boxes, podded drives, electrical motors and/or generators, thrusters, turbines and which in general incorporate particular design features, additional criteria in relation to acceptable dimensions have to be taken into account. For the shafts in such equipment, the provisions of this sub-article apply only to shafts subject mainly to torsion and having traditional design features. Other shafts will be given special consideration by the Society.

2.2.2 Alternative calculation methods

Alternative calculation methods may be considered by the Society. Any alternative calculation method is to include all relevant loads on the complete dynamic shafting system under all permissible operating conditions. Consideration is to be given to the dimensions and arrangements of all shaft connections.

Moreover, an alternative calculation method is to take into account design criteria for continuous and transient operating loads (dimensioning for fatigue strength) and for peak operating loads (dimensioning for yield strength). The fatigue strength analysis may be carried out separately for different load assumptions.

2.2.3 Shafts diameters

The diameter of intermediate shafts, thrust shafts and propellers shafts is not to be less than that determined from the following formula:

$$d = F \cdot k \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/3}$$

where:

- d : Minimum required diameter, in mm
- Q : Factor equal to d_i/d_o, where:
  - d_i : Actual diameter of the shaft bore, in mm (to be taken as 0 for solid shafts)
  - d_o : Outside diameter of the shaft, in mm

Note 1: Where $d_i \le 0,4\ d_o$, Q may be taken equal to 0.

- F : Factor for type of propulsion installation:
  - F = 90 for intermediate and thrust shafts in turbine installations, diesel installations with hydraulic (slip type) couplings and electric propulsion installations
  - F = 94 for all other diesel installation and all propeller shafts
- k : Factor for the particular shaft design features, see Tab 3
- n : Speed of rotation of the shaft, in revolution per minute, corresponding to power P
- P : Maximum continuous power of the propulsion machinery, in kW, for which the classification is requested
- R_m : Specified minimum tensile strength of the shaft material, in N/mm², see [2.1.2].

The diameter of the propeller shaft located forward of the inboard stern tube seal may be gradually reduced to the corresponding diameter required for the intermediate shaft using the minimum specified tensile strength of the propeller shaft in the formula and recognising any limitations given in [2.1.2].

Note 2: Transitions of diameters are to be designed with either a smooth taper or a blending radius equal to the change in diameter.

2.3 Liners

2.3.1 General

Metal liners or other protective coatings approved by the Society are required where propeller shafts are not made of corrosion-resistant material.

Metal liners are generally to be continuous; however, discontinuous liners, i.e. liners consisting of two or more separate lengths, may be accepted by the Society on a case by case basis, provided that:

- they are fitted in way of all supports
- the shaft portion between liners, likely to come into contact with river/sea water, is protected with a coating of suitable material with characteristics, fitting method and thickness approved by the Society.

2.3.2 Scantling

The thickness of metal liners fitted on propeller shafts or on intermediate shafts inside sterntubes is to be not less than the value t, in mm, given by the following formula:

$$t = \frac{75d}{d + 1000}$$

where:

- d : Actual diameter of the shaft, in mm.

Between the sternbushes, the above thickness t may be reduced by 25%.

Table 3 : Values of factor k

Intermediate shafts with						Thrust shafts external to engines		Propeller shafts		
straight sections and integral coupling flange **(1)**	shrink fit coupling **(2)**	keyway, tapered connection **(3) (4)**	keyway, cylindrical connection **(3) (4)**	radial hole **(5)**	longitudinal slots **(6)**	on both sides of thrust collar **(1)**	in way of bearing when a roller bearing is used	flange mounted or keyless taper fitted propellers **(7)**	key fitted propellers **(7)**	between forward end of aft most bearing and forward stern tube seal
1,00	1,00	1,10	1,10	1,10	1,20	1,10	1,10	1,22	1,26	1,15

(1) The fillet radius is to be in accordance with the provisions of [2.5.1].
(2) k values refer to the plain shaft section only. Where shafts may experience vibratory stresses close to permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2% and a blending radius as described in Note 2 of [2.2.3].
(3) At a distance of not less than 0,2 d_o from the end of the keyway the shaft diameter may be reduced to the diameter calculated with k = 1,0.
(4) Keyways are to be in accordance with the provisions of [2.5.5].
(5) Diameter of the radial bore is not to exceed 0,3 d_o.
(6) Subject to limitations as $\ell/d_o < 0{,}8$ and $d_i/d_o < 0{,}8$ and $e/d_o > 0{,}1$ where:
ℓ : Slot length, in mm
e : Slot width, in mm.
The end rounding of the slot is not to be less than e/2. An edge rounding should preferably be avoided as this increases the stress concentration slightly.
The k value is valid for 1, 2, 3 slots, i.e. with slots at, respectively, 360 degrees, 180 degrees and 120 degrees apart.
(7) Applicable to the portion of the propeller shaft between the forward edge of the aftermost shaft bearing and the forward face of the propeller hub (or shaft flange), but not less than 2,5 times the required diameter.

2.4 Stern tube bearings

2.4.1 Oil lubricated aft bearings of antifriction metal

a) The length of bearings lined with white metal or other antifriction metal and with oil glands of a type approved by the Society is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above, provided the nominal bearing pressure is not more than 0,8 N/mm², as determined by static bearing reaction calculations taking into account shaft and propeller weight, as exerting solely on the aft bearing, divided by the projected area of the shaft.

However, the minimum bearing length is to be not less than 1,5 times its actual inner diameter.

2.4.2 Oil lubricated aft bearings of synthetic rubber, reinforced resin or plastics material

a) For bearings of synthetic rubber, reinforced resin or plastics material which are approved by the Society for use as oil lubricated sternbush bearings, the length of the bearing is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above provided the nominal bearing pressure is not more than 0,6 N/mm², as determined according to [2.4.1], item b).

However, the minimum length of the bearing is to be not less than 1,5 times its actual inner diameter.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

c) Synthetic materials for application as oil lubricated stern tube bearings are to be of an approved type.

2.4.3 Water lubricated aft bearings

a) The length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

b) For a bearing of synthetic material, consideration may be given to a bearing length less than 4 times, but in no case less than 2 times, the rule diameter of the shaft in way of the bearing, provided the bearing design and material is substantiated by experiments to the satisfaction of the Society.

c) Synthetic materials for application as water lubricated stern tube bearings are to be Type Approved by the Society.

2.4.4 Grease lubricated aft bearings

The length of grease lubricated bearings is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.5 Oil or grease lubrication system

a) For oil lubricated bearings, provision for oil cooling is to be made.

A gravity tank is to be fitted to supply lubricating oil to the sterntube; the tank is to be located above the full load waterline.

Oil sealing glands are to be suitable for the various sea water temperatures which may be encountered in service.

b) Grease lubricated bearings will be specially considered by the Society.

2.4.6 Water circulation system

For water lubricated bearings, means are to be provided to ensure efficient water circulation. In case of open loop systems, the river water suction is normally to be from a river chest.

The water grooves on the bearings are to be of ample section such as to ensure efficient water circulation and be scarcely affected by wear-down, particularly for bearings of the plastic type.

The shut-off valve or cock controlling the water supply is to be fitted direct to the stuffing box bulkhead or in way of the water inlet to the sterntube, when this is fitted forward of such bulkhead.

2.5 Couplings

2.5.1 Flange couplings

a) Flange couplings of intermediate and thrust shafts and the flange of the forward coupling of the propeller shaft are to have a thickness not less than 0,2 times the rule diameter of the solid intermediate shaft and not less than the coupling bolt diameter calculated for a tensile strength equal to that of the corresponding shaft.

   The fillet radius at the base of solid forged flanges is to be not less than 0,08 times the actual shaft diameter.

   The fillet may be formed of multi-radii in such a way that the stress concentration factor will not be greater than that for a circular fillet with radius 0,08 times the actual shaft diameter.

   For non-solid forged flange couplings, the above fillet radius is not to cause a stress in the fillet higher than that caused in the solid forged flange as above.

   Fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

b) Where the propeller is connected to an integral propeller shaft flange, the thickness of the flange is to be not less than 0,25 times the rule diameter of the aft part of the propeller shaft. The fillet radius at the base of the flange is to be not less than 0,125 times the actual diameter.

   The strength of coupling bolts of the propeller boss to the flange is to be equivalent to that of the aft part of the propeller shaft.

c) Non-solid forged flange couplings and associated keys are to be of a strength equivalent to that of the shaft.

   They are to be carefully fitted and shrunk on to the shafts, and the connection is to be such as to reliably resist the vibratory torque and astern pull.

d) For couplings of intermediate and thrust shafts and for the forward coupling of the propeller shaft having all fitted coupling bolts, the coupling bolt diameter in way of the joining faces of flanges is not to be less than the value d_B, in mm, given by the following formula:

$$d_B = 0{,}65 \cdot \left[\frac{d^3 \cdot (R_m + 160)}{n_B \cdot D_C \cdot R_{mB}}\right]^{0{,}5}$$

   where:

   - d : Rule diameter of solid intermediate shaft, in mm, taking into account the ice strengthening requirements of Pt D, Ch 2, Sec 1, where applicable
   - n_B : Number of fitted coupling bolts
   - D_C : Pitch circle diameter of coupling bolts, in mm
   - R_m : Value of the minimum tensile strength of intermediate shaft material taken for calculation of d, in N/mm²
   - R_{mB} : Value of the minimum tensile strength of coupling bolt material, in N/mm². Where, in compliance with [2.1.1], the use of a steel having R_{mB} in excess of the limits specified in [2.1.4] is allowed for coupling bolts, the value of R_{mB} to be introduced in the formula is not exceed the above limits.

e) Flange couplings with non-fitted coupling bolts may be accepted on the basis of the calculation of bolt tightening, bolt stress due to tightening, and assembly instructions.

   To this end, the torque based on friction between the mating surfaces of flanges is not to be less than 2,8 times the transmitted torque, assuming a friction coefficient for steel on steel of 0,18 (see Note 1). In addition, the bolt stress due to tightening in way of the minimum cross-section is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2 proof stress ($R_{p\,0,2}$), of the bolt material.

   Transmitted torque has the following meanings:

   - For main propulsion systems powered by diesel engines fitted with slip type or high elasticity couplings, by turbines or by electric motors: the mean transmitted torque corresponding to the maximum continuous power P and the relevant speed of rotation n, as defined under [2.2.3].
   - For main propulsion systems powered by diesel engines fitted with couplings other than those mentioned in (a): the mean torque above increased by 20% or by the torque due to torsional vibrations, whichever is the greater.

Note 1: The value 2,8 may be reduced to 2,5 in the following cases:

- vessels having two or more main propulsion shafts
- when the transmitted torque is obtained, for the whole functioning rotational speed range, as the sum of the nominal torque and the alternate torque due to the torsional vibrations, calculated as required in Ch 1, Sec 9.

2.5.2 Shrunk couplings

Non-integral couplings which are shrunk on the shaft by means of the oil pressure injection method or by other means may be accepted on the basis of the calculation of shrinking and induced stresses, and assembly instructions.

To this end, the force due to friction between the mating surfaces is not to be less than 2,8 times the total force due to the transmitted torque and thrust.

The value 2,8 above may be reduced to 2,5 in the cases specified in Note 1 of [2.5.1].

The values of 0,14 and 0,18 will be taken for the friction coefficient in the case of shrinking under oil pressure and dry shrink fitting, respectively.

In addition, the equivalent stress due to shrinkage determined by means of the von Mises-Hencky criterion in the points of maximum stress of the coupling is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the material of the part concerned.

The transmitted torque is that defined under item e) of [2.5.1].

For the determination of the thrust, see Ch 1, Sec 8, [3.1.2].

2.5.3 Other couplings

Types of couplings other than those mentioned in [2.5.1] and [2.5.2] will be specially considered by the Society.

2.5.4 Flexible couplings

a) The scantlings of stiff parts of flexible couplings subjected to torque are to be in compliance with the requirements of [2].

b) For flexible components, the limits specified by the Manufacturer relevant to static and dynamic torque, speed of rotation and dissipated power are not to be exceeded.

c) Where all the engine power is transmitted through one flexible component only (vessels with one propulsion engine and one shafting only), the flexible coupling is to be fitted with a torsional limit device or other suitable means to lock the coupling should the flexible component break.

   In stiff transmission conditions with the above locking device, a sufficiently wide speed range is to be provided, free from excessive torsional vibrations, such as to enable safe navigation and steering of the vessel. As an alternative, a spare flexible element is to be provided on board.

2.5.5 Propeller shaft keys and keyways

a) Keyways are in general not to be used in installations with a barred speed range.

b) Keyways on the propeller shaft cone are to have well rounded corners, with the forward end faired and preferably spooned, so as to minimize notch effects and stress concentrations.

   When these constructional features are intended to obtain an extension of the interval between surveys of the propeller shaft in accordance with the relevant provisions of Pt A, Ch 2, Sec 2, [5.5], they are to be in compliance with Fig 1.

   Different scantlings may be accepted, provided that at least the same reduction in stress concentration is ensured.

   The fillet radius at the bottom of the keyway is to be not less than 1,25% of the actual propeller shaft diameter at the large end of the cone.

   The edges of the key are to be rounded.

   The distance from the large end of the propeller shaft cone to the forward end of the key is to be not less than 20% of the actual propeller shaft diameter in way of the large end of the cone.

   Key securing screws are not to be located within the first one-third of the cone length from its large end; the edges of the holes are to be carefully faired.

c) The sectional area of the key subject to shear stress is to be not less than the value A, in mm², given by the following formula:

$$A = 0{,}4 \cdot \frac{d^3}{d_{PM}}$$

   where:

   d : Rule diameter, in mm, of the intermediate shaft calculated in compliance with [2.2.3], assuming R_m = 400 N/mm²

   d_{PM} : Actual diameter of propeller shaft at mid-length of the key, in mm.

2.6 Monitoring

2.6.1 General

The requirements of Ch 3, Sec 2 apply.

3 Arrangement and installation

3.1 General

3.1.1 The installation is to be carried out according to the instructions of the component Manufacturer or approved documents, when required.

3.1.2 The installation of sterntubes and/or associated non-shrunk bearings is subject to approval of procedures and materials used.

3.1.3 The joints between liner parts are not to be located in way of supports and sealing glands.

Metal liners are to be shrunk on to the shafts by pre-heating or forced on by hydraulic pressure with adequate interference; dowels, screws or other means of securing the liners to the shafts are not acceptable.

3.2 Protection of propeller shaft against corrosion

3.2.1 The propeller shaft surface between the propeller and the sterntube, and in way of propeller nut, is to be suitably protected in order to prevent any entry of river water, unless the shaft is made of austenitic stainless steel.

3.3 Shaft alignment

3.3.1 The alignment of the propulsion machinery and shafting and the spacing and location of the bearings are to be such as to ensure that the loads are compatible with the material used and the limits prescribed by the Manufacturer. The slope in the aft stem tube bearing should normally not exceed 50% of the bearing clearance. The alignment is to be checked on board by the Shipyard by a suitable measurement method.

4 Material tests, workshop inspection and testing, certification

4.1 Material and non-destructive tests, workshop inspections and testing

4.1.1 Material tests

Shafting components are to be tested by the Manufacturer in accordance with Tab 4 and in compliance with the requirements of NR216 Materials and Welding.

4.1.2 Hydrostatic tests

Parts of hydraulic couplings, clutches of hydraulic reverse gears and control units, hubs and hydraulic cylinders of controllable pitch propellers, including piping systems and associated fittings, are to be hydrostatically tested to 1,5 times the maximum working pressure.

Sterntubes, when machine-finished, and propeller shaft liners, when machine-finished on the inside and with an overthickness not exceeding 3 mm on the outside, are to be hydrostatically tested to 0,2 N/mm^2.

4.2 Certification

4.2.1 Testing certification

Society's certificates (C) (see NR216 Materials and Welding, Ch 1, Sec 1, [4.2.1]) are required for material tests of components in items 1 to 5 of Tab 4.

Works' certificates (W) (see NR216 Materials and Welding, Ch 1, Sec 1, [4.2.3]) are required for hydrostatic tests of components indicated in [4.1.2], other than those for which Society's certificates (C) are required.

Figure 1 : Details of forward end of propeller shaft keyway

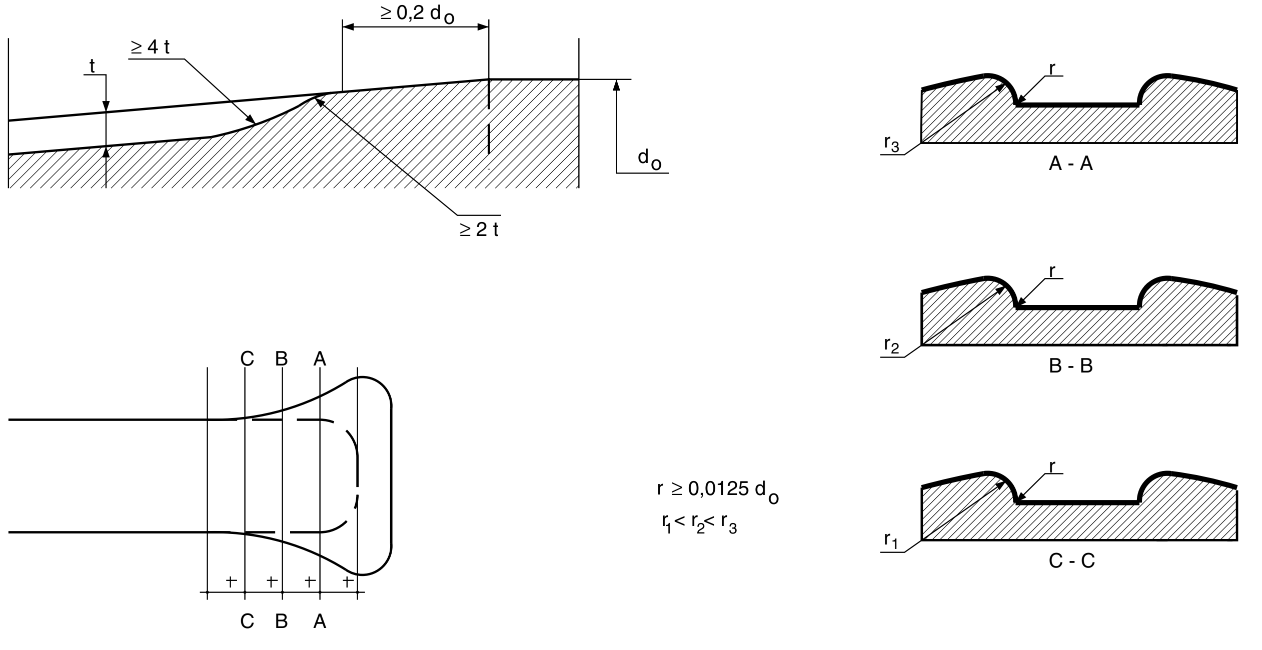


Table 4 : Material and non-destructive tests

Shafting component		Material tests (Mechanical properties and chemical composition)	Non-destructive tests	
			Magnetic particle or liquid penetrant	Ultrasonic
1	Coupling (separate from shafts)	all	if diameter ≥ 100 mm **(1)**	if diameter ≥ 200 mm **(1)**
2	Propeller shafts			
3	Intermediate shafts			
4	Thrust shafts			
5	Cardan shafts (flanges, crosses, shafts, yokes)			
6	Sterntubes	all	–	–
7	Sterntube bushes and other shaft bearings			
8	Propeller shaft liners			
9	Coupling bolts or studs			
10	Flexible couplings (metallic parts only)			
11	Thrust sliding-blocks (frame only)			
(1) 150 mm in case of a rolled bar used in place of a forging				

SECTION 8 PROPELLERS

1 General

1.1 Application

1.1.1 Propulsion propellers

This Section applies to propellers of any size and type intended for propulsion. They include fixed and controllable pitch propellers, including those ducted in fixed nozzles.

Propellers for vessels with ice strengthening, are additionally subject to provisions of Pt D, Ch 2, Sec 1, [4.3].

1.1.2 Exclusions

The requirements of this Section do not apply to propellers and impellers in rotating or bow and stern thrusters, which are covered in Ch 1, Sec 12.

1.2 Definitions

1.2.1 Solid propeller

A solid propeller is a propeller (including hub and blades) cast in one piece.

1.2.2 Built-up propeller

A built-up propeller is a propeller cast in more than one piece. In general, built up propellers have the blades cast separately and fixed to the hub by a system of bolts and studs.

1.2.3 Controllable pitch propellers

Controllable pitch propellers are built-up propellers which include in the hub a mechanism to rotate the blades in order to have the possibility of controlling the propeller pitch in different service conditions.

1.2.4 Nozzle

A nozzle is a circular structural casing enclosing the propeller.

1.2.5 Ducted propeller

A ducted propeller is a propeller installed in a nozzle.

1.2.6 Geometry of propeller

For all geometrical definitions, see Fig 1.

a) Blade area and area ratio

A_P : Projected blade area, i.e. projection of the blade area in the direction of the propeller shaft

A_D : Developed blade area, i.e. area enclosed by the connection line between the end points of the cylindrical profile sections turned in the propeller plane

A_E : Expanded blade area, i.e. area enclosed by the connection line between the end points of the developed and additionally straightened sections

A_O : Disc area calculated by means of the propeller diameter

B : Developed area ratio with $B = A_D / A_O$

b) Rake and rake angle

h : Rake is the horizontal distance between the line connecting the blade tip to the blade root and the vertical line crossing the propeller axis in the same point where the prolongation of the first line crosses it, taken in correspondence of the blade tip. Aft rakes are considered positive, fore rakes are considered negative.

Rake angle is the angle at any point between the tangent to the generating line of the blade at that point and a vertical line passing at the same point. If the blade generating line is straight, there is only one rake angle; if it is curved there are an infinite number of rake angles.

c) Skew angle at tip of blade

ϑ : Skew angle at the tip of blade, i.e. the angle on the projected blade plane between a line starting at the centre of the propeller axis and tangent to the blade midchord line and a line also starting at the centre of the propeller axis and passing at the outer end of this midchord line as measured.

d) Skewed propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

e) Highly skewed propellers and very highly skewed propellers

- highly skewed propellers are propellers having blades with skew angle between 25° and 50°
- very highly skewed propellers are propellers having blades with skew angle exceeding 50°.

f) Leading and trailing edges

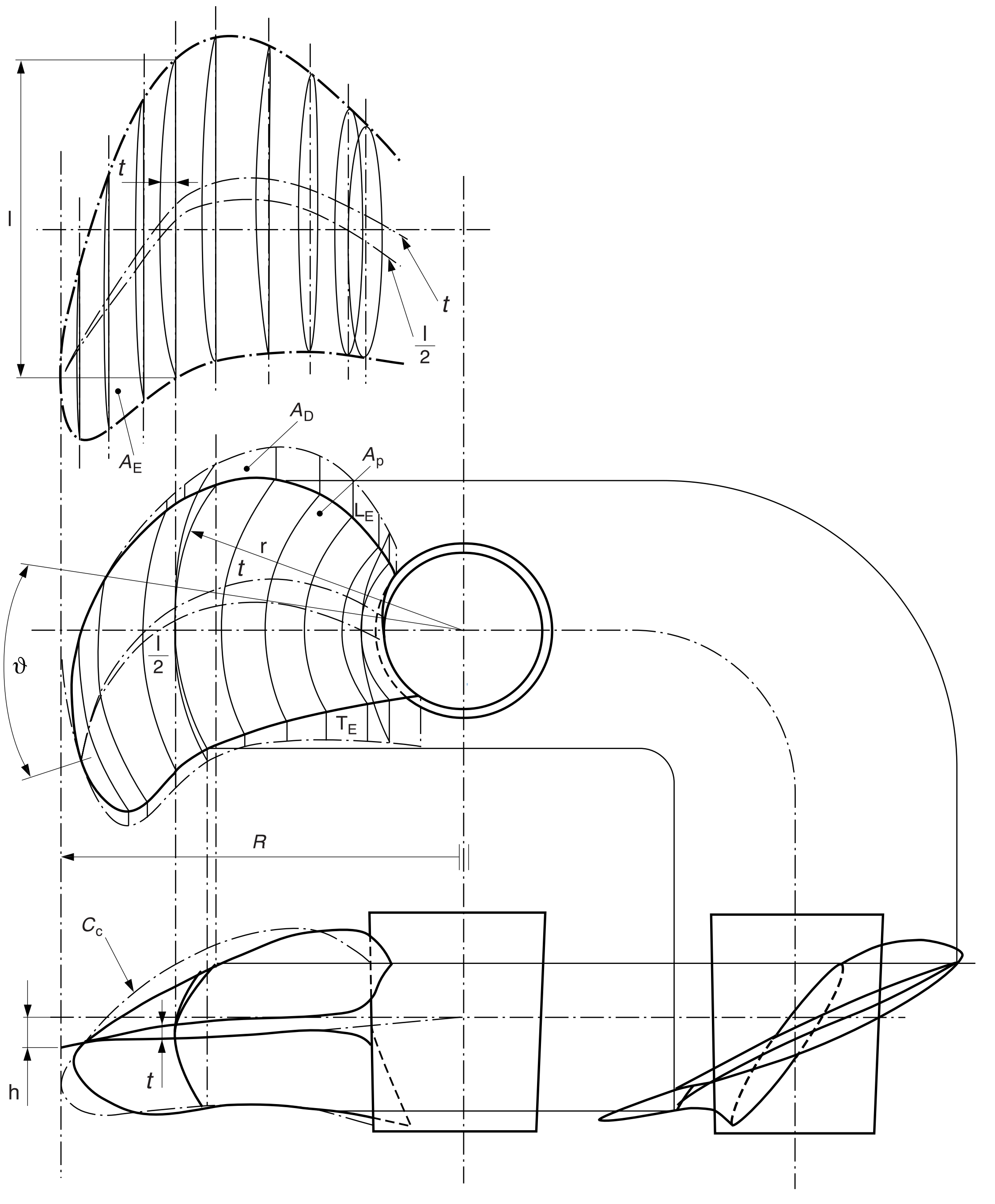
L_E : Leading edge of a propeller blade, i.e. the edge of the blade at side entering the water while the propeller rotates

T_E : Trailing edge of a propeller blade, i.e. the edge of the blade opposite to the leading edge.

1.2.7 Rake angle

Rake angle is the angle at any point between the tangent to the generating line of the blade at that point and a vertical line passing at the same point. If the blade generating line is straight, there is only one rake angle; if it is curved there are an infinite number of rake angles (see Fig 1).

Figure 1 : Description of propeller



1.2.8 Skew angle

Skew angle is the angle between a ray starting at the center of the propeller axis and tangent to the blade midchord line and a ray also starting at the center of the propeller axis and passing at the blade tip (see Fig 1).

1.2.9 Skewed propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

1.2.10 Highly skewed propellers and very highly skewed propellers

Highly skewed propellers are propellers having blades with skew angle exceeding 25°. Very highly skewed propellers are propellers having blades with skew angle exceeding 50°.

1.2.11 Leading edge

The leading edge of a propeller blade is the edge of the blade at side entering the water while the propeller rotates (see Fig 1).

1.2.12 Trailing edge

The trailing edge of a propeller blade is the edge of the blade opposite the leading edge (see Fig 1).

1.2.13 Blade developed area

Blade developed area is the area of the blade surface expanded in one plane.

1.2.14 Developed area ratio

Developed area ratio is the ratio of the total blade developed area to the area of the ring included between the propeller diameter and the hub diameter.

1.3 Documents for review

1.3.1 Solid propellers

The documents listed in Tab 1 are to be submitted for solid propellers intended for propulsion.

All listed plans are to be constructional plans complete with all dimensions and are to contain full indication of types of materials employed.

Table 1 : Documents to be submitted for solid propellers

No.	A/ I **(1)**	Item
1	A	Sectional assembly
2	A	Blade and hub details
3	I	Rating (power, rpm, etc.)
4	A	Data and procedures for fitting propeller to the shaft
(1) A : To be submitted for review I : To be submitted for information.		

1.3.2 Built-up and controllable pitch propellers

The documents listed in Tab 2, as applicable, are to be submitted for built-up and controllable pitch propellers intended for propulsion.

Table 2 : Documents to be submitted for built-up and controllable pitch propellers

No	A/ I **(1)**	Item
1	A/ I	Same documents requested for solid propellers
2	A	Blade bolts and pre-tensioning procedures
3	I	Pitch corresponding to maximum propeller thrust and to normal service condition
4	A	Pitch control mechanism
5	A	Pitch control hydraulic system
(1) A : To be submitted for review I : To be submitted for information.		

1.3.3 Very highly skewed propellers and propellers of unusual design

For very highly skewed propellers and propellers of unusual design, in addition to the documents listed in Tab 1 and Tab 2, as applicable, a detailed hydrodynamic load and stress analysis is to be submitted (see [2.4.3]).

2 Design and construction

2.1 Materials

2.1.1 Normally used materials for propeller hubs and blades

a) Tab 3 indicates the minimum tensile strength R_m (in N/mm²), the density δ (in kg/dm³) and the material factor f of normally used materials.

b) Common bronze, special types of bronze and cast steel used for the construction of propeller hubs and blades are to have a minimum tensile strength of 400 N/mm².

c) Other materials are subject of special consideration by the Society following submission of full material specification.

Table 3 : Normally used materials for propeller blades and hub

Material	R_m	δ	f
Common bronze	400	8,3	7,6
Manganese bronze	440	8,3	7,6
Nickel-manganese bronze	440	8,3	7,9
Aluminium bronze	590	7,6	8,3
Steel	440	7,9	9,0

2.1.2 Materials for studs

In general, steel (preferably nickel-steel) is to be used for manufacturing the studs connecting steel blades to the hub of built-up or controllable pitch propellers, and high tensile brass or stainless steel is to be used for studs connecting bronze blades.

2.2 Solid propellers - Blade thickness

2.2.1

a) The maximum thickness $t_{0.25}$, in mm, of the solid propeller blade at the section at 0,25 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,25} = 3,2\left[f \cdot \frac{1,5 . 10^6 . \rho . M_T + 51 . \delta . \left(\frac{D}{100}\right)^3 . B . l . N^2 . h}{l \cdot z \cdot R_m}\right]^{0,5}$$

where:

f : Material factor as indicated in Tab 3

$\rho = D / H$

H : Mean pitch of propeller, in m. When H is not known, the pitch at 0,7 radius from the propeller axis $H_{0,7}$ may be used instead of H

D : Propeller diameter, in m

M_T : Continuous transmitted torque, in kN.m; where not indicated, the value given by the following formula may be assumed for M_T:

$$M_T = 9,55 \cdot \left(\frac{P}{N}\right)$$

P : Maximum continuous power of propulsion machinery, in kW

N : Rotational speed of the propeller, in rev/min

δ : Density of blade material, in kg/dm³, as indicated in Tab 3

B : Developed area ratio

h : Rake, in mm

l : Expanded width of blade section at 0,25 radius from propeller axis, in mm

z : Number of blades

R_m : Minimum tensile strength of blade material, in N/mm².

b) The maximum thickness $t_{0,6}$, in mm, of the solid propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,6} = 1,9\left[f\,\frac{1,5.10^6.\rho_{0,6}.M_T + 18,4.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l_{0,6}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,6} = D / H_{0,6}$

$H_{0,6}$: Pitch at 0,6 radius from the propeller axis, in m

$l_{0,6}$: Expanded width of blade section at 0,6 radius from propeller axis, in mm.

c) The radius at the blade root is to be at least 3/4 of the minimum thickness required in that position. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account. If the propeller hub extends over 0,25 radius, the thickness calculated by the formula in a) is to be compared with the thickness obtained by linear interpolation of the actual blade thickness up to 0,25 radius.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller material R_m.

2.3 Built-up propellers and controllable pitch propellers

2.3.1 Blade thickness

a) The maximum thickness $t_{0,35}$, in mm, of the blade at the section at 0,35 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,35} = 2,7\left[f\,\frac{1,5.10^6.\rho_{0,7}.M_T + 41.\delta\left(\frac{D}{100}\right)^3 B.l_{0,35}.N^2 h}{l_{0,35}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,7} = D / H_{0,7}$

$H_{0,7}$: Pitch at 0,7 radius from the propeller axis, in m. The pitch to be used in the formula is the actual pitch of the propeller when the propeller develops the maximum thrust

$l_{0,35}$: Expanded width of blade section at 0,35 radius from propeller axis, in mm.

b) The maximum thickness $t_{0,6}$, in mm, of the solid propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the formula in [2.2.1] b), using the value of $l_{0,35}$ in lieu of l.

c) The radius at the blade root is to be at least 3/4 of the minimum thickness required in that position. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller blade material R_m.

2.3.2 Flanges for connection of blades to hubs

a) The diameter D_F, in mm, of the flange for connection to the propeller hub is not to be less than that obtained from the following formula:

$D_F = D_C + 1,8\ d_{PR}$

where:

D_C : Stud pitch circle diameter, in mm

d_{PR} : Diameter of studs.

b) The thickness of the flange is not to be less than 1/10 of the diameter D_F.

2.3.3 Connecting studs

a) The diameter d_{PR} , in mm, at the bottom of the thread of the studs is not to be less than obtained from the following formula:

$$d_{PR} = \left(\frac{4,6.10^7.\rho_{0,7}.M_T + 0,88.\delta.\left(\frac{D}{10}\right)^3.B.l_{0,35}.N^2.h_1}{n_{PR}\cdot z\cdot D_C\cdot R_{m,PR}}\right)^{0,5}$$

where:

h_1 : $h_1 = h + 1,125\ D_C$

n_{PR} : Total number of studs in each blade

$R_{m,PR}$: Minimum tensile strength of stud material, in N/mm².

b) The studs are to be tightened in a controlled manner such that the tension on the studs is approximately 60-70% of their yield strength.

c) The shank of studs may be designed with a minimum diameter equal to 0,9 times the root diameter of the thread.

d) The studs are to be properly secured against unintentional loosening.

2.4 Skewed propellers

2.4.1 Skewed propellers

The thickness of skewed propeller blades may be obtained by the formulae in [2.2] and [2.3.1], as applicable, provided the skew angle is less than 25°.

2.4.2 Highly skewed propellers

a) For solid and controllable pitch propellers having skew angles between 25° and 50°, the blade thickness, in mm, is not to be less than that obtained from the following formulae:

1) for solid propellers:

$$t_{S-0,25} = t_{0,25} \cdot (0,92 + 0,0032\vartheta)$$

2) for built-up and controllable pitch propellers:

$$t_{S-0,35} = t_{0,35} \cdot (0,9 + 0,004\vartheta)$$

3) for all propellers:

$$t_{S-0,6} = t_{0,6} \cdot (0,74 + 0,0129\vartheta - 0,0001\vartheta^2)$$
$$t_{S-0,9} = t_{0,6} \cdot (0,35 + 0,0015\vartheta)$$

where:

$t_{S-0,25}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,25 radius from the propeller axis

$t_{0,25}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,25 radius from the propeller axis, obtained by the formula in [2.2.1]

$t_{S-0,35}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,35 radius from the propeller axis

$t_{0,35}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,35 radius from the propeller axis, obtained by the formula in [2.3.1]

$t_{S-0,6}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,6 radius from the propeller axis

$t_{0,6}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,6 radius from the propeller axis, obtained by the formula in [2.2.1]

$t_{S-0,9}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,9 radius from the propeller axis

ϑ : Skew angle.

b) As an alternative, highly skewed propellers may be accepted on the basis of a stress analysis, as stated in [2.4.3] for very highly skewed propellers.

2.4.3 Very highly skewed propellers

For very highly skewed propellers, the blade thickness is to be obtained by the Manufacturer, using a stress analysis according to a calculation criteria accepted by the Society. The safety factor to be used in this direct analysis is not to be less than 9 with respect to the ultimate tensile strength of the propeller blade material, R_m.

2.5 Ducted propellers

2.5.1 The minimum blade thickness of propellers with wide tip blades running in nozzles is not to be less than the values obtained by the applicable formula in [2.2] or [2.3.1], increased by 10%.

2.6 Features

2.6.1 Blades and hubs

a) All parts of propellers are to be free of defects and are to be built and installed with clearances and tolerances in accordance with sound marine practice.

b) Particular care is to be taken with the surface finish of the blades.

2.6.2 Controllable pitch propellers pitch control system

a) Where the pitch control mechanism is operated hydraulically, two independent, power-driven pump sets are to be fitted. For propulsion plants up to 220 kW, one power-driven pump set is sufficient provided that, in addition, a hand-operated pump is fitted for controlling the blade pitch.

b) Pitch control systems are to be provided with an engine room indicator showing the actual setting of the blades. Further blade position indicators are to be mounted on the bridge and in the engine control room, if any.

c) Suitable devices are to be fitted to ensure that an alteration of the blade setting cannot overload the propulsion plant or cause it to stall.

d) Steps are to be taken to ensure that, in the event of failure of the control system, the setting of the blades:

- does not change, or
- assumes a final position slowly enough to allow the emergency control system to be put into operation.

e) Controllable pitch propeller systems are to be equipped with means of emergency control enabling the controllable pitch propeller to operate should the remote control system fail. This requirement may be complied with by means of a device which locks the propeller blades in the “ahead” setting.

3 Arrangement and installation

3.1 Fitting of propeller on the propeller shaft

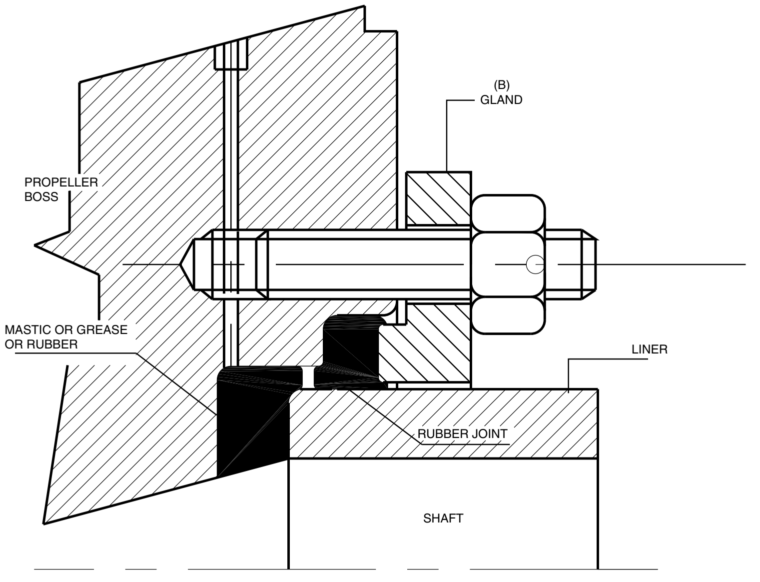
3.1.1 General

a) Screw propeller hubs are to be properly adjusted and fitted on the propeller shaft cone.

b) The forward end of the hole in the hub is to have the edge rounded to a radius of approximately 6 mm.

c) In order to prevent any entry of river water under the liner and onto the end of the propeller shaft, the arrangement of Fig 2 is generally to be adopted for assembling the liner and propeller boss.

Figure 2 : Example of sealing arrangement



d) The external stuffing gland is to be provided with a sea-water resistant rubber ring preferably without joints. The clearance between the liner and the internal air space of the boss is to be as small as possible. The internal air space is to be filled with an appropriate protective material which is insoluble in sea water and non-corrodible or fitted with a rubber ring.

e) All free spaces between the propeller shaft cone, propeller boss, nut and propeller cap are to be filled with a material which is insoluble in sea water and non-corrodible. Arrangements are to be made to allow any air present in these spaces to withdraw at the moment of filling. It is recommended that these spaces be tested under a pressure at least equal to that corresponding to the immersion of the propeller in order to check the tightness obtained after filling.

f) For propeller keys and key area, see Ch 1, Sec 7, [2.5.5].

3.1.2 Shrinkage of keyless propellers

The meaning of the symbols used in the present requirement is as follows:

A : 100% theoretical contact area between propeller boss and shaft, as read from plans and disregarding oil grooves, in mm^2

d_{PM} : Diameter of propeller shaft at the mid-point of the taper in the axial direction, in mm

d_H : Mean outer diameter of propeller hub at the axial position corresponding to d_{PM}, in mm

$K = d_H / d_{PM}$

F : Tangential force at interface, in N

M_T : Continuous torque transmitted, in N.m; where not indicated, M_T may be assumed as indicated in [2.2.1]

C : Coefficient equal to:

- 1,0 for turbines, geared diesel engines, electrical drives and direct-drive reciprocating internal combustion engines with a hydraulic, electromagnetic or high elasticity coupling
- 1,2 for diesel engines having couplings other than those specified above

The Society reserves the right to increase the value of C if the shrinkage needs to absorb an extremely high pulsating torque

T : Temperature of hub and propeller shaft material, in °C, assumed for calculation of pull-up length and push-up load

V : Vessel speed at P power, in km/h

S : Continuous thrust developed for free running vessel, in N

s_F : Safety factor against friction slip at 35°C

θ : Half taper of propeller shaft (for instance: for taper = 1/15, θ = 1/30)

μ : Coefficient of friction between mating surfaces

p_{35} : Surface pressure between mating surfaces, in N/mm^2, at 35°C

p_T : Surface pressure, in N/mm^2, between mating surfaces at temperature T

p_0 : Surface pressure between mating surfaces, in N/mm^2, at 0°C

p_{MAX} : Maximum permissible surface pressure, in N/mm^2, at 0°C

d_{35} : Push-up length, in mm, at 35°C

d_T : Push-up length, in mm, at temperature T

d_{MAX} : Maximum permissible pull-up length, in mm, at 0°C

W_T : Push-up load, in N, at temperature T

σ_{ID} : Equivalent uni-axial stress in the boss according to the von Mises-Hencky criterion, in N/mm²

α_P : Coefficient of linear expansion of shaft material, in mm/(mm°C)

α_M : Coefficient of linear expansion of boss material, in mm/(mm°C)

E_P : Value of the modulus of elasticity of shaft material, in N/ mm²

E_M : Value of the modulus of elasticity of boss material, in N/ mm²

ν_P : Poisson's ratio for shaft material

ν_M : Poisson's ratio for boss material

$R_{S,MIN}$: Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\,0,2}$), of propeller boss material, in N/mm².

For other symbols not defined above, see [2.2].

In the case of keyless shrinking of propellers, the following requirements apply:

a) The manufacturer is to submit together with the required constructional plans specifications containing all elements necessary for verifying the shrinkage. Tests and checks deemed necessary for verifying the characteristics and integrity of the propeller material are also to be specified.

b) Moreover, the manufacturer is to submit an instruction handbook, in which all operations and any precautions necessary for assembling and disassembling the propeller, as well as the values of all relevant parameters, are to be specified. A copy, endorsed by the Society, is to be kept on board each vessel where the propeller is installed.

c) The formulae and other provisions below do not apply to propellers where a sleeve is introduced between shaft and boss or in the case of hollow propeller shafts. In such cases, a direct shrinkage calculation is to be submitted to the Society.

d) The taper of the propeller shaft cone is not to exceed 1/15.

e) Prior to final pull-up, the contact area between the mating surfaces is to be checked and is not to be less than 70% of the theoretical contact area (100%). Non-contact bands extending circumferentially around the boss or over the full length of the boss are not acceptable.

f) After final push-up, the propeller is to be secured by a nut on the propeller shaft. The nut is to be secured to the shaft.

g) The safety factor s_F against friction slip at 35°C is not to be less than 2,8, under the combined action of torque and propeller thrust, based on the maximum continuous power P for which classification is requested at the corresponding speed of rotation N of the propeller, plus pulsating torque due to torsionals.

h) For the oil injection method, the coefficient of friction μ is to be 0,13 in the case of bosses made of bronze, brass or steel. For other methods, the coefficient of friction will be considered in each case by the Society.

i) The maximum equivalent uni-axial stress in the boss at 0°C, based on the von Mises-Hencky criterion, is not to exceed 70% of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the propeller material, based on the test piece value. For cast iron, the value of the above stress is not to exceed 30% of the nominal tensile strength.

j) For the formulae given below, the material properties indicated in the following items are to be assumed:

- Modulus of elasticity, in N/mm²:

  Cast and forged steel: E = 206000

  Cast iron: E = 98000

  Type Cu1 and Cu2 brass: E = 108000

  Type Cu3 and Cu4 brass: E = 118000

- Poisson's ratio:

  Cast and forged steel: ν = 0,29

  All copper based alloys: ν = 0,33

- Coefficient of linear expansion in mm/(mm°C)

  Cast and forged steel and cast iron: $\alpha = 12{,}0 \cdot 10^{-6}$

  All copper based alloys: $\alpha = 17{,}5 \cdot 10^{-6}$

k) For shrinkage calculation the formulae in the following items, which are valid for the ahead condition, are to be applied. They will also provide a sufficient margin of safety in the astern condition.

- Minimum required surface pressure at 35°C:

$$p_{35} = \frac{s_F S}{AB} \cdot \left[-s_F \theta + \left(\mu^2 + B \cdot \frac{F^2}{S^2} \right)^{0,5} \right]$$

  where:

  $B = \mu^2 - s_F^2\,\theta^2$

- Corresponding minimum pull-up length at 35°C:

$$d_{35} = \frac{p_{35} d_{PM}}{2\theta} \cdot \left[\frac{1}{E_M} \cdot \left(\frac{K^2 + 1}{K^2 - 1} + \nu_M \right) + \frac{1 - \nu_P}{E_P} \right]$$

- Minimum pull-up length at temperature T (T<35°C):

$$d_T = d_{35} + \frac{d_{PM}}{2\theta} \cdot (\alpha_M - \alpha_P) \cdot (35 - T)$$

- Corresponding minimum surface pressure at temperature T:

$$p_T = p_{35} \cdot \frac{d_T}{d_{35}}$$

- Minimum push-up load at temperature T:

$$W_T = Ap_T \cdot (\mu + \theta)$$

- Maximum permissible surface pressure at 0°C:

$$p_{MAX} = \frac{0{,}7 R_{S,MIN} \cdot (K^2 - 1)}{(3K^4 + 1)^{0,5}}$$

- Corresponding maximum permissible pull-up length at 0°C:

$$d_{MAX} = d_{35} \cdot \frac{p_{MAX}}{p_{35}}$$

- Tangential force at interface:

$$F = \frac{2000 C M_T}{d_{PM}}$$

- Continuous thrust developed for free running vessel; if the actual value is not given, the value, in N, calculated by one of the following formulae may be considered:

$$S = 950 \cdot \frac{P}{V}$$

$$S = 57, 3 \cdot 10^3 \cdot \frac{P}{H \cdot N}$$

4 Testing and certification

4.1 Material tests

4.1.1 Solid propellers

Material used for the construction of solid propellers is to be tested in accordance with the requirements of NR216 Materials and Welding in the presence of the Surveyor.

4.1.2 Built-up propellers and controllable pitch propellers

In addition to the requirement in [4.1.1], materials for studs and for all other parts of the mechanism transmitting torque are to be tested in the presence of the Surveyor.

4.2 Testing and inspection

4.2.1 Controllable pitch propellers

The complete hydraulic system for the control of the controllable pitch propeller mechanism is to be hydrotested at a pressure equal to 1,5 times the design pressure. The proper operation of the safety valve is to be tested in the presence of the Surveyor.

4.2.2 Balancing

Finished propellers are to be statically balanced in accordance with the specified ISO 484 tolerance class. However, for built-up and controllable pitch propellers, the required static balancing of the complete propeller may be replaced by an individual check of blade weight and gravity centre position.

Refer also to NR216 Materials and welding, Ch 3, Sec 1, [3.8.4.].

4.3 Certification

4.3.1 Certification of propellers

Propellers having the characteristics indicated in [1.1.1] are to be individually tested and certified by the Society.

4.3.2 Mass produced propellers

Mass produced propellers may be accepted within the framework of the type approval program of the Society.

SECTION 9 SHAFT VIBRATIONS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the shafting of the following installations:

- propulsion systems with prime movers developing 220 kW or more
- other systems with internal combustion engines developing 110 kW or more and driving auxiliary machinery intended for essential services.

1.1.2 Exemptions

The requirements of this Section may be waived in cases where satisfactory service operation of similar installations is demonstrated.

2 Design of systems in respect of vibrations

2.1 Principle

2.1.1 General

a) Special consideration shall be given by Manufacturers to the design, construction and installation of propulsion machinery systems so that any mode of their vibrations shall not cause undue stresses in these systems in the normal operating ranges.

b) Calculations are to be carried out for the configurations of the system likely to have influence on the torsional vibrations.

c) Where deemed necessary by the Manufacturer, axial and/or bending vibrations are to be investigated.

2.1.2 Vibration levels

Systems are to have torsional, bending and axial vibrations both in continuous and in transient running acceptable to the Manufacturers, and in accordance with the requirements of this Section.

Where vibrations are found to exceed the limits stated in this Section, the builder of the plant is to propose corrective actions, such as:

- operating restrictions, provided that the owner is informed, or
- modification of the plant.

2.1.3 Condition of components

Systems are to be designed considering the following conditions, as deemed necessary by the Manufacturer:

- engine: cylinder malfunction
- flexible coupling: possible variation of the stiffness or damping characteristics due to heating or ageing
- vibration damper: possible variation of the damping coefficient.

2.2 Modifications of existing plants

2.2.1 Where substantial modifications of existing plants, such as:

- change of the running speed or power of the engine
- replacement of an important component of the system (propeller, flexible coupling, damper) by one of different characteristics, or
- connection of a new component,

are carried out, new vibration analysis is to be submitted for approval.

3 Torsional vibrations

3.1 Documentation to be submitted

3.1.1 Calculations

Torsional vibration calculations are to be submitted for the various configurations of the plants, showing:

- the equivalent dynamic system used for the modelling of the plant, with the indication of:
  - inertia and stiffness values for all the components of the system
  - outer and inner diameters and material properties of the shafts
- the natural frequencies
- the values of the vibratory torques or stresses in the components of the system for the most significant critical speeds and their analysis in respect of the Rules and other acceptance criteria
- the possible restrictions of operation of the plant.

3.1.2 Particulars to be submitted

The following particulars are to be submitted with the torsional vibration calculations:

a) for turbines, multi-engine installations or installations with power take-off systems:
   - description of the operating configurations
   - load sharing law between the various components for each configuration

b) for installations with controllable pitch propellers: the power/rotational speed values resulting from the combinator operation

c) for prime movers: the service speed range and the minimum speed at no load

d) for internal combustion engines:
   - manufacturer and type
   - nominal output and rotational speed
   - mean indicated pressure
   - number of cylinders
   - "V" angle
   - firing angles
   - bore and stroke
   - excitation data, such as the polynomial law of harmonic components of excitations
   - nominal alternating torsional stress considered for crankpin and journal

Note 1: The nominal alternating torsional stress is part of the basic data to be considered for the assessment of the crankshaft. It is defined in NR467, Part C, Chapter 1.

e) for turbines:
   - nominal output and rotational speed
   - power/speed curve and range of operation
   - number of stages, and load sharing between the stages
   - main excitation orders for each rotating disc
   - structural damping of shafts
   - external damping on discs (due to the fluid)

f) for reduction or step-up gears: the speed ratio for each step

g) for flexible couplings:
   - the maximum torque
   - the nominal torque
   - the permissible vibratory torque
   - the permissible heat dissipation
   - the relative damping
   - the torsional dynamic stiffness / transmitted torque relation where relevant

h) for torsional vibration dampers:
   - the manufacturer and type
   - the permissible heat dissipation
   - the damping coefficient
   - the inertial and stiffness properties, as applicable

i) for propellers:
   - the type of propeller: ducted or not ducted
   - the number of propellers of the vessel
   - the number of blades
   - the excitation and damping data, if available

j) for electric motors, generators and pumps: the drawing of the rotating parts, with their mass moment of inertia and main dimensions.

3.2 Definitions, symbols and units

3.2.1 Definitions

a) Torsional vibration stresses referred to in this Article are the stresses resulting from the alternating torque corresponding to the synthesis of the harmonic orders concerned.

b) The misfiring condition of an engine is the malfunction of one cylinder due to the absence of fuel injection (which results in a pure compression or expansion in the cylinder).

3.2.2 Symbols, units

The main symbols used in this Article are as follows:

τ : Torsional vibration stress, as defined in [3.2.1], in N/mm²

τ_1 : Permissible stress due to torsional vibrations for continuous operation, in N/mm²

τ_2 : Permissible stress due to torsional vibrations for transient running, in N/mm²

R_m : Tensile strength of the shaft material, in N/mm²

C_R : Material factor, equal to:

$$\frac{R_m + 160}{18}$$

d : Minimum diameter of the shaft, in mm

C_D : Size factor of the shaft, equal to:

$$0{,}35 + 0{,}93\, d^{-0{,}2}$$

N : Speed of the shaft for which the check is carried out, in rev/min

N_n : Nominal speed of the shaft, in rev/min

N_C : Critical speed, in rev/min

λ : Speed ratio, equal to N/N_n

C_λ : Speed ratio factor, equal to:
- $3 - 2\,\lambda^2$ for $\lambda < 0{,}9$
- $1{,}38$ for $0{,}9 \le \lambda < 1{,}05$

C_k : Factor depending on the stress concentration factor of the shaft design features given in Tab 1.

Table 1 : Values of C_k factor

Intermediate shafts with							Thrust shafts external to engines		Propeller shafts		
straight sections and integral coupling flanges	shrink-fit couplings (1)	keyways, tapered connection (2)	keyways, cylindrical connection (2)	radial hole	longitudinal slot (3)	splined shafts	on both sides of thrust collar	in way of axial bearing where a roller bearing is used as a thrust bearing	flange mounted or keyless fitted propellers (4)	key fitted propellers (4)	between forward end of aft most bearing and forward stern tube seal
1,00	1,00	0,60	0.45	0.50	0.30	0,80	0,85	0,85	0,55	0,55	0.80

(1) C_k values refer to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2% and a blending radius as described in Ch 1, Sec 7, [2.5.1].

(2) Keyways are to be in accordance with the provisions of Ch 1, Sec 7, [2.5.5].

(3) Subject to limitations as $\ell/d_o < 0,8$ and $d_i/d_o < 0,8$ and $e/d_o > 0,10$, where:

ℓ : Slot length, in mm

e : Slot width, in mm

d_i, d_o : As per Ch 1, Sec 7, [2.2.3].

The C_k value is valid for 1, 2 and 3 slots, i.e. with slots at, respectively, 360 degrees 180 degrees and 120 degrees apart.

(4) Applicable to the portion of the propeller shaft between the forward edge of the aftermost shaft bearing and the forward face of the propeller hub (or shaft flange), but not less than 2,5 times the required diameter.

Note 1: Higher values of C_k factor based on direct calculations may also be considered.

Note 2: The determination of C_k factor for shafts other than those given in this Table will be given special consideration by the Society.

3.3 Calculation principles

3.3.1 Method

a) Torsional vibration calculations are to be carried out using a recognised method.

b) Where the calculation method does not include harmonic synthesis, attention is to be paid to the possible superimposition of two or more harmonic orders of different vibration modes which may be present in some restricted ranges.

3.3.2 Scope of the calculations

a) Torsional vibration calculations are to be carried out considering:
   - normal firing of all cylinders, and
   - misfiring of one cylinder.

b) Where the torsional dynamic stiffness of the coupling depends on the transmitted torque, two calculations are to be carried out:
   - one at full load, and
   - one at the minimum load expected in service.

c) For installations with controllable pitch propellers, two calculations are to be carried out:
   - one for full pitch condition, and
   - one for zero pitch condition.

d) The calculations are to take into account other possible sources of excitation, as deemed necessary by the Manufacturer. Electrical sources of excitations, such as static frequency converters, are to be detailed. The same applies to transient conditions such as engine start up, reversing, clutching in, as necessary.

e) The natural frequencies are to be considered up to a value corresponding to 15 times the maximum service speed. Therefore, the excitations are to include harmonic orders up to the fifteenth.

3.3.3 Criteria for acceptance of the torsional vibration loads under normal firing conditions

a) Torsional vibration stresses in the various shafts are not to exceed the limits defined in [3.4]. Higher limits calculated by an alternative method may be considered, subject to special examination by the Society.

   The limit for continuous running τ_1 may be exceeded only in the case of transient running in restricted speed ranges, which are defined in [3.4.5]. In no case are the torsional vibration stresses to exceed the limit for transient running τ^2.

   Propulsion systems are to be capable of running continuously without restrictions at least within the speed range between 0,8 N_n and 1,05 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,8$.

   Auxiliary machinery is to be capable of running continuously without restrictions at least within the range between 0,95 N_n and 1,10 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,95$.

b) Torsional vibration levels in other components are to comply with the provisions of [3.5].

c) The generating set is to show torsional vibration levels which are compatible with the allowable limits for the alternator, shafts, coupling and damper.

3.3.4 Criteria for acceptance of torsional vibration loads under misfiring conditions

a) The provisions of [3.3.3] related to normal firing conditions also apply to misfiring conditions.

Note 1: For propulsion systems operated at constant speed, restricted speed ranges related to misfiring conditions may be accepted for speed ratios $\lambda > 0,8$.

b) Where calculations show that the limits imposed for certain components may be exceeded under misfiring conditions, a suitable device is to be fitted to indicate the occurrence of such conditions.

3.4 Permissible limits for torsional vibration stresses in crankshaft, propulsion shafting and other transmission shafting

3.4.1 General

a) The limits provided below apply to steel shafts. For shafts made of other material, the permissible limits for torsional vibration stresses will be determined by the Society after examination of the results of fatigue tests carried out on the material concerned.

b) These limits apply to the torsional vibration stresses as defined in [3.2.1]. They relate to the shaft minimum section, without taking account of the possible stress concentrations.

3.4.2 Crankshaft

a) Where the crankshaft has been designed in accordance with NR467, Part C, Chapter 1, the torsional vibration stresses in any point of the crankshaft are not to exceed the following limits:
   - for continuous running: $\tau_1 = \tau_N$
   - for transient running: $\tau_2 = 1,7\ \tau_N$,

   where τ_N is the nominal alternating torsional stress on which the crankshaft scantling is based (see Note 1 of [3.1.2]).

b) Where the crankshaft has not been designed in accordance with NR467, Part C, Chapter 1, the torsional vibration stresses in any point of the crankshaft are not to exceed the following limits:
   - for continuous running: $\tau_1 = 0,55\ C_R\ C_D\ C_\lambda$
   - for transient running: $\tau_2 = 2,3\ \tau_1$

3.4.3 Intermediate shafts, thrust shafts and propeller shafts

The torsional vibration stresses in any intermediate, thrust and propeller shafts are not to exceed the following limits:

- for continuous running: $\tau_1 = C_R\ C_k\ C_D\ C_\lambda$
- for transient running: $\tau_2 = 1,7\ \tau_1\ C_k^{\ -0,5}$

3.4.4 Transmission shafting for generating sets and other auxiliary machinery

The torsional vibration stresses in the transmission shafting for generating sets and other auxiliary machinery, such as pumps or compressors, are not to exceed the following limits:

- for continuous running: $\tau_1 = 0,90\ C_R\ C_D$
- for transient running: $\tau_2 = 5,4\ \tau_1$

3.4.5 Restricted speed ranges

a) Where the torsional vibration stresses exceed the limit τ_1 for continuous running, restricted speed ranges are to be imposed which are to be passed through rapidly.

b) The limits of the restricted speed range related to a critical speed Nc are to be calculated in accordance with the following formula:

$$\frac{16 \cdot N_c}{18 - \lambda} \le N \le \frac{(18 - \lambda) \cdot N_c}{16}$$

c) Where the resonance curve of a critical speed is obtained from torsional vibration measurements, the restricted speed range may be established considering the speeds for which the stress limit for continuous running τ_1 is exceeded.

d) Where restricted speed ranges are imposed, they are to be crossed out on the tachometers and an instruction plate is to be fitted at the control stations indicating that:
   - the continuous operation of the engine within the considered speed range is not permitted
   - this speed range is to be passed through rapidly.

e) When restricted speed ranges are imposed, the accuracy of the tachometers is to be checked in such ranges as well as in their vicinity.

f) Restricted speed ranges in one-cylinder misfiring conditions of single propulsion engine vessels are to enable safe navigation.

3.5 Permissible vibration levels in components other than shafts

3.5.1 Gears

a) The torsional vibration torque in any gear step is not to exceed 30% of the torque corresponding to the approved rating throughout the service speed range.

   Where the torque transmitted at nominal speed is less than that corresponding to the approved rating, higher torsional vibration torques may be accepted, subject to special consideration by the Society.

b) Gear hammering induced by torsional vibration torque reversal is not permitted throughout the service speed range, except during transient running at speed ratios $\lambda \le 0,3$.

   Where calculations show the existence of torsional vibration torque reversals for speed ratios $\lambda > 0,3$, the corresponding speed ranges are to be identified by appropriate investigations during river trials and considered as restricted speed ranges in accordance with [3.4.5].

3.5.2 Generators

a) In the case of alternating current generators, the torsional vibration amplitude at the rotor is not to exceed ± 2,5 electrical degrees at service rotational speed under full load working conditions.

b) Vibratory inertia torques due to torsional vibrations and imposed on the rotating parts of the generator are not to exceed the values M_A, in N.m, calculated by the following formulae, as appropriate:

- for $0,95 \leq \lambda \leq 1,10$: $M_A = \pm 2,5\ M_T$
- for $\lambda \leq 0,95$: $M_A = \pm 6,0\ M_T$

where:

M_T : Mean torque transmitted by the engine under full load running conditions, in N.m

Note 1: In the case of two or more generators driven by the same engine, the portion of M_T transmitted to each generator is to be considered.

λ : Speed ratio defined in [3.2.2].

3.5.3 Flexible couplings

a) Flexible couplings are to be capable of withstanding the mean transmitted torque and the torsional vibration torque throughout the service speed range, without exceeding the limits for continuous operation imposed by the manufacturer (permissible vibratory torque and power loss).

Where such limits are exceeded under misfiring conditions, appropriate restrictions of power or speed are to be established.

b) The coupling selection for the generating set is to take into account the stresses and torques imposed on it by the torsional vibration of the system.

3.5.4 Dampers

a) Torsional vibration dampers are to be such that the permissible power loss recommended by the manufacturer is not exceeded throughout the service speed range.

b) Dampers for which a failure may lead to a significant vibration overload of the installation will be the subject of special consideration.

3.6 Torsional vibration measurements

3.6.1 General

a) The Society may require torsional vibration measurements to be carried out under its attendance in the following cases:

- where the calculations indicate the possibility of dangerous critical speeds in the operating speed range
- where doubts arise as to the actual stress amplitudes or critical speed location, or
- where restricted speed ranges need to be verified.

b) Where measurements are required, a comprehensive report including the analysis of the results is to be submitted to the Society.

3.6.2 Method of measurement

When measurements are required, the method of measurement is to be submitted to the Society for approval. The type of measuring equipment and the location of the measurement points are to be specified.

SECTION 10 PIPING SYSTEMS

1 General

1.1 Scope and application

1.1.1 These Rules apply to piping systems, including valves, fittings and pumps, which are necessary for the operation of the main propulsion plant together with its auxiliaries and equipment. They also apply to piping systems used in the operation of the vessel whose failure could directly or indirectly impair the safety of vessel or cargo, and to piping systems which are dealt with in other Sections of the Rules.

Cargo pipelines on vessels for the carriage of chemicals in bulk are additionally subject to the provisions of Pt D, Ch 3, Sec 3 to Pt D, Ch 3, Sec 6.

Cargo pipelines on vessels for the carriage of liquefied gases in bulk are additionally subject to the provisions of Pt D, Ch 3, Sec 2.

1.1.2

a) General requirements applying to all piping systems are contained in Articles:

- [2] for their design and construction
- [3] for the welding of steel pipes
- [4] for the bending of pipes
- [5] for their arrangement and installation
- [20] for their certification, inspection and testing.

b) Specific requirements for vessel piping systems and machinery piping systems are given in Articles [6] to [19].

1.2 Documentation to be submitted

1.2.1 The documents listed in Tab 1 as well as the additional documents listed in Tab 2 are also to be submitted.

1.3 Definitions

1.3.1 Piping and piping systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include boilers, turbines, internal combustion engines and reduction gears.

Note 1: The equipment other than piping is to be designed in accordance with the relevant Sections of Part C, Chapter 1.

1.3.2 Pressures

a) Maximum allowable working pressure, PB, in bar (formula symbol: $p_{e,zul}$)

   This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design requirements, the working temperature and undisturbed operation.

b) Nominal pressure, PN, in bar

   This is the term applied to a selected pressure temperature relation used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20°C.

c) Test pressure, PP, in bar (formula symbol: p_p)

   This is the pressure to which components or piping systems are subjected for testing purposes.

d) Design pressure, PR, in bar (formula symbol: p_C)

   This is the maximum allowable working pressure PB for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

1.3.3 Design temperature

The design temperature, T in °C, of a piping system is the maximum temperature of the medium inside the system.

1.3.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils.

1.4 Class of piping systems

1.4.1 Piping systems are subdivided into two classes, denoted as class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings. These classes are defined in Tab 3.

Table 1 : Documents to be submitted

Item No	I/A **(1)**	Document **(2)**
1	A	Drawing showing the arrangement of the river chests and vessel side valves
2	A	Diagram of the bilge and ballast systems (in and outside machinery spaces), including calculation for the bilge main, bilge branch lines and bilge pumps capacity as per Rule requirements
3	A	Specification of the central priming system intended for bilge pumps, when provided
4	A	Diagram of the drinking water, scuppers and sanitary discharge systems
5	A	Diagram of the air, sounding and overflow systems
6	A	Diagram of cooling systems (river water and fresh water)
7	A	Diagram of fuel oil system
8	A	Drawings of the fuel oil tanks not forming part of the vessel's structure
9	A	Diagram of the lubricating oil system
10	A	Diagram of the thermal oil system
11	A	Diagram of the hydraulic systems intended for essential services or located in machinery spaces
12	A	Diagram of steam system, including safety valve exhaust and drain pipes
13	 A I	For high temperature steam pipes: • stress calculation note • drawing showing the actual arrangement of the piping in three dimensions
14	A	Diagram of the boiler feed water and condensate system
15	A	Diagram of the compressed air system
16	A	Diagram of the hydraulic and pneumatic remote control systems
17	A	Diagram of the remote level gauging system
18	A	Diagram of the exhaust gas system
19	A	Diagram of drip trays and gutterway draining system
20	A	Arrangement of the ventilation system
21	A	Drawings and specification of valves and accessories

(1) A = to be submitted for review
I = to be submitted for information.
(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

Table 2 : Information to be submitted

Item No	I/A **(1)**	Document
1	I	Nature, service temperature and pressure of the fluids
2	A	Material, external diameter and wall thickness of the pipes
3	A	Type of the connections between pipe lengths, including details of the weldings, where provided
4	A	Material, type and size of the accessories
5	A	Capacity, prime mover and, when requested, location of the pumps
6	A	Constructional drawings of independent tanks showing the height of the overflow and air pipe above the tank top
7	A	For plastic pipes: • the chemical composition • the physical and mechanical characteristics in function of temperature • the characteristics of inflammability and fire resistance • the resistance to the products intended to be conveyed

(1) A = to be submitted for review
I = to be submitted for information.

Table 3 : Class of piping systems

Medium conveyed by the piping system	Pipe class II	Pipe class III
Toxic media Flammable media heated above the flash point Flammable media having a flash point below 60°C Liquefied gases Corrosive media	all	not applicable
Steam, thermal oil	PR ≤ 16 and T ≤ 300	PR ≤ 7 and T ≤ 170
Liquid fuels	PR ≤ 16 and T ≤ 150	PR ≤ 7 and T ≤ 60
Cargo pipelines for tankers	all	all
Open-ended pipelines (without shutoff), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	all	all
Other media **(1)**	PR ≤ 40 and T ≤ 300	PR ≤ 16 and T ≤ 200

(1) Including water, air, gases, lubricating oil, hydraulic oil.
Note 1: Design pressure PR, in bar and Design temperature T, in °C.

2 General requirements for design and construction

2.1 General principles

2.1.1 Piping systems are to be constructed and manufactured on the basis of standards generally used in vessel building.

2.1.2 Welded connections instead of detachable connections should be used for pipelines carrying toxic media and inflammable liquefied gases.

2.1.3 Expansion in piping systems due to heating and shifting of their suspensions caused by deformation of the vessel are to be compensated by bends, compensators and flexible pipe connections. The arrangement of suitable fixed points is to be taken into consideration

2.2 Materials

2.2.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended. See Tab 4.

Table 4 : Medium limit temperature

Material	Medium limit temperature
Copper and aluminium brass	200°C
Copper nickel alloys	300°C
High-temperature bronze	230°C

2.2.2 Use of metallic materials

a) Metallic materials are to be used in accordance with Tab 5.

b) Materials for class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of NR216 Materials and Welding.

c) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

d) Mechanical characteristics required for metallic materials are specified in NR216 Materials and Welding.

2.2.3 Use of plastics

Plastic pipes may be used after special approval by the Society.

Pipes, connecting pieces, valves and fittings made of plastic materials are to be subjected by the manufacturer to a continuous Society-approved quality control.

Pipe penetrations through watertight bulkheads and decks as well as through fire divisions are to be approved by the Society. Plastic pipes are to be continuously and permanently marked with the following particulars:

- manufacturer's marking
- standard specification number
- outside diameter and wall thickness of pipe
- year of manufacture.

Valves and connecting pieces made of plastic must, as a minimum requirement, be marked with the manufacturer's marking and the outside diameter of the pipe.

2.3 Pipe minimum wall thickness

2.3.1 The pipe thicknesses given in Tab 6 to Tab 10 are the assigned minimum thicknesses, where:

d_a : Outside diameter of pipe, in mm

t : Wall thickness, in mm.

Table 5 : Conditions of use of metallic materials

Material	Allowable classes	Maximum design temperature **(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II	400 **(2)**	Class II pipes are to be seamless drawn pipes **(3)**
Copper and aluminium brass	III, II	200	• not to be used in fuel oil systems, except for class III pipes of a diameter not exceeding 25 mm not passing through fuel oil tanks • not to be used for boiler blow-down valves not for associated pieces for connection to the shell plating • pipes made of copper and copper alloys are to be seamless
Copper-nickel	III, II	300	
Special high temperature resistant bronze	III, II	260	
Stainless steel	III, II	300	Austenitic stainless steel is not to be used for river/sea water systems
Spheroidal graphite cast iron	III, II **(4)**	350	• minimum elongation is not to be less than 12% on a gauge length of $5,65 \cdot S^{0,5}$, where S is the actual cross-sectional area of the test piece • not to be used for boiler blow-down valves not for associated pieces for connection to the shell plating
Grey cast iron	III II **(4)**	220	Grey cast iron is not to be used for the following systems: • boiler blow-down systems and other piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the bulkhead deck • vessel side valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems and thermal oil systems
Aluminium and aluminium alloys	III, II	200	Aluminium and aluminium alloys are not to be used on the following systems: • flammable oil systems • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • bilge system in boiler or machinery spaces or in spaces containing fuel oil tanks or pumping units • scuppers and overboard discharges except for pipes led to the bottoms or to the shell above the bulkhead deck or fitted at their upper end with closing means operated from a position above the bulkhead deck • boiler blow-down valves not for associated pieces for connection to the shell plating

(1) Maximum design temperature is not to exceed that assigned to the class of piping.
(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100 000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer.
(3) Pipes fabricated by a welding procedure approved by the Society may also be used.
(4) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.

2.4 Thickness of pressure piping

2.4.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 6 to Tab 10.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

b : Thickness reduction due to bending defined in [2.4.3], in mm

c : Corrosion allowance defined in [2.4.4], in mm

a : Negative manufacturing tolerance percentage:

- a = 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society
- a = 12,5 for hot laminated seamless steel pipes
- a is subject to special consideration by the Society in the other cases

t_0 : Coefficient, in mm, equal to:

$$t_0 = \frac{p_C \cdot d_a}{20Ke + p_C}$$

with:

p_C : Design pressure, in bar, defined in [1.3.2]

d_a : Pipe external diameter, in mm

K : Permissible stress defined in [2.4.2]

e : Weld efficiency factor:

- e = 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society
- e is specially considered by the Society for the other welded pipes, depending on the service and the manufacture procedure.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

Table 6 : Steel pipes

d_a (mm)	t (mm)	d_a (mm)	t (mm)
up to 10,2	1,6	from 114,3	3,2
from 13,5	1,8	from 133,0	3,6
from 20,0	2,0	from 152,4	4,0
from 48,3	2,3	from 177,8	4,5
from 70,0	2,6	from 244,5	5,0
from 88,9	2,9	from 298,5	5,6

Note 1: For systems where carbon dioxide is stored at ambient temperature, see Tab 7.
Note 2: For steel pipes located inside tanks, see also [5.2.3].

Table 7 : Steel pipes for CO_2 systems

d_a (mm)	t (mm)	
	Between bottles and master valves	Between master valves and nozzles
up to 26,9	3,2	2,6
from 48,3	4,0	3,2
from 60,3	4,5	3,6
from 76,1	5,0	3,6
from 88,9	5,6	4,0
from 101,6	6,3	4,0
from 114,3	7,1	4,5
from 127,8	8,0	4,5
from 139,7	8,0	5,0
from 168,3	8,8	5,6

Table 8 : Copper and copper alloy pipes

Copper pipes		Copper alloy pipes	
d_a (mm)	t (mm)	d_a (mm)	t (mm)
up to 12,2	1,0	up to 22,0	1,0
from 14,0	1,5	from 25,0	1,5
from 44,5	2,0	from 76,0	2,0
from 60,0	2,5	from 108,0	2,5
from 108,0	3,0	from 219,0	3,0
from 159,0	3,5		

Table 9 : Stainless steel pipes

d_a (mm)	t (mm)
0 - 50	1,7
54 - 70	2,0
73 -140	2,1
141 -220	2,8
270 -280	3,4
320 -360	4,0
400 - 460	4,2
500 - 560	4,8

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Table 10 : Aluminium and aluminium alloy pipes

d_a (mm)	t (mm)
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.
Note 2: For river water pipes, the minimum thickness is not to be less than 5 mm.

2.4.2 Permissible stress

a) The permissible stress K is given in:

- Tab 11 for carbon and carbon-manganese steel pipes
- Tab 12 for alloy steel pipes, and
- Tab 13 for copper and copper alloy pipes,

as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of K is not given in Tab 11 or Tab 12, it is to be taken equal to:

$$K = \min\left(\frac{R_{m,20}}{2,7}, \frac{R_e}{A}, \frac{\sigma_R}{A}, \sigma\right)$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm²

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm²

σ_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm²

A : Safety factor to be taken equal to:

- 1,6 when R_e and s_R values result from tests attended by the Society
- 1,8 otherwise

σ : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm².

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by the Society.

Table 11 : Permissible stress K for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm²)	Design temperature (°C)												
	≤50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 12 : Permissible stress K for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		≤ 50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	44
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr1/2Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 1/4Cr1Mo normalised and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr1Mo normalised and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
1/2Cr 1/2Mo 1/4V	460	101	99	97	94	82	72	62	53	45	37

Table 13 : Permissible stress K for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength (N/mm²)	Design temperature (°C)										
		≤ 50	75	100	125	150	175	200	225	250	275	300
Copper	215	41	41	40	40	34	27,5	18,5				
Aluminium brass	325	78	78	78	78	78	51	24,5				
Copper-nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59	56	52	48	44
Copper-nickel 70/30	365	81	79	77	75	73	71	69	67	65,5	64	62

Table 14 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance (mm)
Superheated steam	0,3
Saturated steam	0,8
Steam coils in cargo tanks and liquid fuel tanks	2,0
Feed water for boilers in open circuit systems	1,5
Feed water for boilers in closed circuit systems	0,5
Blow-down systems for boilers	1,5
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Thermal oil	1,0
Fresh water	0,8
River water	3,0
Cargo systems for oil tankers	2,0
Cargo systems for chemical tankers	3,0
Cargo systems for vessels carrying liquefied gases	0,3

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.
Note 2: The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%.
Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

2.4.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{d_a t_0}{2{,}5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

d_a , t_0 : As defined in [2.4.1].

b) When the bending radius is not given, the thickness reduction is to be taken equal to:

$b = t_0 / 10$

c) For straight pipes, the thickness reduction b is to be taken equal to 0.

2.4.4 Corrosion allowance

The values of corrosion allowance c are given for steel pipes in Tab 14 and for non-ferrous metallic pipes in Tab 15.

2.4.5 Tees

As well as complying with the provisions of [2.4.1] to [2.4.4], the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = \left(1 + \frac{d_1}{d_a}\right) \cdot t_0$$

where:

d_1 : External diameter of the branch pipe

d_a , t_0 : As defined in [2.4.1].

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.5 Pipe connections

2.5.1 Dimensions and calculation

The dimensions of flanges and bolting are to comply with recognized standards.

2.5.2 Pipe connections

The following pipe connections may be used:

- fully penetrating butt welds with/without provision to improve the quality of the root
- socket welds with suitable fillet weld thickness and possibly in accordance with recognized standards
- screw connections of approved type.

For the use of these pipe connections, see Tab 16.

Screwed socket connections and similar connections are not permitted for pipes of classes II and III. Screwed socket connections are allowed only for subordinate systems (e.g. sanitary and hot-water heating systems) operating at low pressures. Screwed pipe connections and pipe coupling may be used subject to special approval.

Table 15 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance (mm) **(2)**
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper-nickel alloys with less than 10% of Ni	0,8
Copper-nickel alloys with at least 10% of Ni	0,5
Aluminium and aluminium alloys	0,5

(1) The corrosion allowance for other materials will be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded.
(2) In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.

Table 16 : Pipe connections

Types of connections	Pipe class	Nominal diameter
Welded butt-joints with special provisions for root side	II, III	all
Welded butt-joints without special provisions for root side	II, III	
Welded sockets	III	
Screwed sockets	see [2.5.2] for subordinate systems	< 50

Steel flanges may be used under considering the allowed pressures and temperatures as stated in the corresponding standards.

Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals. Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

a) welding neck flanges according to standard up to 200°C or 300°C for all pipe classes

b) loose flanges with welding collar; as for item a)

c) plain brazed flanges: only for pipe class III up to a nominal pressure of 16 bar and a temperature of 120°C.

Approved pipe couplings are permitted in the following piping systems outside engine rooms:

- bilge and ballast systems
- fuel and oil systems
- fire extinguishing and deck washing systems
- cargo oil pipes
- air, filling and sounding pipes
- sanitary drain pipes
- drinking water pipes.

These couplings may only be used inside machinery spaces if they have been approved by the Society as flame-resistant.

The use of pipe couplings is not permitted in:

- fuel and seawater lines inside cargo spaces
- bilge lines inside fuel tanks and ballast tanks.

2.6 Hose assemblies and compensators

2.6.1 Scope

The following Rules are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel-, lubricating oil-, hydraulic oil-, bilge-, ballast-, fresh water cooling-, river water cooling-, compressed air-, auxiliary steam, exhaust gas and thermal oil systems.

2.6.2 Definitions

a) Hose assemblies consist of metallic or non-metallic hoses completed with end fittings ready for installation.

b) Compensators consist of bellows with end fittings as well as anchors for absorption of axial loads where angular or lateral flexibility is to be ensured. End fittings may be flanges, welding ends or approved pipe unions.

c) Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

d) High pressure hose assemblies and compensators

   Hose assemblies or compensators which are suitable for use in systems with predominant dynamic load characteristics.

e) Low pressure hose assemblies and compensators

   Hose assemblies or compensators which are suitable for use in systems with predominant static load characteristics.

f) Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators

   The maximum allowable working pressure of high pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

   The maximum allowable working pressure respectively nominal pressure for low pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the components.

g) Test pressure

   For non-metallic high pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

   For non-metallic low pressure hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

   For metallic hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

h) Burst pressure

   For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or 4 times the nominal pressure. Excepted hereof are non-metallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure.

2.6.3 Requirements

a) Hoses and compensators used in the systems mentioned in [2.6.1] are to be of approved type.

b) Manufacturers of hose assemblies and compensators must be recognized by the Society.

c) Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

d) The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar is to be considered as the minimum working pressure.

e) Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and river water systems are to be flame-resistant.

2.6.4 Installations

a) Non-metallic hose assemblies shall only be used at locations where they are required for compensation of relative movements. They shall be kept as short as possible under consideration of the installation instructions of the hose manufacturer.

b) The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

c) Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

d) In fresh water systems with a working pressure ≤ 5 bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

e) Where hose assemblies and compensators are installed in the vicinity of hot components they must be provided with approved heat-resistant sleeves.

2.6.5 Vessel cargo hoses

Vessel cargo hoses for cargo-handling on chemical tankers and gas tankers shall be type approved.

Mounting of end fittings is to be carried out only by approved manufacturers.

Vessel cargo hoses are to be subjected to final inspection at the manufacturer under supervision of a Society's Surveyor as follows:

- visual inspection
- hydrostatic pressure test with 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure. The nominal pressure shall be at least 10 bar
- measuring of the electrical resistance between the end fittings. The resistance shall not exceed 1 kΩ.

2.6.6 Marking

Hose assemblies and compensators must be permanently marked with the following particulars:

- manufacturer's mark or symbol
- date of manufacturing
- type
- nominal diameter
- maximum allowable working pressure respectively nominal pressure
- test certificate number and sign of the responsible Society inspection.

2.7 Shutoff devices

2.7.1 Shutoff devices must comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover.

2.7.2 Hand-operated shutoff devices are to be closed by turning in the clockwise direction.

2.7.3 Indicators are to be provided showing the open/closed position of valves unless their position is shown by other means.

2.7.4 Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service must not be used.

2.8 Outboard connections

2.8.1 Outboards are to be made of steel or appropriate non-brittle material.

2.8.2 Valves may only be mounted on the vessel's side by means of reinforcing flanges or thick-walled connecting pipes.

2.8.3 Vessel's side valves shall be easily accessible. Water inlet and outlet valves must be capable of being operated from above the floor plates. Cocks on the vessel's side must be so arranged that the handle can only be removed when the cock is closed.

2.8.4 Where a discharge pipe is connected to the vessel's hull below the bulkhead deck, the wall gross thickness of the pipe sections extending between the shell and the nearest shutoff device is to be equal to that of the shell plating in way of the connection, but need not exceed 8 mm.

2.8.5 Outboard connections are to be fitted with shutoff valves.

2.9 Remote controlled valves

2.9.1 Scope

These Rules apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

2.9.2 Construction

Remote controlled bilge valves and valves important to the safety of the vessel are to be equipped with an emergency operating arrangement.

2.9.3 Arrangement of valves

The accessibility of the valves for maintenance and repairing is to be taken into consideration.

Valves in bilge lines and sanitary pipes must always be accessible.

Bilge lines valves and control lines are to be located as far as possible from the bottom and sides of the vessel.

The requirements stated hereabove also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

Remote-controlled valves mounted on high and wing fuel tanks must be capable of being closed from outside the compartment in which they are installed.

Where remote controlled valves are arranged inside cargo tanks, valves should always be fitted in the tank adjoining that to which they relate. A direct arrangement of the remote controlled valves in the tanks concerned is allowed only if each tank is fitted with two suction lines each of which is provided with a remote controlled valve.

2.9.4 Control stands

The control devices of remote controlled valves are to be arranged together in one control stand.

The control devices are to be clearly and permanently identified and marked.

It must be recognized at the control stand whether the valves are open or closed.

In the case of bilge valves and valves for changeable tanks, the closed position is to be indicated by limit-position indicators approved by the Society as well as by visual indicators at the control stand.

On passenger vessels, the control stand for remote controlled bilge valves is to be located outside the machinery spaces and above the bulkhead deck.

2.9.5 Power units

Power units are to be equipped with at least two independent sets for supplying power for remote controlled valves.

The energy required for the closing of valves which are not closed by spring power is to be supplied by a pressure accumulator.

Pneumatically operated valves can be supplied with air from the general compressed air system.

Where the quick-closing valves of fuel tanks are closed pneumatically, a separate pressure accumulator is to be provided. This is to be of adequate capacity and is to be located outside the engine room. Filling of this accumulator by a direct connection to the general compressed air system is allowed. A non-return valve is to be arranged in the filling connection of the pressure accumulator.

The accumulator is to be provided either with a pressure control device with a visual and acoustic alarm or with a hand-compressor as a second filling appliance.

The hand-compressor is to be located outside the engine room.

2.9.6 After installation on board, the entire system is to be subjected to an operational test.

2.10 Pumps

2.10.1 Displacement pumps must be equipped with sufficiently dimensioned relief valves without shutoff to prevent any excessive overpressure in the pump housing.

2.10.2 Rotary pumps must be capable of being operated without damage even when the delivery line is closed.

2.10.3 Pumps mounted in parallel are to be protected against overloading by means of non-return valves fitted at the outlet side.

2.10.4 Pumps for essential services are subject to adequate pressure and running tests.

2.11 Protection of piping systems against overpressure

2.11.1 The following piping systems are to be fitted with safety valves to avoid unallowable overpressures:

- piping systems and valves in which liquids can be enclosed and heated
- piping systems which may be exposed in service to pressures in excess of the design pressure.

Safety valves must be capable of discharging the medium at a maximum pressure increase of 10%. Safety valves are to be fitted on the low pressure side of reducing valves.

2.11.2 Air escaping from the pressure-relief valves of the pressurised air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.

3 Welding of steel piping

3.1 General

3.1.1 Welding of steel pipes is to comply with applicable requirements of NR467, Pt C, Ch 1, [3].

4 Bending of pipes

4.1 Application

4.1.1 This Article applies to pipes made of:

- alloy or non-alloy steels
- copper and copper alloys.

4.2 Bending process

4.2.1 General

The bending process is to be such as not to have a detrimental influence on the characteristics of the materials or on the strength of the pipes.

4.2.2 Bending radius

Unless otherwise justified, the bending radius measured on the centreline of the pipe is not to be less than:

- twice the external diameter for copper and copper alloy pipes
- three times the external diameter for cold bent steel pipes.

4.2.3 Acceptance criteria

a) The pipes are to be bent in such a way that, in each transverse section, the difference between the maximum and minimum diameters after bending does not exceed 10% of the mean diameter; higher values, but not exceeding 15%, may be allowed in the case of pipes which are not subjected in service to appreciable bending stresses due to thermal expansion or contraction.

b) The bending is to be such that the depth of the corrugations is as small as possible and does not exceed 5% of their length.

4.2.4 Hot bending

a) In the case of hot bending, all arrangements are to be made to permit careful checking of the metal temperature and to prevent rapid cooling, especially for alloy steels.

b) Hot bending is to be generally carried out in the temperature range 850°C-1000°C for all steel grades; however, a decreased temperature down to 750°C may be accepted during the forming process.

4.3 Heat treatment after bending

4.3.1 Copper and copper alloy

Copper and copper alloy pipes are to be suitably annealed after cold bending if their external diameter exceeds 50 mm.

4.3.2 Steel

a) After hot bending carried out within the temperature range specified in [4.2.4], the following applies:
   - for C, C-Mn and C-Mo steels, no subsequent heat treatment is required
   - for Cr-Mo and C-Mo-V steels, a subsequent stress relieving heat treatment in accordance with Tab 17 is required.

b) After hot bending performed outside the temperature range specified in [4.2.4], a subsequent new heat treatment in accordance with Tab 18 is required for all grades.

c) After cold bending at a radius lower than 4 times the external diameter of the pipe, a heat treatment in accordance with Tab 18 is required.

Table 17 : Heat treatment temperature

Type of steel	Thickness of thicker part (mm)	Stress relief treatment temperature (°C)
C and C-Mn steels	t ≥ 15 **(1)** **(2)**	550 to 620
0,3 Mo	t ≥ 15 **(1)**	580 to 640
1 Cr 0,5 Mo	t ≥ 8	620 to 680
2,25 Cr 1 Mo 0,5 Cr 0,5 Mo V	any **(3)**	650 to 720

(1) Where steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which post-weld heat treatment is to be applied may be increased, subject to the special agreement of the Society.

(2) For C and C-Mn steels, stress relieving heat treatment may be omitted up to 30 mm thickness, subject to the special agreement of the Society.

(3) For 2,25Cr 1Mo and 0,5Cr 0,5Mo V grade steels, heat treatment may be omitted for pipes having thickness lower than 8 mm, diameter not exceeding 100 mm and service temperature not exceeding 450°C.

Table 18 : Heat treatment after bending

Type of steel	Heat treatment and temperature (°C)
C and C-Mn	Normalising 880 to 940
0,3 Mo	Normalising 900 to 940
1Cr-0,5Mo	Normalising 900 to 960 Tempering 640 to 720
2,25Cr-1Mo	Normalising 900 to 960 Tempering 650 to 780
0,5Cr-0,5Mo-0,25V	Normalising 930 to 980 Tempering 670 to 720

5 Arrangement and installation of piping systems

5.1 General

5.1.1 Unless otherwise specified, piping and pumping systems covered by the Rules are to be permanently fixed on board vessel.

5.1.2 Piping systems must be adequately identified according to their purpose. Valves are to be permanently and clearly marked.

5.1.3 Piping systems are to be so arranged that they can be completely emptied, drained and vented. Piping systems in which the accumulation of liquids during operation could cause damage must be equipped with special drain arrangements.

5.2 Location of tanks and piping system components

5.2.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with [5.9].

5.2.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board vessels having to comply with the provisions of [5.5].

5.2.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness or tunnels, in particular for:
   - bilge pipes
   - ballast pipes
   - scuppers and sanitary discharges
   - air, sounding and overflow pipes
   - fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or flange connections.

5.2.4 Piping and electrical apparatus

As far as possible, pipes are not to pass near switchboards or other electrical apparatus. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid or steam on live parts.

5.3 Passage through bulkheads or decks

5.3.1 General

For vessels other than dry cargo vessels, see also the additional requirements for the relevant service notations.

5.3.2 Penetration of watertight bulkheads or decks and fire divisions

a) Where penetrations of watertight bulkheads or decks and fire divisions are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity and fire integrity.

b) Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

c) Where bolted connections are used when passing through watertight bulkheads or decks, the bolts are not to be screwed through the plating. Where welded connections are used, they are to be welded on both sides of the bulkhead or deck.

5.3.3 Passage through the collision bulkhead

A maximum of two pipes may pass through the collision bulkhead below the main deck, unless otherwise justified. Such pipes are to be fitted with suitable valves operable from above the main deck. The valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are easily accessible and the space in which they are fitted is not a cargo space.

An indicator is to show whether these valves are open or shut.

5.4 Independence of lines

5.4.1 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying liquid cargo, lubricating oil and fuel oil, with the exception of:

- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.5 Prevention of progressive flooding

5.5.1 In order to comply with the subdivision and damage stability requirements, provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is damaged or broken in any other compartment by collision or grounding.

5.5.2 For this purpose, if pipes are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the vessel is not impaired.

5.6 Provision for expansion

5.6.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the vessel's structure, having due regard to the:

- temperature of the fluid conveyed
- coefficient of thermal expansion of the pipes material
- deformation of the vessel's hull.

5.6.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.7 Supporting of the pipes

5.7.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the vessel's structure by means of collars or similar devices.

5.7.2 Arrangement of supports

Shipyards are to take care that:

a) the arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected

b) heavy components in the piping system, such as valves, are to be independently supported.

5.8 Valves, accessories and fittings

5.8.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

5.8.2 Valves and accessories

In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:

- above the floor, or
- when this is not possible, immediately under the floor, provided provision is made for their easy access and control in service.

5.8.3 Flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be in compliance with [2.6]. They are to be installed in clearly visible and readily accessible locations.

b) The number of flexible hoses and expansion joints is to be kept to minimum.

c) In general, flexible hoses and expansion joints are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

d) The installation of a flexible hose assembly or an expansion joint is to be in accordance with the manufacturer's instructions and use limitations, with particular attention to the following:
   - orientation
   - end connection support (where necessary)
   - avoidance of hose contact that could cause rubbing and abrasion
   - minimum bend radii.

e) Flexible hose assemblies or expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

f) Where flexible hoses or an expansion joint are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated, as far as practicable, by the use of screens or other similar protection, to the satisfaction of the Society.

g) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

h) Isolating valves are to be provided permitting the isolation of flexible hoses intended to convey flammable oil or compressed air.

i) Expansion joints are to be protected against over extension or over compression.

j) Where they are likely to suffer external damage, flexible hoses and expansion joints of the bellows type are to be provided with adequate protection.

5.8.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.8.5 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.8.6 Nameplates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.9 Additional arrangements for flammable fluids

5.9.1 General

All necessary precautions are to be taken to reduce fire risks from flammable liquids, such as:

- drips
- leaks under pressure
- overflow
- hydrocarbon accumulation in particular under lower floors
- discharges of oil vapours during heating
- soot or unburnt residue in smoke stacks or exhaust pipes.

Unless otherwise specified, the requirements in [5.9.3] apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.9.2 Prohibition of carriage of flammable oils in forepeak tanks

Fuel oil, lubricating oil and other flammable oils are not to be carried in forepeak tanks or tanks forward of the collision bulkhead.

5.9.3 Prevention of flammable oil leakage ignition

a) As far as practicable, the piping arrangement in the flammable oil systems shall comply generally with the following:
   - The conveying of flammable oils through accommodation and service spaces is to be avoided. Where it is not possible, the arrangement may be subject to special consideration by the Society, provided that the pipes are of a material approved having regard to the fire risk.
   - The pipes are not to be located immediately above or close to the hot surfaces (exhaust manifolds, silencers, steam pipelines, boilers, etc.), electrical installations or other sources of ignition. Otherwise, suitably protection (screening and effective drainage to the safe position) is to be provided to prevent of spraying or leakage onto the sources of ignition.

- Parts of the piping systems conveying heated flammable oils under pressure exceeding 1,8 bar are to be placed above the platform or in any other position where defects and leakage can readily be observed. The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:
   - hot surfaces, including those of boilers, heaters, steam pipes, exhaust manifolds and silencers
   - electrical equipment
   - air intakes
   - other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 1,8 bar such as pumps, filters and heaters are to comply with the provisions of item b) above.

d) Pipe connections, expansion joints and flexible parts of flammable oil lines are to be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes, or on other sources of ignition.

e) Any relief valve or air vent cock fitted within the flammable liquid systems is to discharge to a safe position, such as an appropriate tank.

f) Appropriate means are to be provided to prevent undue opening (due to vibrations) of air venting cocks fitted on equipment or piping containing flammable liquid under pressure.

5.9.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:
   - under independent tanks
   - under burners
   - under purifiers and any other oil processing equipment
   - under pumps, heat exchangers and filters
   - under valves and all accessories subject to oil leakage
   - surrounding internal combustion engines.

c) The coaming height of drip trays is to be appropriate for the service and not less than 75 mm.

d) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

e) The draining system of the room where thermal fluid heaters are fitted, as well as the save all of the latter, are not to allow any fire extension outside this room.

5.9.5 Drain tank

a) The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

b) In vessels required to be fitted with a double bottom, appropriate precautions are to be taken when the drain tank is constructed in the double bottom, in order to avoid flooding of the machinery space where drip trays are located, in the event of accidentally running aground.

5.9.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.9.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Bilge systems

6.1 Application

6.1.1 This Article does not apply to bilge systems of non-propelled vessels. See [19].

6.1.2 The equipment of vessels with oil-separating facilities is to conform to applicable Society's Rules.

6.1.3 Multihull vessels

Bilge system of multihull vessels shall be specially considered by the Society.

6.2 Principle

6.2.1 General

An efficient bilge pumping system shall be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil or liquid cargo and for which other efficient means of pumping are to be provided, under all practical conditions.

Bilge pumping system is not intended at coping with water ingress resulting from structural or main river water piping damage.

6.2.2 Availability of the bilge system

The bilge system is to be able to work while the other essential installations of the vessel, especially the fire-fighting installations, are in service.

6.2.3 Bilge and ballast systems

The arrangement of the bilge and ballast pumping system shall be such as to prevent the possibility of water passing from the river and from water ballast spaces into the cargo and machinery spaces, or from one compartment to another.

Provisions shall be made to prevent any deep tank having bilge and ballast connections being inadvertently flooded from the river when containing cargo, or being discharged through a bilge pump when containing water ballast.

6.3 Design of bilge systems

6.3.1 General

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces mentioned in [6.2.1] through bilge branches, distribution boxes and bilge suctions, except for some small spaces where individual suctions by means of hand pumps may be accepted as stated in [6.6.3] and [6.7.5].

b) If deemed acceptable by the Society, bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the vessel is not impaired.

6.3.2 Number and distribution of bilge suctions

a) Draining of watertight spaces is to be possible, when the vessel is on an even keel and either is upright or has a list of up to 5°, by means of at least:

- two suctions at each side in machinery spaces, including one branch bilge suction and one direct suction
- one suction at each side in other spaces.

See also [6.5.4].

b) Bilge suctions are to be arranged as follows:

- wing suctions are generally to be provided except in the case of short and narrow compartments when a single suction ensures effective draining in the above conditions
- in the case of compartments of unusual form, additional suctions may be required to ensure effective draining under the conditions mentioned in item a).

c) In all cases, arrangements are to be made such as to allow a free and easy flow of water to bilge suctions.

6.3.3 Prevention of communication between spaces Independence of the lines

a) Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

b) Bilge lines are to be entirely independent and distinct from other lines except where permitted in [5.4].

c) In vessels designed for the carriage of flammable or toxic liquids in enclosed cargo spaces, the bilge pumping system is to be designed to prevent the inadvertent pumping of such liquids through machinery space piping or pumps.

6.4 Draining of cargo spaces

6.4.1 General

a) Cargo holds are to be fitted with bilge suctions connected to the bilge main.

b) Drainage arrangements for cargo holds likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes are to comply with [7.1].

c) Drainage of enclosed cargo spaces intended to carry dangerous goods shall be provided in accordance with Part D, Chapter 3.

6.4.2 Vessels without double bottom

a) In vessels without double bottom, bilge suctions are to be provided in the holds:

- at the aft end in the centreline where the rise of floor exceeds 5°
- at the aft end on each side in other cases.

b) Additional suctions may be required if, due to the particular shape of the floor, the water within the compartment cannot be entirely drained by means of the suctions mentioned in item a) above.

6.4.3 Vessels with double bottom

a) In vessels with double bottom, bilge suctions are to be provided in the holds on each side aft. Where the double bottom plating extends from side to side, the bilge suctions are to be led to wells located at the wings. Where the double bottom plating slopes down to the centreline by more than 5°, a centreline well with a suction is also to be provided.

b) If the inner bottom is of a particular design, shows discontinuity or is provided with longitudinal wells, the number and position of bilge suctions will be given special consideration by the Society.

6.4.4 Vessels with holds over 30 m in length

In holds greater than 30 m in length, bilge suctions are to be provided in the fore and aft ends.

6.4.5 Draining of cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

See Pt D, Ch 1, Sec 5, [3.2].

6.5 Draining of machinery spaces

6.5.1 General

The bilges of every main and essential auxiliary machinery spaces shall be capable of being pumped as follows:

- through the bilge suctions connected to the main bilge system, and
- through one direct suction connected to the largest independent bilge pump and having a diameter not less than that of the main bilge pipe.

Where all main and essential auxiliary machinery are located in a single watertight space, the bilge suctions are to be distributed and arranged in accordance with the provisions of [6.5.4].

6.5.2 Branch bilge suction

The branch bilge suction is to be connected to the bilge main.

6.5.3 Direct suction

The direct suction is to be led direct to an independent power bilge pump and so arranged that it can be used independently of the main bilge line.

The use of ejectors for pumping through the direct suction will be given special consideration.

6.5.4 Number and distribution of suctions in propulsion machinery spaces

a) In propulsion machinery spaces:

- where the bottom of the space, bottom plating or top of the double bottom slope down to the centreline by more than 5°, bilge suctions are to include at least two centreline suctions, i.e. one branch bilge suction and one direct suction
- where the bottom of the space is horizontal or slopes down to the sides and in all passenger vessels, bilge suctions are to be so arranged that the bilges can be completely pumped even under disadvantageous trim conditions.

b) Where the propulsion machinery space is located aft, suctions are normally to be provided on each side at the fore end and, except where not practicable due to the shape of the space, on each side at the aft end of the space.

c) In electrically propelled vessels, provision is to be made to prevent accumulation of water under electric generators and motors.

6.5.5 Monitoring

For monitoring of level of machinery space bilges, see Ch 3, Sec 2.

6.6 Draining of dry spaces other than cargo holds and machinery spaces

6.6.1 General

a) Except where otherwise specified, bilge suctions are to be branch bilge suctions, i.e. suctions connected to a bilge main.

b) Draining arrangements of tanks are to comply with the provisions of [7].

6.6.2 Fore and after peaks

Where the peak tanks are not connected to the ballast system, separate means of pumping are to be provided. Where the after peak terminates at the engine room, it may be drained to the engine room bilge through a pipe fitted with a shutoff valve. Similar emptying of the fore peak into an adjoining space is not permitted.

6.6.3 Spaces above peak tanks

These spaces may either be connected to the bilge system or be pumped by means of hand-operated bilge pumps. Spaces above the after peak may be drained to the machinery space, provided that the drain line is fitted with a self-closing shutoff valve at a clearly visible and easily accessible position. The drain pipes shall have an inside diameter of at least 40 mm.

6.6.4 Cofferdams and void spaces

Bilge pumping arrangements are to be provided for cofferdams and void spaces.

6.6.5 Chain lockers

Chain lockers may be connected to the main bilge system or drained by a hand pump. Draining to the fore peak tank is not permitted.

6.7 Bilge pumps

6.7.1 Number of bilge pumps

Vessels with a propulsion power of up to 225 kW must have one bilge pump, which may be driven from the main engine. Where the propulsion power is greater than 225 kW, a second bilge pump driven independently of the main propulsion plant must be provided.

6.7.2 Use of ejectors

One of the pumps may be replaced by a hydraulic ejector connected to a high pressure water pump and capable of ensuring the drainage under similar conditions to those obtained with the other pump.

On passenger vessels, the pump supplying the ejector is not to be used for other services.

6.7.3 Use of other pumps for bilge duties

a) Other pumps may be used for bilge duties, such as fire, general service, sanitary service or ballast pumps, provided that:

- they meet the capacity requirements
- suitable piping arrangements are made
- pumps are available for bilge duty when necessary.

b) The use of bilge pumps for fire duty is to comply with the provisions of Ch 4, Sec 4.

6.7.4 Capacity of independent pumps

a) The minimum capacity of the main pump is not to be less than:

$$Q_1 = 6 \cdot 10^{-3}\, d_1^{\,2}$$

where:

Q_1 : Minimum capacity of the main pump, in m^3/h

d_1 : Internal diameter, in mm, of the main bilge pipe as defined in [6.8.1].

b) The minimum capacity of the second pump is not to be less than:

$$Q_2 = 6 \cdot 10^{-3}\, d_2^{\,2}$$

where:

Q_2 : Minimum capacity of the second pump, in m^3/h

d_2 : Internal diameter, in mm, of the branch bilge pipe as defined in [6.8.1].

c) If the capacity of one of the pumps is less than the Rule capacity, the deficiency may be compensated by an excess capacity of the other pump; as a rule, such deficiency is not permitted to exceed 30% of the Rule capacity.

Note 1: This provision does not apply to passenger vessels.

6.7.5 Choice of the pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Ballast and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system.

c) For compartments of small sizes, hand pumps operable from a position located above the load waterline are acceptable.

6.7.6 Connection of power pumps

a) Bilge pumps and other power pumps serving essential services which have common suction or discharge are to be connected to the pipes in such a way that:
   - compartments and piping lines remain segregated in order to prevent possible intercommunication
   - the operation of any pump is not affected by the simultaneous operation of other pumps.

b) The isolation of any bilge pump for examination, repair or maintenance is to be made possible without impeding the operation of the remaining bilge pumps.

6.8 Size of bilge pipes

6.8.1 The following apply to vessels other than tankers.

The inside diameter of bilge pipes is not to be less than 35 mm nor than the values derived from following formulae:

a) Main bilge pipes:

$$d_1 = 1,5\sqrt{(B+D)L} + 25$$

b) Branch bilge pipes:

$$d_2 = 2,0\sqrt{(B+D)\ell} + 25$$

where:

d_1	:	Inside diameter of main bilge pipe, in mm
d_2	:	Inside diameter of branch bilge pipe, in mm
L	:	Rule length, in m, defined in Pt B, Ch 1, Sec 2
B	:	Breadth, in m, defined in Pt B, Ch 1, Sec 2
D	:	Depth, in m, defined in Pt B, Ch 1, Sec 2
ℓ	:	Length of the watertight compartment, in m.

The branch bilge pipe diameter may be taken not greater than the diameter of the main bilge pipe.

6.9 Bilge accessories

6.9.1 Screw-down non-return valves

a) Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another:
   - on the pipe connections to bilge distribution boxes
   - on the suctions of pumps which also have connections from the river or from compartments normally intended to contain liquid
   - on flexible bilge hose connections
   - at the open end of bilge pipes passing through deep tanks
   - in the discharge pipe of the pump, where the direct suction is connected to a centrifugal pump which can also be used for cooling water, ballast water or fire extinguishing.

b) Screw-down and other non-return valves are to be of a recognised type which does not offer undue obstruction to the flow of water.

6.9.2 Mud boxes

In machinery spaces, termination pipes of bilge suctions are to be straight and vertical and are to be led to mud boxes so arranged as to be easily inspected and cleaned.

The lower end of the termination pipe is not to be fitted with a strum box.

6.9.3 Strum boxes

a) In compartments other than machinery spaces, the open ends of bilge suction pipes are to be fitted with strum boxes or strainers having holes not more than 10 mm in diameter. The total area of such holes is to be not less than twice the required cross-sectional area of the suction pipe.

b) Strum boxes are to be so designed that they can be cleaned without having to remove any joint of the suction pipe.

6.10 Bilge piping arrangement

6.10.1 Passage through double bottom compartments

Bilge pipes are not to pass through double bottom compartments. If such arrangement is unavoidable, the parts of bilge pipes passing through double bottom compartments are to have reinforced thickness as per Tab 14 for steel pipes.

6.10.2 Passage through deep tanks

The parts of bilge pipes passing through deep tanks intended to contain water ballast, fresh water, liquid cargo or fuel oil are normally to be contained within pipe tunnels. Alternatively, such parts are to have reinforced thickness, as per Tab 14 for steel pipes, and are to be made either of one piece or several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered; the number of joints is to be as small as possible. These pipes are to be provided at their ends in the holds with non-return valves.

6.10.3 Provision for expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends. Sliding joints are not permitted for this purpose.

6.10.4 Pipe connections

A direct suction from the engine room must be connected to the largest of the specified bilge pumps. Its diameter shall not be less than that of the main bilge pipe.

However, the direct suction in the engine room need be fitted with only one screw-down non-return valve.

Connections used for bilge pipes passing through tanks are to be welded joints or reinforced flange connections.

6.10.5 Access to valves and distribution boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement shall be in positions which are accessible under ordinary circumstances

7 Ballast systems

7.1 Design of ballast systems

7.1.1 Independence of ballast lines

Ballast lines are to be entirely independent and distinct from other lines except where permitted in [5.4].

7.1.2 Prevention of undesirable communication between spaces or with the river

Ballast systems in connection with bilge systems are to be so designed as to avoid any risk of undesirable communication between spaces or with the river.

7.1.3 Alternative carriage of ballast water or other liquids and dry cargo

Holds and deep tanks designed for the alternative carriage of water ballast, fuel oil or dry cargo are to have their filling and suction lines provided with blind flanges or appropriate change-over devices to prevent any mishandling.

7.2 Ballast pumping arrangement

7.2.1 Filling and suction pipes

a) All tanks including aft and fore peak and double bottom tanks intended for ballast water are to be provided with suitable filling and suction pipes connected to special power driven pumps of adequate capacity.

b) Small tanks used for the carriage of domestic fresh water may be served by hand pumps.

c) Suctions are to be so positioned that the transfer of river water can be suitably carried out in the normal operating conditions of the vessel. In particular, two suctions may be required in long compartments.

7.2.2 Pumps

At least two power driven ballast pumps are to be provided, one of which may be driven by the propulsion unit. Sanitary and general service pumps may be accepted as independent power ballast pumps.

Bilge pumps may be used for ballast water transfer provided that:

- they meet the capacity requirements
- suitable piping arrangements are made
- pumps are available for bilge duty when necessary.

7.2.3 Passage of ballast pipes through tanks

If not contained in pipe tunnels, the ballast steel pipes passing through tanks intended to contain fresh water, fuel oil or liquid cargo are:

- to have reinforced thickness, as per Tab 14
- to consist either of a single piece or of several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered
- to have a minimal number of joints in these lines
- to have expansion bends in these lines within the tank, where needed
- not to have slip joints.

7.2.4 Ballast valves and piping arrangements

a) Ballast tank valves

Valves controlling flow to ballast tanks are to be arranged so that they remain closed at all times except when ballasting. Where butterfly valves are used, they are to be of a type able to prevent movement of the valve position due to vibration or flow of fluids.

b) Remote control valves

Remote control valves, where fitted, are to be arranged so that they close and remain closed in the event of loss of control power. The valves may remain in the last ordered position upon loss of power, provided that there is a readily accessible manual means to close the valves upon loss of power.

Remote control valves are to be clearly identified as to the tanks they serve and are to be provided with position indicators at the ballast control station.

8 Drinking water, scuppers and sanitary discharges

8.1 Drinking water systems

8.1.1 Drinking water tanks

a) Scantlings of drinking water tanks forming part of the vessel's structure are to comply with Pt B, Ch 5, Sec 5.

Scantlings of independent drinking water tanks are to comply with Pt B, Ch 6, Sec 7, [3].

b) Drinking water tanks shall not share walls with other tanks.

c) Pipes which do not carry drinking water shall not be routed through drinking water tanks.

d) Air and overflow pipes of drinking water tanks are to comply with [9]. They may not be connected to other pipes and may not be routed through tanks which do not contain drinking water. The upper openings of air and overflow pipes are to be protected against the entry of insects.

e) Sounding pipes must terminate at a sufficient height above the deck and may not be laid through tanks which contain other media than water.

8.1.2 Drinking water piping

a) Drinking water piping may not be connected to piping systems carrying other media and may not be laid through tanks not containing drinking water.

b) The supply of drinking water into tanks other than drinking water tanks, e.g. expansion tanks of engine fresh water cooling systems, must take place through open funnels or devices to prevent flow-back.

c) The filling connections of drinking water tanks are to be placed at a sufficient height above the deck and must be capable of being closed.

8.1.3 Drinking water pumps

Separate drinking water pumps are to be provided for drinking water systems.

8.2 Scuppers and sanitary discharges

8.2.1 Application

a) This sub-article applies to:
   - scuppers and sanitary discharge systems, and
   - discharges from sewage tanks.

b) Discharges in connection with machinery operation are dealt with in [2.8].

8.2.2 For scuppers and overboard discharges materials and scantlings, see Pt B, Ch 6, Sec 7, [4].

8.2.3 Sewage and grey water discharges

The requirements specified below are general and should apply to any vessel fitted with sewage and grey water piping systems.

a) Except otherwise specified, the sewage (or black water) means:
   - drainage and other wastes from any form of toilets and urinals
   - drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises
   - drainage from spaces containing living animals, or
   - other waste waters when mixed with the drainages defined above.

b) Grey water means other sanitary discharges which are not sewage.

c) In general, sewage systems should be of a design which will avoid the possible generation of toxic and flammable gases (such as hydrogen sulphide, methane, ammonia) during the sewage collection and treatment. Additional means of protection is to be suitable ventilation of the pipework and tanks.

d) Drain lines from the hospital area should be, as far as practicable, separated from other discharges and fitted to the drain collector at the lowest level.

e) Sewage and grey water may be collected into storage tanks together or separately, either for holding prior to transfer to a treatment unit, or for later discharge. Any tank used for holding sewage shall comply with the following:
   - suitable air pipes shall be fitted, leading to the open deck
   - design and configuration of those tanks should be such as to facilitate the effective drainage and flushing of the tanks
   - suitable means for flushing of the tanks shall be provided
   - such tanks are to be efficiently protected against corrosion
   - tanks shall have a means to indicate visually the amount of its content
   - suitable means for emptying sewage tanks through the standard discharge connection to reception facilities shall be provided. Ballast and bilge pumps are not be used for that purpose.

f) Air pipes from the sewage and grey water systems are to be independent of all other air pipes and to be led to the outside of the vessel, away from any air intake. Such pipes should not terminate in areas to which personnel have frequent access and should be clear of any sources of ignition.

g) The overboard discharges shall be located as far from river water inlets as possible, seen in the direction of travel. In general, the sewage outlets should be located below loadline.

h) The sewage and grey water discharge lines are to be fitted at the vessels' side with screw-down valve and non-return valve.

The non-return valve may be omitted where the open inlets of the sanitary discharge are situated sufficiently high above the bulkhead deck and the pipe wall thicknesses are equal to that of the vessel’s shell.

9 Air, sounding and overflow pipes

9.1 Air pipes

9.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations.

9.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments, the vessel being assumed to be on an even keel.

c) Where only one air pipe is provided, it is not to be used as a filling pipe.

9.1.3 Location of open ends of air pipes

a) Air pipes of double bottom compartments, tunnels, deep tanks and other compartments which can come into contact with the river/sea or be flooded in the event of hull damage are to be led to above the bulkhead deck.

Note 1: In vessels not provided with a double bottom, air pipes of small cofferdams or tanks not containing fuel oil or lubricating oil may discharge within the space concerned.

b) Air pipes of tanks intended to be pumped up are to be led to the open above the bulkhead deck.

c) Air pipes other than those of flammable oil tanks may be led to enclosed cargo spaces situated above the bulkhead deck, provided that:
   - overflow pipes are fitted in accordance with [9.3.4], where the tanks may be filled by pumping

- enclosed cargo spaces are fitted with scuppers discharging overboard and being capable of draining all the water which may enter through the air pipes without giving rise to any water accumulation
- suitable drainage arrangement is to be fitted below the air pipe outlet, leading to the nearest scupper
- such arrangement is not to impair integrity of fire divisions or watertight decks and bulkheads subject to the damage stability requirements.

d) The air pipe of the scupper tank is to be led to above bulkhead deck.

9.1.4 Height of air pipes

The open ends of air pipes are to be so arranged as to prevent the free entry of water in the compartment.

The height d_{AP}, in m, of air pipes extending above the bulkhead deck is to be such that:

$z_{AP} \geq \max(T + h_2;\ z_{LE}) + \delta_{AP}$

where:

z_{AP} : Z co-ordinate, in m, of the top of air pipe

z_{LE} : Z co-ordinate, in m, of the lower end (above bulkhead deck) of air pipe

h_2 : Reference value of the relative motion, in m, defined in Pt B, Ch 3, Sec 3, [2.2.1]

T : Draught, in m, defined in Pt B, Ch 1, Sec 2

δ_{AP} : Increase of air pipe height, in m, to determined according to Tab 19.

Table 19 : Increase of air pipe

Range of navigation	δ_{AP}, in m	
	Closing device fitted	No closing device fitted
IN	0,15	0,2
IN(x ≤ 2)		2n
n : Navigation coefficient defined in Pt B, Ch 3, Sec 1, [5.2]		

9.1.5 Construction of air pipes

Where tanks are filled by pumping through permanently installed pipelines, the inside cross-section of the air pipes must equal at least 125% that of the corresponding filling pipe.

9.1.6 Special arrangements for air pipes of flammable oil tanks

Air pipes from fuel oil and thermal oil tanks are to discharge to a safe position on the open deck where no danger will be incurred from issuing oil or gases.

Air pipes of lubricating or hydraulic oil storage tanks, which are neither heated nor subject to flooding in the event of hull damage, may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

Air pipes of lubricating oil tanks, gear and engine crankshaft casings shall not be led to a common line.

9.1.7 Other arrangements for air pipes

Air pipes are to be laid vertically. Air pipes passing through cargo holds are to be protected against damage.

Cofferdams and void spaces with bilge connections must be provided with air pipes terminating above the open deck.

9.2 Sounding pipes

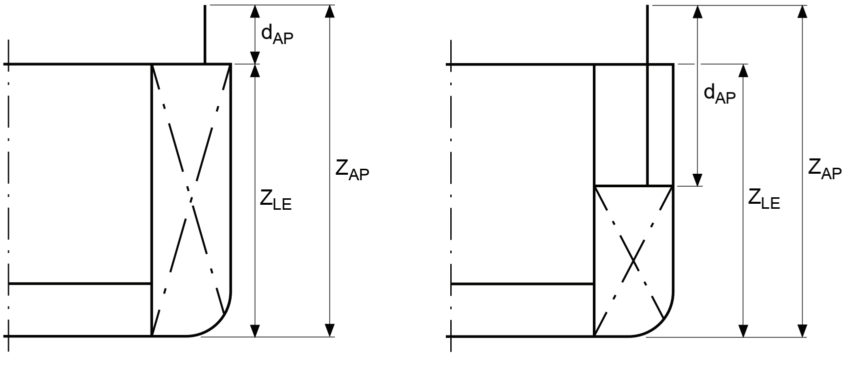
9.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times, i.e. void spaces, cofferdams and bilges (bilge wells).

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:
- a level gauge of an approved type efficiently protected against shocks, or
- a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

c) The internal diameter of sounding pipes is not to be less than 32 mm. Where sounding pipes pass through refrigerated spaces, or through the insulation of refrigerated spaces in which the temperature may be below 0°C, their internal diameter is to be at least 60 mm.

Figure 1 : Height of air pipes



9.2.2 General arrangement

As far as possible, sounding pipes are to be laid straight and are to extend as near as possible to the bottom of the tank.

Sounding pipes which terminate below the deepest load waterline are to be fitted with self-closing shutoff devices. Such sounding pipes are only permissible in spaces which are accessible at all times. All other sounding pipes are to be extended to the open deck. The sounding pipe openings must always be accessible and fitted with watertight closures.

Sounding pipes of tanks are to be provided close to the top of the tank with holes for equalizing the pressure.

A striking pad is to be fitted under every sounding pipe. Where sounding pipes are connected to the tanks over a lateral branch pipe, the branch-off under the sounding pipe is to be adequately reinforced.

9.2.3 Sounding pipes for fuel and lubricating oil tanks

Where sounding pipes cannot be extended above the open deck, they must be provided with self-closing shutoff devices as well as with self-closing test valves.

The openings of sounding pipes must be located at a sufficient distance from boilers, electrical equipment and hot components.

Sounding pipes shall not terminate in accommodation or service spaces. They are not to be used as filling pipes.

9.3 Overflow pipes

9.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the cross-sectional area of air pipes is less than that prescribed in [9.1.5].

9.3.2 Design of overflow systems

a) Overflow pipes are to be led:
   - either outside, or
   - in the case of fuel oil or lubricating oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Overflows from service tanks are generally to be led back either to the fuel bunkers, or to an overflow tank of appropriate capacity.

c) Where tanks containing the same or different liquids are connected to a common overflow system, the arrangement is to be such as to prevent any risk of:
   - intercommunication between the various tanks due to movements of liquid when emptying or filling, or due to the inclination of the vessel
   - overfilling of any tank from another assumed flooded due to hull damage.

   For this purpose, overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary.

d) Arrangements are to be made so that a compartment cannot be flooded from the river water through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

e) Where tanks alternately containing fuel oil and ballast water are connected to a common overflow system, arrangements are to be made to prevent the ballast water overflowing into the tanks containing fuel oil and vice-versa.

9.3.3 Overflow tanks

a) Overflow tanks are to be fitted with an air pipe complying with [9.1] which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

   Such means are to discharge to a position which is safe in the opinion of the Society.

b) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing. Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

9.3.4 Specific arrangements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 50 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

d) Where overflow sight glasses are provided, they shall be in a vertically dropping line on readily visible position, fitted with adequate protection from mechanical damage and well lit.

   The overflow sight glasses are not to be used in fuel oil systems.

   Use of the overflow sight glasses in lubricating oil systems may be accepted provided that:
   - they are so designed that oil does not impinge on the glass
   - the glass is to be of heat resisting quality.

10 Water cooling systems

10.1 Application

10.1.1 This Article applies to cooling systems using the following cooling media:
- river water
- fresh water.

Lubricating oil and air cooling systems will be given special consideration.

10.2 Principle

10.2.1 River water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers' recommended limits during all operations, including starting and manoeuvring, under the inclination angles and the ambient conditions specified in Ch 1, Sec 1.

10.3 Design of river water cooling systems

10.3.1 River chest

Each river chest is to be provided with an air pipe which can be shutoff and which must extend above the bulkhead deck (see Pt B, Ch 1, Sec 2, [2.12], for definition). The inside diameter of the air pipe must be compatible with the size of the river chests and shall not be less than 30 mm.

Where compressed air is used to blow through river chests, the pressure shall not exceed 2 bar.

10.3.2 Intake valves

Two valves are to be provided for main propulsion plants:
- one valve at the water inlet secured:
  - directly on the shell plating, or
  - on river chest built on the shell plating, with scantlings in compliance with Pt B, Ch 6, Sec 7, [2]
- one valve at the cooler inlet.

The cooling water pumps of important auxiliaries should be connected to the river chests over separate valves.

10.3.3 Filters

The suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

10.4 Design of fresh water cooling systems

10.4.1 General

Fresh water cooling systems are to be designed according to the applicable requirements of [10.3].

10.4.2 Expansion tanks

The fresh water cooling system is to be provided with expansion tanks located at a sufficient height. The tanks are to be fitted with a filling connection, a water level indicator and an air pipe. A venting shall connect the highest point of the cooling water common pipe to the expansion tank.

In closed circuits, the expansion tanks are to be fitted with overpressure/underpressure valves.

10.4.3 Water coolers

For fresh water coolers forming part of the vessel's shell plating and for special outboard coolers, provision must be made for satisfactory deaeration of the cooling water.

10.5 Control and monitoring

10.5.1 For control and monitoring of water cooling systems of diesel engines, see Ch 3, Sec 2, Tab 1.

11 Fuel oil systems

11.1 Application

11.1.1 Scope

This Article applies to all fuel oil systems supplying any kind of installation.

The fuel oils used on board are to comply with Ch 1, Sec 1, [2.9].

11.1.2 For fuel oil supply equipment forming part of:
- diesel engines: see Ch 1, Sec 2, [2.4.2]
- boilers and thermal oil heaters: see Ch 1, Sec 4.

11.2 Fuel oil tanks

11.2.1 Liquid fuel oil must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

11.2.2 Fuel oil tanks provided in the machinery space are not to be located above the boilers nor in places where they are likely to reach a high temperature, unless special arrangements are provided with the agreement of the Society.

11.2.3 Where a cargo space is adjacent to a fuel oil bunker/tank which is provided with heating system, the fuel oil bunker/tank boundaries are to be adequately heat insulated.

11.2.4 Arrangements are to be made to restrict leaks through the bulkheads of liquid fuel tanks adjacent to the cargo space.

11.2.5 Gutterways are to be fitted at the foot of bunker bulkheads, in the cargo space and in the machinery space in order to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The gutterways may however be dispensed with if the bulkheads are entirely welded.

11.2.6 Where ceilings are fitted on the tank top or on the top of deep tanks intended for the carriage of fuel oil, they are to rest on grounds 30 mm in depth so arranged as to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The ceilings may be positioned directly on the plating in the case of welded top platings.

11.2.7 Tanks and fuel pipes are to be so located and equipped that fuel cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see [9]).

If tanks are interconnected, the cross section of the connecting pipe shall be at least 1,25 times the cross section of the filler neck.

11.2.8 Fuel supply

The fuel supply is to be stored in several tanks so that, even in event of damage to one tank, the fuel supply will not be entirely lost (at least 1 storage tank and 1 service/settling tank).

11.2.9 Location

The location of fuel oil tanks is to be in compliance with Pt B, Ch 2, Sec 1, [2.1], particularly as regards the installation of cofferdams, the separation between fuel oil tanks or bunkers and other spaces of the vessel.

No fuel oil tanks may be located forward of the collision bulkhead.

11.2.10 Scantlings

Scantlings of fuel oil tanks forming part of the vessel's structure are to comply with Pt B, Ch 5, Sec 5.

Scantlings of independent fuel oil tanks are to comply with Pt B, Ch 6, Sec 7, [3].

11.3 Fuel tank fittings and mountings

11.3.1 For fuel filling and suction systems see [11.5]. For air, overflow and sounding pipes, see [9].

The open ends of air pipes and overflow pipes leading to the deck shall be provided with a protecting screen.

11.3.2 Service tanks are to be so arranged that water and residues can settle out despite the movement of the vessel.

11.3.3 Free discharge and drainage lines must be fitted with self-closing shutoff valves.

11.3.4 Tank gauges

The following tank gauges are permitted:

- sounding pipes
- oil level indicating devices
- oil gauges with flat glasses and self-closing shutoff valves at the connections to the tank and protected against external damage.

For fuel storage tanks, the provision of sounding pipes is sufficient. Such sounding pipes need not be fitted to tanks equipped with oil level indicating devices which have been type-tested by the Society.

Fuel service tank supplying the main propulsion unit, important auxiliaries and the driving engines for bow thruster are to be fitted with visual and audible low level alarm which has been approved by the Society.

See also Ch 3, Sec 2.

The low level alarm shall be fitted at a height which enables the vessel to reach a safe location in accordance with the class notation without refilling the service tank.

Sight glasses and oil gauges fitted directly on the side of the tank and round glass oil gauges are not permitted.

Sounding pipes of fuel tanks may not terminate in accommodation nor shall they terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise.

11.4 Attachment of mountings and fittings to fuel tanks

11.4.1 Only appliances, mountings and fittings forming part of the fuel tank equipment may generally be fitted to tank surfaces.

11.4.2 Valves and pipe connections are to be attached to strengthening flanges welded to the tank surfaces. Holes for attachment bolts must not be drilled in the tank surfaces. Instead of strengthening flanges, short, thick pipe flange connections may be welded into the tank surfaces.

11.5 Filling and delivery system

11.5.1 The filling of fuels is to be effected from the open deck through permanently installed lines.

11.6 Tank filling and suction systems

11.6.1 Fuel pumps are to be equipped with emergency stops.

11.6.2 All suction lines from fuel oil tanks and bunkers, and filling lines terminating below the maximum oil level in the tank must be fitted with remote controlled shutoff valves directly on the tank.

11.6.3 The emergency stops and the remote-controlled shutoff valves must be capable of being operated from a permanently accessible open deck and protected from unauthorized use.

11.6.4 Air and sounding pipes shall not be used to fill fuel tanks.

11.6.5 The inlet openings of suction pipes must be located above the drain pipes.

11.6.6 Service tanks of up to 50 litres capacity mounted directly on diesel engines need not be fitted with remote controlled shutoff valves.

11.7 Pipe layout

11.7.1 Fuel lines may not pass through tanks containing feedwater, drinking water or lubricating oil.

11.7.2 Fuel lines may not be laid in the vicinity of hot engine components, boilers or electrical equipment. The number of detachable pipe connections is to be limited. Shutoff valves in fuel lines shall be operable from above the floor plates in machinery spaces.

Glass and plastic components are not permitted in fuel systems.

11.7.3 Shutoff valves in fuel return (spill) lines to tanks may be permitted, ensuring that return line to the tanks under normal operating conditions will not be blocked.

11.8 Filters

11.8.1 Fuel supply lines to continuously operating engines are to be fitted with duplex filters with a changeover cock or with self-cleaning filters. By-pass arrangements are not permitted.

11.9 Control and monitoring

11.9.1 See Ch 3, Sec 2.

12 Lubricating oil systems

12.1 Application

12.1.1 Scope

This Article applies to lubricating oil systems serving all kind of installations (e.g., diesel engines, turbines, reduction gears, clutches), for lubrication purposes.

12.1.2 For lubricating oil supply equipment forming part of:

- diesel engines: see Ch 1, Sec 2, [2.4.3]
- reduction gears and clutches: see Ch 1, Sec 6.

12.2 Lubricating oil tank

12.2.1 Lubricating oil must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

12.2.2 Lubricating oil tanks and their fittings shall not be located directly above engines or exhaust pipes.

12.2.3 Lubricating oil tanks and pipes are to be so located and equipped that lubricating oil cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see [9]).

12.2.4 The location of lubricating oil tanks is to be in compliance with Pt B, Ch 2, Sec 1, [2.1], particularly as regards the installation of cofferdams, the separation between lubricating oil tanks and other spaces of the vessel.

No lubricating oil tanks may be located forward of the collision bulkhead.

12.2.5 Scantlings of lubricating oil tanks forming part of the vessel's structure are to comply with Pt B, Ch 5, Sec 5.

Scantlings of independent lubricating oil tanks are to comply with Pt B, Ch 6, Sec 7, [3].

12.2.6 Control and monitoring

See Ch 3, Sec 2.

12.3 Tank fittings and mountings

12.3.1 Oil level glasses are to be connected to the tanks by means of self-closing shutoff valves.

12.4 Capacity and construction of tanks

12.4.1 Lubricating oil circulating tanks should be sufficiently large to ensure that the dwelling time of the oil is long enough for the expulsion of air bubbles, the settling out of residues etc. The tanks must be large enough to hold at least the lubricating oil contained in the entire circulation system.

12.4.2 Measures, such as the provision of baffles or limber holes are to be taken to ensure that the entire contents of the tank remain in circulation. Limber holes should be located as near the bottom of the tank as possible. Lubricating oil drain pipes from engines are to be submerged closed to the tank bottom at their outlet ends. Suction pipe connections should be placed as far as is practicable from oil drain pipes so that neither air nor sludge can be sucked up irrespective of the inclination of the vessel.

12.4.3 Lubricating oil drain tanks are to be equipped with vent pipes in compliance with [9].

12.5 Lubricating oil piping

12.5.1 Lubricating oil systems are to be constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines and to ensure adequate heat transfer.

12.5.2 Priming pumps

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

12.6 Lubricating oil pumps

12.6.1 The suction connections of lubricating oil pumps are to be located as far as possible from drain pipes.

12.7 Filters

12.7.1 Change-over duplex filters or automatic back-flushing filters are to be mounted in lubricating oil lines on the delivery side of the pumps.

13 Thermal oil systems

13.1 General

13.1.1 Thermal oil systems shall be installed in accordance with applicable provisions of Ch 1, Sec 3.

13.1.2 Thermal oil must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

13.1.3 Thermal oil tanks and their fittings shall not be located directly above engines or exhaust pipes.

13.1.4 Thermal oil tanks and pipes are to be so located and equipped that thermal oil cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see [9]).

13.1.5 The location of thermal oil tanks is to be in compliance with Pt B, Ch 2, Sec 1, [2.1], particularly as regards the installation of cofferdams, the separation between thermal oil tanks and other spaces of the vessel.

No thermal oil tanks may be located forward of the collision bulkhead.

13.2 Pumps

13.2.1 Circulating pumps

At least two circulating pumps are to be provided, of such a capacity as to maintain a sufficient flow in the heaters with any one pump out of action.

However, for circulating systems supplying non-essential services, one circulating pump only may be accepted.

13.2.2 Transfer pumps

A transfer pump is to be installed for filling the expansion tank.

13.2.3 The pumps are to be so mounted that any oil leakage can be safely disposed of.

13.2.4 For emergency stopping, see Ch 4, Sec 2, [2.1].

13.3 Valves

13.3.1 Only valves made of ductile materials may be used.

13.3.2 Valves shall be designed for a nominal pressure of PN 16.

13.3.3 Valves are to be mounted in accessible positions.

13.3.4 Non-return valves are to be fitted in the pressure lines of the pumps.

13.3.5 Valves in return pipes are to be secured in the open position.

13.4 Piping

13.4.1 The material of the sealing joints is to be suitable for permanent operation at the design temperature and resistant to the thermal oil.

13.4.2 Provision is to be made for thermal expansion by an appropriate pipe layout and the use of suitable compensators.

13.4.3 The pipe lines are to be preferably connected by means of welding. The number of detachable pipe connections is to be minimized.

13.4.4 The laying of pipes through accommodation, public or service spaces is not permitted.

13.4.5 Pipelines passing through cargo holds are to be installed in such a way that no damage can be caused.

13.4.6 Pipe penetrations through bulkheads and decks are to be insulated against conduction of heat.

13.4.7 The venting is to be so arranged that air/oil mixtures can be carried away without danger.

13.5 Testing

13.5.1 Tightness and operational tests

After installation, the entire arrangement is to be subjected to tightness and operational testing under the supervision of the Society.

13.5.2 Hydraulic tests

For hydraulic tests, see [20].

13.6 Equipment of thermal oil tanks

13.6.1 For the equipment of thermal oil tanks, see Ch 1, Sec 3, [3.3].

14 Hydraulic systems

14.1 General

14.1.1 Scope

The Rules contained in this Article apply to hydraulic power installations used, for example, to operate closing appliances in the vessel's shell, landing ramps and hoists. The Rules are to be applied in analogous manner to vessel's other hydraulic systems.

14.1.2 Hydraulic oil must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

14.1.3 Hydraulic oil tanks and their fittings shall not be located directly above engines or exhaust pipes.

14.1.4 Hydraulic oil tanks and pipes are to be so located and equipped that hydraulic oil cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see [9]).

14.1.5 The location of hydraulic oil tanks is to be in compliance with Pt B, Ch 2, Sec 1, [2.1], particularly as regards the installation of cofferdams, the separation between hydraulic oil tanks and other spaces of the vessel.

No Hydraulic oil tanks may be located forward of the collision bulkhead.

14.1.6 Scantlings of hydraulic oil tanks forming part of the vessel's structure are to comply with Pt B, Ch 5, Sec 5.

Scantlings of independent hydraulic oil tanks are to comply with Pt B, Ch 6, Sec 7, [3].

14.2 Dimensional design

14.2.1 For the design of pressure vessels, see Ch 1, Sec 3, [2], for the dimensions of pipes, see [2.4].

14.3 Materials

14.3.1 Approved materials

Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with NR216 Materials and Welding. The use of other materials is subject to special agreement with the Society.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

Pipes are to be made of seamless or longitudinally welded steel tubes.

The pressure-loaded walls of valves, fittings, pumps, motors, etc., are subject to the requirements of [20].

14.3.2 Testing of materials

The materials of pressure casings and pressure oil lines must possess mechanical characteristics in conformity with NR216 Materials and Welding. Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in NR216 Materials and Welding.

14.4 Design and equipment

14.4.1 Control

a) Hydraulic systems may be supplied either from a common power station or from a number of power stations, each serving a particular system.

b) Where the supply is from a common power station and in the case of hydraulic drives whose piping system is connected to other hydraulic systems, a second pump set is to be provided.

c) Hydraulic systems shall not be capable of being initiated merely by starting the pump. The movement of the equipment is to be controlled from special operating stations. The controls are to be so arranged that, as soon as they are released, the movement of the hoist ceases immediately.

d) Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hydraulic equipment should normally be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating stations are then to be equipped with indicators for monitoring the movement of the hoist.

e) In or immediately at each power unit (ram or similar) used to operate equipment which moves vertically or rotates about a horizontal axis, suitable precautions must be taken to ensure a slow descent following a pipe rupture.

14.4.2 Pipes

a) The pipes of hydraulic systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

b) Pipes are to be installed at a sufficient distance from the vessel's shell. As far as possible, pipes should not pass through cargo spaces. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

c) Pipes are to be so installed that they are free from stress and vibration.

d) The piping system is to be fitted with filters for cleaning the hydraulic fluid.

e) Equipment is to be provided to enable the hydraulic system to be vented.

f) The hydraulic fluids must be suitable for the intended ambient and service temperatures.

g) Where the hydraulic system includes accumulators, the accumulator chamber must be permanently connected to the safety valve of the associated system. The gas chamber of the accumulators shall only be filled with inert gases. Gas and hydraulic fluid are to be separated by accumulator bags, diaphragms or similar devices.

14.4.3 Oil level indicators

Tanks within the hydraulic system are to be equipped with oil level indicators.

An alarm located in the wheelhouse is to fitted for the lowest permissible oil level.

14.4.4 Hose lines

Hose assemblies comprise hoses and their fittings in a fully assembled and tested condition.

High pressure hose assemblies are to be used if necessary for flexible connections. These hose assemblies must meet the requirements of [2.6] or an equivalent standard. The hose assemblies must be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose assemblies are to be flame-resistant or to be protected correspondingly.

14.5 Testing in manufacturer's works

14.5.1 Testing of power units

The power units of hydraulic systems are required to undergo test on a test stand. The relevant works test certificates are to be presented at time to the final inspection of the hydraulic system.

For electric motors, see Ch 2, Sec 4.

Hydraulic pumps are to be subjected to pressure and operational tests in compliance with [20.4.6].

Tightness tests are to be performed on components to which this is appropriate.

15 Steam systems

15.1 Laying out of steam systems

15.1.1 Steam systems are to be so installed and supported that expected stresses due to thermal expansion, external loads and shifting of the supporting structure under both normal and interrupted service conditions will be safely compensated.

15.1.2 Steam lines are to be so installed that water pockets will be avoided.

15.1.3 Means are to be provided for the reliable drainage of the piping system.

15.1.4 Pipe penetrations through bulkheads and decks are to be insulated to prevent heat conduction.

15.1.5 Steam lines are to be effectively insulated to prevent heat losses.

At points where there is a possibility of contact, the surface temperature of the insulated steam systems may not exceed 80°C.

Wherever necessary, additional protection arrangements against unintended contact are to be provided.

The surface temperature of steam systems in the pump rooms of tankers may nowhere exceed 220°C.

It is to be ensured that the steam lines are fitted with sufficient expansion arrangements.

Where a system can be entered from a system with higher pressure, the former is to be provided with reducing valves and relief valves on the low pressure side.

Welded connections in steam systems are subject to the applicable requirements of NR216 Materials and Welding.

15.2 Steam strainers

15.2.1 Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.

15.3 Steam connections

15.3.1 Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam out arrangements, are to be so secured that fuel and oil cannot penetrate into the steam systems.

16 Boiler feedwater and circulating arrangement, condensate recirculation

16.1 Feed water pumps

16.1.1 At least two feedwater pumps are to be provided for each boiler installation.

16.1.2 Feedwater pumps are to be so arranged or equipped that no backflow of water can occur when the pumps are at a standstill.

16.1.3 Feedwater pumps are to be used only for feeding boilers.

16.2 Capacity of feed water pumps

16.2.1 Where two feedwater pumps are provided, the capacity of each is to be equivalent to at least 1,25 times the maximum permitted output of all the connected steam producers.

16.2.2 Where more than two feedwater pumps are installed, the capacity of all other feedwater pumps in the event of the failure of the pump with the largest capacity is to comply with the requirements of [16.2.1].

16.2.3 For continuous flow boilers the capacity of the feedwater pumps is to be at least 1,0 time the maximum steam output.

16.3 Delivery pressure of feedwater pumps

16.3.1 Feedwater pumps are to be so laid out that the delivery pressure can satisfy the following requirements:

- the required capacity according to [16.2]] is to be achieved against the maximum allowable working pressure of the steam producer
- the safety valves must have a capacity equal 1,0 times the approved steam output at 1,1 times the allowable working pressure.

The resistances to flow in the piping between the feedwater pump and the boiler are to be taken into consideration. In the case of continuous flow boilers the total resistance of the boiler must be taken into account.

16.4 Power supply to feedwater pumps

16.4.1 For electric drives, a separate lead from the common bus-bar to each pump motor is sufficient.

16.5 Feedwater systems

16.5.1 General

Feedwater systems may not pass through tanks which do not contain feedwater.

16.5.2 Feedwater systems for boilers

a) Each boiler is to be provided with a main and an auxiliary feedwater systems.

b) Each feedwater system is to be fitted with a shutoff valve and a check valve at the boiler inlet. Where the shutoff valve and the check valve are not directly connected in series, the intermediate pipe is to be fitted with a drain.

c) Each feedwater pump is to be fitted with a shutoff valve on the suction side and a screw-down non-return valve on the delivery side. The pipes are to be so arranged that each pump can supply each feedwater system.

d) Continuous flow boilers need not to be fitted with the valves required in item b) provided that the heating of the boiler is automatically switched off should the feedwater supply fail and that the feedwater pump supplies only one boiler.

16.6 Boiler water circulating systems

16.6.1 Each forced-circulation boiler is to be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation is to be signalled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.

16.6.2 The provision of only one circulating pump for each boiler is sufficient if:

- a common stand-by circulating pump is provided which can be connected to any boiler, or
- the burners of oil-fired auxiliary boilers are so arranged that they are automatically shut off should the circulating pump fail and the heat stored in the boiler does not cause any unacceptable evaporation of the water present in the boiler.

16.7 Condensate recirculation

16.7.1 The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil etc.) is to be led to condensate observation tanks. These tanks are to be fitted with air vents.

17 Compressed air systems

17.1 Application

17.1.1 This Article applies to compressed air systems intended for essential services, and in particular to:

- starting of engines
- control and monitoring.

17.2 Principle

17.2.1 General

a) As a rule, compressed air systems are to be so designed that the compressed air delivered to the consumers:
   - is free from oil and water, as necessary
   - does not have an excessive temperature.

b) Compressed air systems are to be so designed as to prevent overpressure in any part of the systems.

17.2.2 Availability

a) Compressed air systems are to be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained. The filling connections of the compressed air receivers shall be fitted with a non-return valve.

b) The compressed air system for starting the main and auxiliary engines is to be arranged so that the necessary initial charge of starting air can be developed on board vessel without external aid. If, for this purpose, an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

c) Where compressed air is necessary to restore propulsion, the arrangements for bringing main and auxiliary machinery into operation are to have capacity such that the starting energy and any power supplies for engine operation are available within 30 minutes.

d) Where the compressed air is necessary for the air whistle or other safety services, it is to be available from two compressed air receivers. At least one of them is to be starting air receiver for main engines. The separate connection, dedicated for this purpose, is to be provided directly from the compressed air main.

17.3 Design of starting air systems

17.3.1 Air supply for starting the main and auxiliary engines

a) The total capacity of the compressed air available for starting purpose is to be sufficient to provide, without replenishment, not less than 12 consecutive starts alternating between ahead and astern of each main engine of the reversible type, and not less than 6 consecutive starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

   The number of starts refers to the engine in cold and ready-to-start condition (all the driven equipment that cannot be disconnected is to be taken into account).

   A greater number of starts may be required when the engine is in warm running condition.

   At least 3 consecutive starts is to be possible for each engine driving electric generators and engines for other purposes. The capacity of a starting system serving two or more of the above specified purposes is to be the sum of the capacity requirements.

b) For multi-engine propulsion plants, the capacity of the starting air receivers is to be sufficient to ensure at least 3 consecutive starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

   Regardless of the above, for any other specific installation the number of starts may be specially considered by the Society and depending upon the arrangement of the engines and the transmission of their output to the propellers in each particular case.

17.3.2 Number and capacity of air compressors

a) Where main and auxiliary engines are arranged for starting by compressed air, two or more air compressors are to be fitted with a total capacity sufficient to supply within one hour the quantity of air needed to satisfy the provisions of [17.3.1] charging the receivers from atmospheric pressure. This capacity is to be approximately equally divided between the number of compressors fitted, excluding the emergency compressor fitted in pursuance of item c) below.

b) At least one of the compressors is to be independent of the engines for which starting air is supplied and is to have a capacity of not less than 50% of the total required in item a).

c) Where, for the purpose of [17.2.2], an emergency air compressor is fitted, this unit is to be power driven by internal combustion engine, electric motor or steam engine.

   Suitable hand starting arrangement or independent electrical starting batteries may be accepted. In the case of small installations, a hand-operated compressor of approved capacity may be accepted.

17.3.3 Number and capacity of air receivers

a) Where main engines are arranged for starting by compressed air, at least two air receivers are to be fitted of approximately equal capacity and capable of being used independently.

b) The total capacity of air receivers is to be sufficient to provide without replenishment the number of starts required in [17.3.1]. When other users such as auxiliary engine starting systems, control systems, whistle, etc. are connected to the starting air receivers, their air consumption is also to be taken into account.

   Compressed air receivers are to comply with the requirements of Ch 1, Sec 3.

17.4 Design of air compressors

17.4.1 Prevention of excessive temperature of discharged air

Air compressors are to be so designed that the temperature of discharged air cannot exceed 95°C. For this purpose, the air compressors are to provided where necessary with:

- suitable cooling means
- fusible plugs or alarm devices set at a temperature not exceeding 120°C.

17.4.2 Prevention of overpressure

a) Air compressors are to be fitted with a relief valve complying with [2.11].

b) Means are to be provided to prevent overpressure wherever water jackets or casings of air compressors may be subjected to dangerous overpressure due to leakage from air pressure parts.

c) Water space casings of intermediate coolers of air compressors are to be protected against any overpressure which might occur in the event of rupture of air cooler tubes.

17.4.3 Provision for draining

Air compressors are to be fitted with a drain valve.

17.5 Control and monitoring of compressed air systems

17.5.1 Monitoring

For diesel engines starting system, alarms and safeguards are to be provided for compressed air systems in accordance with Ch 3, Sec 2, Tab 1.

17.5.2 Automatic controls

Automatic pressure control is to be provided for maintaining the air pressure in the air receivers within the required limits.

17.6 Arrangement of compressed air piping systems

17.6.1 Prevention of overpressure

Suitable pressure relief arrangements are to be provided for all systems.

17.6.2 Air supply to compressors

a) Provisions are to be made to reduce to a minimum the entry of oil into air pressure systems.

b) Air compressors are to be located in spaces provided with sufficient ventilation.

17.6.3 Air treatment and draining

a) Provisions are be made to drain air pressure systems.

b) Efficient oil and water separators, or filters, are to be provided on the discharge of compressors, and drains are to be installed on compressed air pipes wherever deemed necessary.

17.6.4 Lines between compressors, receivers and engines

All discharge pipes from starting air compressors are to be lead directly to the starting air receivers, and all starting pipes from the air receivers to main or auxiliary engines are to be entirely separate from the compressor discharge pipe system.

17.6.5 Protective devices for starting air mains

Non-return valves and other safety devices are to be provided on the starting air mains of each engine in accordance with the provisions of Ch 1, Sec 2, [3.1.1].

18 Exhaust gas systems

18.1 General

18.1.1 Application

This Article applies to:

- exhaust gas pipes from engines
- smoke ducts from boilers.

18.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

18.2 Design of exhaust systems

18.2.1 Limitation of exhaust line surface temperature

a) Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:
   - their surface temperature may exceed 220°C, or
   - they pass through spaces of the vessel where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Ch 1, Sec 1, [3.7.1].

18.2.2 Limitation of pressure losses

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine or boiler manufacturers.

18.2.3 Intercommunication of engine exhaust gas lines or boiler smoke ducts

a) Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas boiler or economiser, unless each exhaust pipe is provided with a suitable isolating device.

b) Smoke ducts from boilers discharging to a common funnel are to be separated to a height sufficient to prevent smoke passing from a boiler which is operating to a boiler out of action.

18.2.4 Boilers designed for alternative oil firing and exhaust gas operation

Where boilers are designed for alternative oil firing and exhaust gas operation, the exhaust gas pipe from the engine is to be fitted with an isolating device and safety arrangements to prevent the starting of the fuel oil burning units if the isolating device is not in the closed position.

18.2.5 Exhaust gas pipe terminations

a) Where exhaust pipes are led overboard close to the load waterline, means are to be provided to prevent water from entering the engine or the vessel.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

18.2.6 Control and monitoring

A high temperature alarm is to be provided in the exhaust gas manifolds of thermal oil heaters to detect any outbreak of fire.

18.3 Arrangement of exhaust piping systems

18.3.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

18.3.2 Provision for draining

a) Drains are to be provided where necessary in exhaust systems, and in particular in exhaust ducting below exhaust gas boilers, in order to prevent water flowing into the engine.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

18.3.3 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

19 Bilge systems for non propelled vessels

19.1 Bilge system in vessels having no source of electrical power

19.1.1 General

Where there is no source of electrical power on board, hand pumps are to be provided, in sufficient number and so positioned as to permit an adequate drainage of all the compartments of the vessel.

19.1.2 Arrangement of the bilge system

The bilge system is to comply with one of the following arrangements:

a) at least one pump is provided for each compartment

b) at least two pumps connected to a bilge main are to be provided. The main is to have branch pipes allowing the draining of each compartment through at least one suction.

19.1.3 Hand pumps

a) Hand pumps are to be capable of being operated from positions above the load waterline and are to be readily accessible at any time.

b) Hand pump suction lift is to be well within the capacity of the pump.

19.1.4 Size of bilge pipes

The size of bilge pipes is to be determined in compliance with [6.8].

19.2 Bilge system in vessels having a source of electrical power

19.2.1 General

On board non propelled vessels having a source of electrical power, mechanical pumps are to be provided for draining the various compartments of the vessel.

The Society may waive the requirements of this sub-article for vessels not intended to carry passengers complying with [19.1].

19.2.2 Arrangement of the bilge system

The bilge system is to comply with the provisions of [6.3] to [6.6] applicable to the spaces concerned, except that direct suction need not be provided.

19.2.3 Bilge pumps

The number and capacity of the bilge pumps are to comply with the relevant requirements of [6.7].

19.2.4 Size of bilge pipes

The size of bilge pipes is to comply with the relevant requirements of [6.8].

20 Certification, inspection and testing of piping systems

20.1 Application

20.1.1 This Article defines the certification and workshop inspection and testing programme to be performed on:

- the various components of piping systems
- the materials used for their manufacture.

On board testing is dealt with in Ch 1, Sec 15.

20.2 Type tests

20.2.1 Type tests of flexible hoses and expansion joints

a) For the flexible hoses or expansion joints which are to comply with [2.6], relevant type approval tests are to be carried out on each type and each size.

b) The flexible hose or an expansion joint subjected to the tests is to be fitted with their connections.

c) Type approval tests are to be carried out in accordance with applicable requirements of NR467, Pt C, Ch 1, Sec 10.

d) All flexible hose assemblies or expansion joints are to be satisfactorily prototype burst tested to an international standard (see Note 1) to demonstrate that they are able to withstand a pressure not less than 4 times their design pressure without indication of failure or leakage.

Note 1: The international standards (e.g. EN or SAE standards) for burst testing of non-metallic hoses require the pressure to be increased until burst without any holding period. Burst is to occur at a pressure greater than 4 times the maximum working pressure.

20.3 Testing of materials

20.3.1 The proof of the quality of materials for pipe class II is to be in the form of an inspection certificate. For this purpose, the manufacturer of the material must have been accepted by the Society.

20.3.2 For components in pipe class III, a works certificate issued by the manufacturer of the material according to EN 10204 3.1 or equivalent is sufficient.

20.3.3 Welded joints in pipelines of class II are to be tested in accordance with NR216 Materials and Welding.

20.4 Hydrostatic testing of piping systems and their components

20.4.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

20.4.2 Pressure tests of piping before assembly on board

All class II pipes as well as steam lines, feedwater pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3,5 bar together with their associated fittings, connecting pieces, branches and bends, after completion of manufacture but before insulation and coating, if this is provided, shall be subjected to a hydraulic pressure test in the presence of the Surveyor at the following value of pressure:

$p_p = 1,5\ p_C$

where:

p_C : Design pressure defined in [2.4.1].

Where for technical reasons it is not possible to carry out complete hydraulic pressure tests on all sections of piping before assembly on board, proposals are to be submitted for approval to the Society for testing the closing lengths of piping, particularly in respect of closing seams.

When the hydraulic pressure test of piping is carried out on board, these tests may be conducted in conjunction with the tests required under [20.4.3].

Pressure testing of pipes with a nominal diameter less than 15 mm may be omitted at the Society's discretion depending on the application.

20.4.3 Pressure tests of piping after assembly on board

In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests are to be applied. In particular the following applies:

- heating coils in tanks and fuel lines must be tested to not less than 1,5 PB but in no case less than 4 bar
- liquefied gas process piping systems are to be leak tested (by air, halides, etc.) to a pressure depending on the leak detection method applied.

20.4.4 Hydrostatic tests of valves

The following valves are to be subjected in the manufacturer's works to a hydraulic pressure test in the presence of a Society Surveyor:

a) valves of pipe class II to 1,5 PR

b) valves mounted on the vessel's side not less than 5 bar.

The valves specified under items a) and b) shall also undergo a tightness test at 1,0 times the nominal pressure.

For the valves of steam boilers, see Ch 1, Sec 3, [3.2].

20.4.5 Hydrostatic tests of fuel oil bunkers and tanks not forming part of the vessel's structure

Fuel oil bunkers and tanks not forming part of the vessel's structure are to be subjected to a hydrostatic test in compliance with Pt B, Ch 8, Sec 4.

20.4.6 Hydrostatic tests of pumps and compressors

Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the test pressure p_p, in bar determined by the following formulae:

- $p_p = 1,5\ p_{e,zul}$ where $p_{e,zul} \leq 200$
- $p_p = p_{e,zul} + 100$ where $p_{e,zul} > 200$

where:

$p_{e,zul}$: Maximum allowable working pressure, in bar, as defined in [1.3.2].

Tightness tests are to be performed on components to which this is appropriate.

20.4.7 Hydrostatic test of flexible hoses and expansion joints

Hose assemblies and compensators are to be subjected in the manufacturer's works to a pressure test in accordance with [2.6.2] under the supervision of the Society.

20.5 Testing of piping system components during manufacturing

20.5.1 Pumps

Bilge and fire pumps are to undergo a performance test.

20.6 Inspection and testing of piping systems

20.6.1 The inspections and tests required for piping systems and their components are summarized in Tab 20.

Table 20 : Inspection and testing at works for piping systems and their components

<table>
<tr><th colspan="2" rowspan="2">Item (1)</th><th colspan="2">Tests for the materials (2)</th><th colspan="3">Inspections and tests for the product (2)</th></tr>
<tr><th>Tests required (3)</th><th>Type of material certificate (4)</th><th>During manufacturing (NDT)</th><th>After completion</th><th>Type of product certificate (4)</th></tr>
<tr><td rowspan="2">Raw pipes</td><td>class II</td><td rowspan="2">[20.3]</td><td>C (5)</td><td rowspan="2">[3] (6)</td><td rowspan="2">[20.4.2]
[20.4.3]</td><td>C (5)</td></tr>
<tr><td>class III</td><td>W</td><td>W</td></tr>
<tr><td rowspan="2">Valves and fittings</td><td>class II</td><td rowspan="2">[20.3]</td><td>C (5)</td><td rowspan="2">[3] (6)</td><td rowspan="2">[20.4.4]</td><td>C (5)</td></tr>
<tr><td>class III, ND > 100
class III, ND ≤ 100</td><td>C (5)
W</td><td>C (5)
W</td></tr>
<tr><td colspan="2">Flexible hoses and expansion joints</td><td>[20.3]</td><td>C (5)</td><td></td><td>[20.4.7]</td><td>C (5)</td></tr>
<tr><td rowspan="6">Pumps and compressors within piping systems covered by Sections of Part C, Chapter 1 (7)</td><td>when belonging to a class II piping system</td><td>[20.3]</td><td>W</td><td></td><td rowspan="6">[20.4.6]</td><td>C (5)</td></tr>
<tr><td>bilge and fire pump</td><td>[20.3]</td><td>W</td><td></td><td>C (5)</td></tr>
<tr><td>feed pumps for main boilers</td><td>[20.3]</td><td>C (5)</td><td>[3] (6) (8)</td><td>C (5)</td></tr>
<tr><td>forced circulation pumps for main boilers</td><td>[20.3]</td><td>C (5)</td><td></td><td>C (5)</td></tr>
<tr><td>when belonging to one of the following class III piping systems if design pressure exceeds 3,5 bar:
• boiler feed water or forced circulating
• fuel oil or other flammable oil
• compressed air</td><td>[20.3]</td><td>W</td><td></td><td>C (5)</td></tr>
<tr><td>when belonging to other class III piping systems</td><td></td><td></td><td></td><td>W</td></tr>
</table>

(1) ND = Nominal diameter of the pipe, valve or fitting, in mm.
Class of pipping systems is to be determined in accordance with [1.4].
(2) [x.y.z] = test required, as per referent regulation. In general, the material are to comply with [2.2]
(3) where required by the table, material tests are to be carried out for the components subject to pressure, such as valve body, pump and compressor casings, etc. They are also to be carried out for the assembling bolts of feed water pumps and forced circulating pumps serving main boilers. Requirements for material testing are detailed in NR216 Materials and Welding, Ch 2, Sec 2.
(4) C = class inspection certificate ; W = works' certificate.
(5) or alternative type of certificate, depending on the Survey Scheme.
(6) if of welded construction.
(7) for other pumps and compressors, see additional Rules relevant for related system.
(8) for main parts, before assembling.

SECTION 11 STEERING GEAR

1 General

1.1 Application

1.1.1 Scope

Unless otherwise specified, the requirements of this Section apply to the steering gear systems of all mechanically propelled vessels, and to the steering mechanism of thrusters used as means of propulsion.

1.1.2 Cross references

In addition to the those provided in this Section, steering gear systems are also to comply with the requirements of:

- Ch 1, Sec 15, as regards tests on board
- Pt B, Ch 7, Sec 1, as regards the rudder and the rudder stock.

1.2 Documentation to be submitted

1.2.1 Documents to be submitted for all steering gear

Before starting construction, all plans and specifications listed in Tab 1 are to be submitted to the Society for review.

1.3 Definitions

1.3.1 Steering system

Steering system means vessels's directional control system, including main steering gear, auxiliary steering gear, steering gear control system and rudder if any.

Table 1 : Documents to be submitted for steering gear

Item No	Status of the review **(1)**	Description of the document **(2)**
1	I	Assembly drawing of the steering gear including sliding blocks, guides, stops and other similar components
2	I	General description of the installation and of its functioning principle
3	I	Operating manuals of the steering gear and of its main components
4	I	Description of the operational modes intended for steering in normal and emergency conditions
5	A	For hydraulic steering gear, the schematic layout of the hydraulic piping of power actuating systems, including the hydraulic fluid refilling system, with indication of: • the design pressure • the maximum working pressure expected in service • the diameter, thickness, material specification and connection details of the pipes • the hydraulic fluid tank capacity • the flashpoint of the hydraulic fluid
6	I	For hydraulic pumps of power units, the assembly longitudinal and transverse sectional drawings and the characteristic curves
7	A	Assembly drawings of the rudder actuators and constructional drawings of their components, with, for hydraulic actuators, indication of: • the design torque • the maximum working pressure • the relief valve setting pressure
8	I	Constructional drawings of the relief valves for protection of the hydraulic actuators, with indication of: • the setting pressure • the relieving capacity
9	A	Diagrams of the electric power circuits
10	A	Functional diagram of control, monitoring and safety systems including the remote control from the navigating bridge, with indication of the location of control, monitoring and safety devices
11	A	Constructional drawings of the strength parts providing a mechanical transmission of forces to the rudder stock (tiller, quadrant, connecting rods and other similar items), with the calculation notes of the shrink-fit connections
12	I/A	For azimuth thrusters used as steering means, the specification and drawings of the steering mechanism and, where applicable, documents 2 to 6 and 8 to 11 above

(1) Submission of the drawings may be requested:
for review, shown as “A”; for information, shown as “I”.
(2) Constructional drawings are to be accompanied by the specification of the materials employed and, where applicable, by the welding details and welding procedures.

1.3.2 Steering gear control system

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3.3 Main steering gear

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the vessel under normal service conditions.

1.3.4 Steering gear power unit

Steering gear power unit is:

- in the case of electric steering gear, an electric motor and its associated electrical equipment
- in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump
- in the case of other hydraulic steering gear, a driving engine and connected pump.

1.3.5 Auxiliary steering gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the vessel in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.3.6 Power actuating system

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

1.3.7 Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.8 Maximum ahead service speed

Maximum ahead service speed is the greatest speed which the vessel is designed to maintain in service at the deepest draught.

1.3.9 Maximum astern speed

Maximum astern speed is the speed which it is estimated the vessel can attain at the designed maximum astern power at the deepest draught.

1.3.10 Maximum working pressure

Maximum working pressure is the maximum expected pressure in the system when the steering gear is operated to comply with the provisions of [2.2.1] item b).

1.4 Symbols

1.4.1 The following symbols are used for strength criteria of steering gear components:

V : Maximum ahead service speed, in km/h, with the vessel on maximum load waterline; this value is not to be taken less than 8 km/h

d_s : Rule diameter of the rudder stock in way of the tiller, in mm, defined in Pt B, Ch 7, Sec 1, [3.1.2] and calculated with a material factor $k_1 = 1$. For conical coupling, d_s is to be taken as specified in Fig 1

d_{se} : Actual diameter of the upper part of the rudder stock in way of the tiller, in mm (in the case of a tapered coupling, this diameter is measured at the base of the assembly)

T_R : Rule design torque of the rudder stock given, in kN.m, by the following formula:

$$T_R = 13{,}5 \cdot d_s^{\,3} \cdot 10^{-6}$$

T_E : For hand emergency operation, design torque due to forces induced by the rudder, in kN.m, given by the following formula:

$$T_E = 0{,}62 \cdot \left(\frac{V_E + 3,704}{V + 3,704}\right)^2 \cdot T_R$$

where:

$V_E = 0{,}5\ V$

T_G : For main hydraulic or electrohydraulic steering gear, torque induced by the main steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

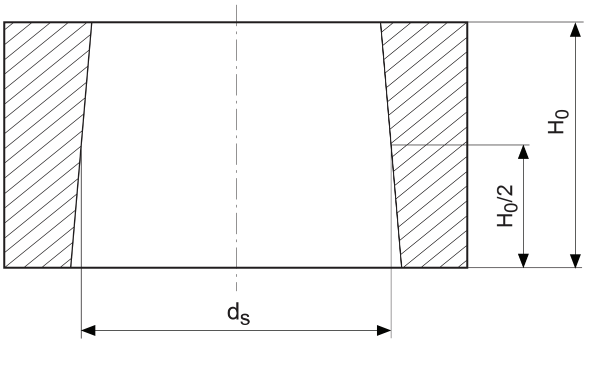
Note 1: For hand-operated main steering gear, the following value is to be used: $T_G = 1{,}25\ T_R$

T_A : For auxiliary hydraulic or electrohydraulic steering gears, torque induced by the auxiliary steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

Note 2: For hand-operated auxiliary steering gear, the following value is to be used: $T_A = 1{,}25\ T_E$

T'_G : For steering gear which can activate the rudder with a reduced number of actuators, the value of T_G in such conditions

Figure 1 : Boss dimensions



σ : Normal stress due to the bending moments and the tensile and compressive forces, in N/mm²

τ : Tangential stress due to the torsional moment and the shear forces, in N/mm²

σ_a : Permissible stress, in N/mm²

σ_c : Combined stress, determined by the following formula:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2}$$

R : Value of the minimum specified tensile strength of the material at ambient temperature, in N/mm²

R_e : Value of the minimum specified yield strength of the material at ambient temperature, in N/mm²

R'_e : Design yield strength, in N/mm², determined by the following formulae:

- where $R \geq 1,4\ R_e$: $R'_e = R_e$
- where $R < 1,4\ R_e$: $R'_e = 0,417\ (R_e + R)$

2 Design and construction

2.1 General

2.1.1 Unless expressly provided otherwise, every vessel is to be provided with main steering gear and auxiliary steering gear to the satisfaction of the Society.

Each steering gear must be able to operate the rudder for its own and independent of the other. The Society may agree to components being used jointly by the main and auxiliary steering gear.

2.2 Strength, performance and power operation of the steering gear

2.2.1 Main steering gear

The main steering gear and rudder stock are to be:

a) of adequate strength and capable of steering the vessel at maximum ahead service speed, which is to be demonstrated

b) capable of putting the rudder over from 35° on one side to 35° on the other side with the vessel at its deepest draught and running ahead at maximum ahead service speed and, under the same conditions, from 35° on either side to 35° on the other side in not more than 28 seconds

c) operated by power where necessary to fulfil the requirements of item b), and

d) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

2.2.2 Auxiliary steering gear

The auxiliary steering gear is to be:

a) of adequate strength and sufficient to steer the vessel at navigable speed and capable of being brought speedily into action in an emergency

b) operated by power where necessary to meet the requirements of item a).

2.2.3 Hand operation

Manual operation is acceptable for rudder stock diameters up to 150 mm calculated for torsional loads in accordance with Pt B, Ch 7, Sec 1, [3.1.2].

Not more than 30 turns of the handwheel shall be necessary to put the rudder from one hard over position to the other. Taking account of the efficiency of the system, the force required to operate the handwheel should generally not exceed 200 N.

2.3 Control of the steering gear

2.3.1 Control of the main steering gear

a) Control of the main steering gear is to be provided on the wheelhouse.

b) Where the main steering gear is arranged in accordance with [2.4.2], two independent control systems are to be provided, both operable from the wheelhouse. This does not require duplication of the steering wheel or steering lever.

2.3.2 Control of the auxiliary steering gear

a) Control of the auxiliary steering gear is to be provided on the wheelhouse, in the steering gear compartment or in another suitable position.

b) If the auxiliary steering gear is power operated, its control system is also to be independent of that of the main steering gear.

2.4 Availability

2.4.1 Arrangement of main and auxiliary means for actuating the rudder

The main steering gear and the auxiliary means for actuating the rudder are to be arranged so that a single failure in one will not render the other inoperative.

2.4.2 Omission of the auxiliary steering gear

Where the main steering gear comprises two or more identical power units, auxiliary steering gear need not be fitted, provided that the main steering gear is capable of operating the rudder:

a) as required in [2.2.1], item b), while operating with all power units

b) as required in [2.2.2], item a), while any one of the power units is out of operation.

2.4.3 Hydraulic power supply

Hydraulic power installations supplying steering gear may also supply other equipment at the same time provided that the operation of the steering gear is not affected by:

a) the operation of this equipment, or

b) any failure of this equipment or of its hydraulic supply piping.

2.5 Mechanical components

2.5.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of the Society.

b) Any non-duplicated essential component is, where appropriate, to utilise anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings, which are to be permanently lubricated or provided with lubrication fittings.

c) The construction is to be such as to minimise local concentration of stress.

d) All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

2.5.2 Materials and welds

a) All steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material complying with the requirements of NR216 Materials and Welding. In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

b) The use of grey cast iron is not permitted, except for redundant parts with low stress level, subject to special consideration by the Society. It is not permitted for cylinders.

c) The welding details and welding procedures are to be submitted for review/approval.

d) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be of full penetration type or of equivalent strength.

2.5.3 Scantling of components

The scantling of steering gear components is to be determined considering the design torque M_T and the permissible value σ_a of the combined stress, as given in:

- Tab 2 for components which are protected against overloads induced by the rudder
- Tab 3 for components which are not protected against overloads induced by the rudder.

Table 2 : Scantling of components protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_G	• if $T_G \leq 1,25\ T_R$: $\sigma_a = 1,25\ \sigma_0$ • if $1,25\ T_R < T_G < 1,50\ T_R$: $\sigma_a = \sigma_0\ T_G/T_R$ • if $T_G \geq 1,50\ T_R$: $\sigma_a = 1,50\ \sigma_0$ where $\sigma_0 = 0,55\ R'_e$
Normal operation, with a reduced number of actuators	T'_G	• if $T'_G \leq 1,25\ T_R$: $\sigma_a = 1,25\ \sigma_0$ • if $1,25\ T_R < T'_G < 1,50\ T_R$: $\sigma_a = \sigma_0\ T_G/T_R$ • if $T'_G \geq 1,50\ T_R$: $\sigma_a = 1,50\ \sigma_0$ where $\sigma_0 = 0,55\ R'_e$
Emergency operation achieved by hydraulic or electrohydraulic steering gear	min (T_R ; 0,8 T_A)	0,69 R'_e
Emergency operation, with a reduced number of actuators	min (T_R ; 0,8 T'_G)	0,69 R'_e
Emergency operation achieved by hand	T_E	0,69 R'_e

Table 3 : Scantling of components not protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_R	0,55 R'_e
Normal operation, with a reduced number of actuators	min (T_R ; 0,8 T'_G)	0,55 R'_e
Emergency operation achieved by hydraulic or electrohydraulic steering gear	min (T_R ; 0,8 T_A)	0,69 R'_e
Emergency operation, with a reduced number of actuators	min (T_R ; 0,8 T'_G)	0,69 R'_e
Emergency operation achieved by hand	T_E	0,69 R'_e

2.5.4 Tillers, quadrants and rotors

a) The scantling of the tiller is to be determined as follows:

- the depth H_0 of the boss is not to be less than 0,75 d_s
- the radial thickness of the boss in way of the tiller is not to be less than the greater of:

$$0,3 \cdot d_s \cdot \sqrt{\frac{235}{R'_e}}$$

$$0,25 \cdot d_s$$

- the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value Z_b, in cm^3, calculated from the following formula:

$$Z_b = \frac{0{,}147 \cdot d_s^3}{1000} \cdot \frac{L'}{L} \cdot \frac{R_e}{R'_e}$$

where:

L : Distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig 2)

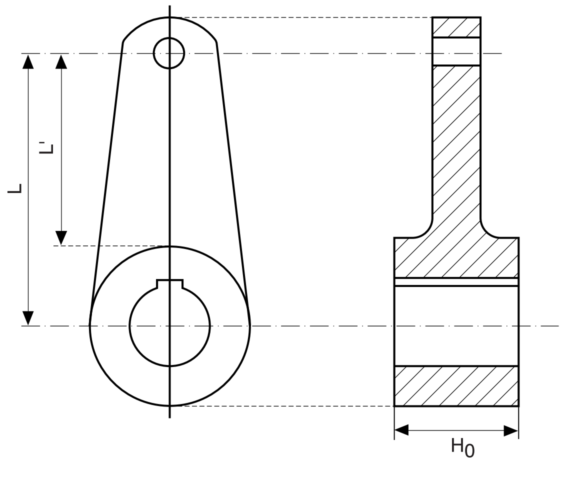
L′ : Distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig 2)

- the width and thickness of the tiller arm in way of the point of application of the load are not to be less than one half of those required by the above formula
- in the case of double arm tillers, the section modulus of each arm is not to be less than one half of the section modulus required by the above formula.

b) The scantling of the quadrants is to be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm is not to be less than one half or one third, respectively, of the section modulus required for the tiller.

Arms of loose quadrants not keyed to the rudder stock may be of reduced dimensions to the satisfaction of the Society, and the depth of the boss may be reduced by 10%.

Figure 2 : Tiller arm



c) Keys are to satisfy the following provisions:

- the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm²
- the width of the key is not to be less than 0,25 d_S
- the thickness of the key is not to be less than 0,10 d_S
- the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5% of the key thickness.

d) Bolted tillers and quadrants are to satisfy the following provisions:

- the diameter of the bolts is not to be less than the value d_b, in mm, calculated from the following formula:

$$d_b = 153 \sqrt{\frac{T_R}{n(b + 0{,}5 d_{se})} \cdot \frac{235}{R_{eb}}}$$

where:

n : Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2)

b : Distance between bolts and stock axis, in mm (see Fig 3)

R_{eb} : Yield stress, in N/mm², of the bolt material

- the thickness of each of the tightening flanges of the two parts of the tiller is not to be less than the following value:

$$1,85 \cdot d_b \cdot \sqrt{\frac{n \cdot (b - 0,5 \cdot D_e)}{H_0} \cdot \frac{R_{eb}}{R'_e}}$$

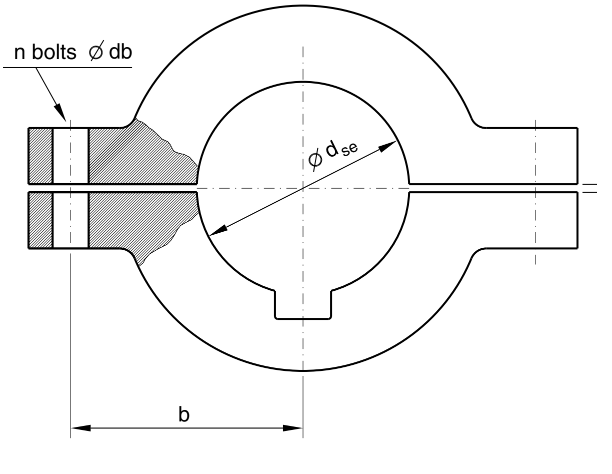
where:

D_e : External boss diameter, in mm (average value)

- in order to ensure the efficient tightening of the coupling around the stock, the two parts of the tiller are to bored together with a shim having a thickness not less than the value j, in mm, calculated from the following formula:

j = 0,0015 d_S

Figure 3 : Bolted tillers



e) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:
   - the safety factor against slippage is not to be less than:
     - for keyed connections: 1
     - for keyless connections: 2
   - the friction coefficient is to be taken equal to:
     - in the case of hydraulic fitting: 0,15 for steel and 0,13 for spheroidal graphite cast iron
     - in the case of dry shrink fitting: 0,17
   - the combined stress according to the von Mises criterion, due to the maximum pressure induced by the shrink fitting and calculated in way of the most stressed points of the shrunk parts, is not to exceed 80% of the yield stress of the material considered

Note 1: Alternative stress values based on FEM calculations may also be considered by the Society.

   - the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

2.5.5 Piston rods

The scantling of the piston rod is to be determined taking into account the bending moments, if any, in addition to compressive or traction forces and is to satisfy the following provisions:

a) $\sigma_C \leq \sigma_a$

where:

σ_C : Combined stress as per [1.4.1]

σ_a : Permissible stress as per [2.5.3]

b) In respect of the buckling strength:

$$\frac{4}{\pi D_2{}^2} \cdot \left(\omega F_c + \frac{8M}{D_2}\right) \leq 0,9\sigma_a$$

where:

D_2 : Piston rod diameter, in mm

F_C : Compression force in the rod, in N, when it extends to its maximum stroke

M : Possible bending moment in the piston rod, in N.mm, in way of the fore end of the cylinder rod bearing

$\omega = \beta + (\beta^2 - \alpha)^{0,5}$

with:

$$\alpha = 0,0072\left(\frac{\ell_S}{D_2}\right)^2 \frac{R_e'}{235}$$

$\beta = 0,48 + 0,5\ \alpha + 0,1\ \alpha^{0,5}$

ℓ_S : Length, in mm, of the maximum unsupported reach of the cylinder rod.

2.6 Hydraulic system

2.6.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure shall be at least 1,25 times the maximum working pressure to be expected under the operational conditions considered, taking into account any pressure which may exist in the low pressure side of the system.

b) The power piping for hydraulic steering gear is to be arranged so that transfer between units can be readily effected.

c) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

d) The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirements of Ch 1, Sec 10, [14], unless otherwise stated.

2.6.2 Materials

a) Ram cylinders, pressure housings of rotary vane type actuators, hydraulic power piping, valves, flanges and fittings are to be of steel or other approved ductile material.

b) In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

   Grey cast iron may be accepted for valve bodies and redundant parts with low stress level, excluding cylinders, subject to special consideration.

2.6.3 Isolating valves

Shut-off valves, non-return valves or other appropriate devices are to be provided to:

- comply with the availability requirements of [2.4]
- keep the rudder steady in position in case of emergency.

In particular, for all vessels with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly fitted on the actuator.

2.6.4 Flexible hoses

a) Flexible hoses may be installed between two points where flexibility is required but are not to be subjected to torsional deflection (twisting) under normal operation. In general, the hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery.

b) Hoses are to be high pressure hydraulic hoses according to recognised standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

c) They are to be of a type approved by the Society.

d) The burst pressure of hoses is to be not less than four times the design pressure.

2.6.5 Relief valves

a) Relief valves shall be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves shall not exceed the design pressure. The valves shall be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

b) The setting pressure of the relief valves is not to be less than 1,25 times the maximum working pressure.

c) The minimum discharge capacity of the relief valve(s) is not to be less than the total capacity of the pumps which can deliver through it (them), increased by 10%. Under such conditions, the rise in pressure is not to exceed 10% of the setting pressure. In this respect, due consideration is to be given to the foreseen extreme ambient conditions in relation to oil viscosity.

2.6.6 Hydraulic oil reservoirs

Hydraulic power-operated steering gear shall be provided with a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms shall be given on the wheelhouse and in the machinery space where they can be readily observed.

2.6.7 Hydraulic pumps

a) Hydraulic pumps are to be type tested in accordance with the provisions of [6.1.1].

b) Special care is to be given to the alignment of the pump and the driving motor.

2.6.8 Filters

a) Hydraulic power-operated steering gear shall be provided with arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system.

b) Filters of appropriate mesh fineness are to be provided in the piping system, in particular to ensure the protection of the pumps

2.7 Electrical systems

2.7.1 General

For electrical systems of the main steering gear and the auxiliary steering gear, see Ch 2, Sec 10, [1] and Ch 2, Sec 10, [2].

2.8 Alarms and indications

2.8.1 For alarms and indications, see Ch 3, Sec 2.

3 Design and construction - Requirements for vessels equipped with several rudders

3.1 Principle

3.1.1 General

In addition to the provisions of Article [2], vessels equipped with two or more aft rudders are to comply with the provisions of the present Article.

3.1.2 Availability

Where the vessel is fitted with two or more rudders, each having its own actuation system, the latter need not be duplicated.

3.1.3 Equivalent rudder stock diameter

Where the rudders are served by a common actuating system, the diameter of the rudder stock referred to in [2.2.1] is to be replaced by the equivalent diameter d obtained from the following formula:

$$d = \sqrt[3]{\sum_j d_j^3}$$

with:

d_j : Rule diameter of the upper part of the rudder stock of each rudder in way of the tiller, excluding strengthening for navigation in ice.

3.2 Synchronisation

3.2.1 General

A system for synchronising the movement of the rudders is to be fitted by, either:

- a mechanical coupling, or
- other systems giving automatic synchronising adjustment.

3.2.2 Non-mechanical synchronisation

Where the synchronisation of the rudder motion is not achieved by a mechanical coupling, the following provisions are to be met:

a) the angular position of each rudder is to be indicated in the wheelhouse

b) the rudder angle indicators are to be independent from each other and, in particular, from the synchronising system

c) in case of failure of the synchronising system, means are to be provided for disconnecting this system so that steering capability can be maintained or rapidly regained.

4 Design and construction - Requirements for vessels equipped with alternative propulsion and steering systems without rudder

4.1 Principle

4.1.1 General

For vessels with alternative propulsion and steering systems such as:

- azimuth thrusters
- water-jets
- cycloidal propellers,

the provisions of this Article are to be applied in addition to those of Ch 1, Sec 12.

4.1.2 Actuation system

Thrusters used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

4.1.3 Control system

Where the steering means of the vessel consists of two or more thrusters, their control system is to include a device ensuring an automatic synchronisation of the thruster rotation, unless each thruster is so designed as to withstand any additional forces resulting from the thrust exerted by the other thrusters.

4.2 Use of azimuth thrusters

4.2.1 Azimuth thrusters used as sole steering means

Where the vessel is fitted with one azimuth thruster used as the sole steering means, this thruster is to comply with [2.2.1], except that:

a) the main actuation system is required to be capable of a rotational speed of at least 0,4 RPM and to be operated by power where the expected steering torque exceeds 1,5 kN·m

b) the auxiliary actuation system is required to be capable of a rotational speed of at least 0,1 RPM and to be operated by power where the expected steering torque exceeds 3 kN·m.

4.2.2 Azimuth thrusters used as auxiliary steering gear

Where the auxiliary steering gear referred to in [2.2.2] consists of one or more azimuth thrusters, at least one such thruster is to be capable of:

- steering the vessel at maximum ahead service speed
- being brought speedily into action in case of emergency
- having a rotational speed of at least 0,4 RPM.

The auxiliary actuation system referred to in [4.1.2] need not be fitted.

4.2.3 Omission of the auxiliary actuation system

Where the steering means of the vessel consists of two independent azimuth thrusters or more, the auxiliary actuation system referred to in [4.1.2] need not be fitted provided that:

- the thrusters are so designed that the vessel can be steered with any one out of operation
- the actuation system of each thruster complies with [4.2.1], item b).

4.3 Use of water-jets

4.3.1 The use of water-jets as steering means will be given special consideration by the Society.

5 Arrangement and installation

5.1 General

5.1.1 The steering gear are to be so installed that they are accessible at all times and can be maintained without difficulty.

5.2 Rudder actuator installation

5.2.1

a) Rudder actuators are to be installed on foundations of strong construction so designed as to allow the transmission to the vessel structure of the forces resulting from the torque applied by the rudder and/or by the actuator, considering the strength criteria defined in [2.5.3] and [5.3.1]. The structure of the vessel in way of the foundations is to be suitably strengthened.

b) Where the rudder actuators are bolted to the hull, the grade of the bolts used is not to be less than 8.8. Unless the bolts are adjusted and fitted with a controlled tightening, strong shocks are to be fitted in order to prevent any lateral displacement of the rudder actuator.

5.3 Locking equipment

5.3.1 Steering gear systems are to be equipped with a locking system effective in all rudder positions.

For hydraulic plants shutoff valves directly at the cylinder are accepted instead.

5.4 Rudder angle indication

5.4.1 The rudder position must be clearly indicated in the wheelhouse and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle must be signalled by a device (rudder position indicator) which is actuated either by the rudder stock itself or by parts which are rigidly connected to it.

5.4.2 The rudder position at any moment must also be indicated at the steering gear itself.

5.5 Piping

5.5.1 The pipes of hydraulic steering gear systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

Pipes are to be installed at a sufficient distance from the vessel's shell. As far as possible, pipes should not pass through cargo spaces.

Pipes are to be so installed that they are free from stress and vibration.

5.5.2 The pipes of main and auxiliary steering gear systems are normally to be laid independently of each other. With the Society's consent, the joint use of pipes for the main and auxiliary steering gear systems may be permitted.

In such cases the design pressure for pipes and joints shall be 1,3 times the maximum permissible working pressure.

5.5.3 No other power consumers may be connected to the hydraulic steering gear drive unit. Where there are two independent drive units such a connection to one of the two systems is however acceptable if the consumers are connected to the return line and may be disconnected from the drive unit by means of an isolating device.

5.6 Overload protections

5.6.1 Mechanical rudder stops

a) The steering gear is to be provided with strong rudder stops capable of mechanically stopping the rotation of the rudder at an angle slightly greater than its maximum working angle. Alternatively, these stops may be fitted on the vessel to act on another point of the mechanical transmission system between the rudder actuator and the rudder blade. These stops may be built in with the actuator design.

b) The scantlings of the rudder stops and of the components transmitting to the vessel's structure the forces applied on these stops are to be determined for the greater value of the torques T_R or T_G.

   Where $T_G \geq 1,5T_R$, the rudder stops are to be fitted between the rudder actuator and the rudder stock, unless the rudder stock as well as all the components transmitting mechanical forces between the rudder actuator and the rudder blade are suitably strengthened.

5.6.2 Rudder angle limiters

a) Power-operated steering gear is to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronised with the gear itself and not with the steering gear control.

b) For power-operated steering gears and where the rudder may be oriented to more than 35° at very reduced speed, it is recommended to fit a limit system 35° for full speed. A notice is to be displayed at all steering wheel stations indicating that rudder angles of more than 35° are to be used only at very reduced speed.

5.6.3 Relief valves

Relief valves are to be fitted in accordance with [2.6.5].

5.6.4 Buffers

Buffers are to be provided on all vessels fitted with mechanical steering gear. They may be omitted on hydraulic gear equipped with relief valves or with calibrated bypasses.

6 Certification, inspection and testing

6.1 Testing of power units

6.1.1 The power units are required to undergo test on a test stand. The relevant works test certificates are to be presented at the time of the final inspection of the steering gear.

For electric motors, see Ch 2, Sec 4.

Hydraulic pumps are to be subjected to pressure and operational tests. Where the drive power of the hydraulic pump is 50 kW or more, these tests are to be carried out in presence of a Society Surveyor.

6.2 Testing of materials

6.2.1 Components subject to pressure or transmitting mechanical forces

a) Materials of components subject to pressure or transmitting mechanical forces, specifically:
   - cylindrical shells of hydraulic cylinders, rams and piston rods
   - tillers, quadrants
   - rotors and rotor housings for rotary vane steering gear
   - hydraulic pump casings
   - and hydraulic accumulators, if any,

   are to be duly tested, including examination for internal defects, in accordance with the requirements of NR216 Materials and Welding.

b) A works' certificate may be accepted for low stressed parts, provided that all characteristics for which verification is required are guaranteed by such certificate.

6.2.2 Hydraulic piping, valves and accessories

Tests for materials of hydraulic piping, valves and accessories are to comply with the provisions of Ch 1, Sec 10, [20.3].

6.3 Inspection and tests during manufacturing

6.3.1 Components subject to pressure or transmitting mechanical forces

a) The mechanical components referred to in [6.2.1] are to be subjected to appropriate non-destructive tests. For hydraulic cylinder shells, pump casings and accumulators, refer to Ch 1, Sec 3, [7].

b) Defects may be repaired by welding only on forged parts or steel castings of weldable quality. Such repairs are to be conducted under the supervision of the Surveyor in accordance with the applicable requirements of NR216 Materials and Welding.

6.3.2 Hydraulic piping, valves and accessories

Hydraulic piping, valves and accessories are to be inspected and tested during manufacturing in accordance with Ch 1, Sec 10, [20].

6.4 Inspection and tests after completion

6.4.1 Hydrostatic tests

a) Hydraulic cylinder shells and accumulators are to be subjected to hydrostatic tests according to the relevant provisions of Ch 1, Sec 3, [7].

b) Hydraulic piping, valves and accessories and hydraulic pumps are to be subjected to hydrostatic tests according to the relevant provisions of Ch 1, Sec 10, [20.4].

6.4.2 Onboard tests

After installation on board the vessel, the steering gear is to be subjected to the tests detailed in Ch 1, Sec 15, [3.7].

6.4.3 River trials

For the requirements of river trials, refer to Ch 1, Sec 15.

SECTION 12 THRUSTERS

1 General

1.1 Application

1.1.1 Thrusters developing power equal to 110 kW or more

The requirements of this Section apply to the following types of thrusters developing power equal to 110 kW or more:

- transverse thrusters intended for manoeuvring
- thrusters intended for propulsion and steering.

Thrusters intended for propulsion and steering of vessels with ice strengthening are to comply with the additional requirements of Pt D, Ch 2, Sec 1, [4.3].

Transverse thrusters intended for manoeuvring of vessels with an ice class notation are required to comply with the additional requirement Pt D, Ch 2, Sec 1, [5.3.1] only.

1.1.2 Thrusters developing power less than 110 kW

Thrusters of less than 110 kW are to be built in accordance with sound marine practice and tested as required in [3.2] to the satisfaction of the Surveyor.

1.2 Definitions

1.2.1 Thruster

A thruster is a propeller installed in a revolving nozzle or in a special transverse tunnel in the vessel, or a water-jet. A thruster may be intended for propulsion, manoeuvring and steering or any combination thereof. Propulsion propellers in fixed nozzles are not considered thrusters (see Ch 1, Sec 8, [1.1.1]).

1.2.2 Transverse thruster

A transverse thruster is an athwartship thruster developing a thrust in a transverse direction for manoeuvring purposes.

1.2.3 Azimuth thruster

An azimuth thruster is a thruster which has the capability to rotate through 360° in order to develop thrust in any direction.

1.2.4 Water-jet

A water-jet is equipment constituted by a tubular casing (or duct) enclosing an impeller. The shape of the casing is such as to enable the impeller to produce a water-jet of such intensity as to give a positive thrust. Water-jets may have means for deviating the jet of water in order to provide a steering function.

Table 1 : Plans to be submitted for athwartship thrusters and azimuth thrusters

No.	A/I **(1)**	ITEM
General requirements for all thrusters		
1	I	General arrangement of the thruster
2	A	Propeller, including the applicable details mentioned in Ch 1, Sec 8
3	A	Bearing details
4	A	Propeller and intermediate shafts
5	A	Gears, including the applicable details mentioned in Ch 1, Sec 6
Specific requirements for transverse thrusters		
6	A	Structure of the tunnel showing the materials and their thickness
7	A	Structural equipment or other connecting devices which transmit the thrust from the propeller to the tunnel
8	A	Sealing devices (propeller shaft gland and thruster-tunnel connection)
9	A	For the adjustable pitch propellers: pitch control device and corresponding monitoring system
Specific requirements for rotating and azimuth thrusters		
10	A	Structural items (nozzle, bracing, etc.)
11	A	Structural connection to hull
12	A	Rotating mechanism of the thruster
13	A	Thruster control system
14	A	Piping systems connected to thruster
(1) A = to be submitted for review I = to be submitted for information.		

Table 2 : Plans to be submitted for water-jets

No	A/I **(1)**	ITEM
1	I	General arrangement of the water-jet
2	A	Casing (duct) (location and shape) showing the materials, the thicknesses and the forces acting on the hull
3	A	Details of the shafts, flanges, keys
4	I	Sealing gland
5	A	Bearings
6	A	Impeller
7	A	Steering and reversing buckets and their control devices as well as the corresponding hydraulic diagrams

(1) A = to be submitted for review
I = to be submitted for information.

Table 3 : Data and documents to be submitted for athwartship thrusters, azimuth thrusters and water-jets

No	A/I **(1)**	ITEM
1	I	Rated power and revolutions
2	I	Rated thrust
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties
4	A	Where parts of thrusters are of welded construction, all particulars on the design of welded joints, welding procedures, heat treatments and non-destructive examinations after welding
5	I	Where applicable, background information on previous operating experience in similar applications

(1) A = to be submitted for review
I = to be submitted for information.

1.3 Thrusters intended for propulsion

1.3.1 In general, at least two azimuth thrusters are to be fitted in vessels where these are the sole means of propulsion. Single azimuth thruster installations will be specially considered by the Society on a case by case basis.

This requirement also applies to water-jets.

1.4 Documentation to be submitted

1.4.1 Plans to be submitted for athwartship thrusters and azimuth thrusters

For thrusters developing power equal to 110 kW or more, the plans listed in Tab 1 are to be submitted.

1.4.2 Plans to be submitted for water-jets

The plans listed in Tab 2 are to be submitted.

1.4.3 Additional data to be submitted

The data and documents listed in Tab 3 are to be submitted by the manufacturer together with the plans.

2 Design and Construction

2.1 Materials

2.1.1 Propellers

For requirements relative to material intended for propellers, see Ch 1, Sec 8, [2.1.1].

2.1.2 Other thruster components

For the requirements relative to materials intended for other parts of the thrusters, such as gears, shaft, couplings, etc., refer to the applicable parts of the Rules.

2.2 Transverse thrusters and azimuth thrusters

2.2.1 Prime movers

a) Diesel engines intended for driving thrusters are to comply with the applicable requirements of Ch 1, Sec 2.

b) Electric motors intended for driving thrusters and their feeding systems are to comply with the requirements of Ch 2, Sec 4. In particular:

- provisions are to be made to prevent starting of the motors whenever there are insufficient generators in operation
- intermittent duty thrusters will be the subject of special consideration by the Society.

2.2.2 Propellers

a) For propellers of thrusters intended for propulsion, the requirements of Ch 1, Sec 8, [2.5] apply.

b) For propellers of thrusters intended for manoeuvring only, the requirements of Ch 1, Sec 8, [2.5] also apply, although the increase in thickness of 10% does not need to be applied.

2.2.3 Shafts

a) For propeller shafts of thrusters intended for propulsion, the requirements of Ch 1, Sec 7, [2.2.3] apply.

b) For propellers of thrusters intended for manoeuvring only, the minimum diameter d_S of the shaft, in mm, is not to be less than the value obtained by the following formula:

$$d_S = [(C \cdot M_T)^2 + (D \cdot M)^2]^{1/6} \cdot \left(\frac{1}{1 - Q^4}\right)^{1/3}$$

where:

M_T : Maximum transmitted torque, in N·m; where not indicated, M_T may be assumed equal to: $M_T = 9550\ (P/N)$

where:

P : Maximum power of the thruster prime mover, in kW

N : Rotational speed of the propeller, in rev/min

M : Bending moment, in N·m, at the shaft section under consideration

C : Coefficient equal to:

$$C = 10{,}2 + \frac{28000}{R_{S,MIN}}$$

D : Coefficient equal to:

$$D = \frac{170000}{412 + R_{S,MIN}}$$

$R_{S,\ MIN}$: Minimum yield strength of the shaft material, in N/mm²

Q : Coefficient equal to:

- for solid shafts: Q = 0
- for hollow shafts: Q = the ratio between the diameter of the hole and the external diameter of the shaft. If Q ≤ 0,3, Q may be assumed equal to 0.

The above diameter d_S is to be increased by 10% in the case of keyed connection to the propeller in way of key.

2.2.4 Gears

a) Gears of thrusters intended for propulsion are to be in accordance with the applicable requirements of Ch 1, Sec 6, applying the safety factors for propulsion gears.

b) Gears of thrusters intended for manoeuvring only are to be in accordance with the applicable requirements of Ch 1, Sec 6, applying the safety factors for auxiliary gears.

2.2.5 Nozzles and connections to hull for azimuth thrusters

a) For the requirements relative to the nozzle structure, see Pt B, Ch 7, Sec 1, [8].

b) The scantlings of the nozzle connection to the hull and the welding type and size will be specially considered by the Society, which reserves the right to require detailed stress analysis in the case of certain high power installations.

c) For steerable thrusters, the equivalent rudder stock diameter is to be calculated in accordance with the requirements of Pt B, Ch 7, Sec 1.

2.2.6 Transverse thruster tunnel

a) The thickness of the tunnel is not to be less than the adjacent part of the hull.

b) Special consideration will be given by the Society to tunnels connected to the hull by connecting devices other than welding.

2.2.7 Electrical supply for steerable thrusters

The generating and distribution system is to be designed in such a way that the steering capability of the thruster can be maintained or regained within a period of 45 seconds, in the event of single failure of the system, and that the effectiveness of the steering capability is not reduced by more than 50% under such conditions. Details of the means provided for this purpose are to be submitted to the Society.

2.3 Water-jets

2.3.1 Shafts

The diameter of the shaft supporting the impeller is not to be less than the diameter d_2, in mm, obtained by the following formula:

$$d_2 = 100 f h \cdot \left(\frac{P}{N}\right)^{1/3} \cdot \left(\frac{1}{1 - Q^4}\right)^{1/3}$$

where:

P : Power, in kW

N: : Rotational speed, in rpm

f : Calculated as follows:

$$f = \left(\frac{560}{R_m + 160}\right)^{1/3}$$

where R_m is the ultimate tensile strength of the shaft material, in N/mm²

h: :
- h = 1,00 when the shaft is only transmitting torque loads, and when the weight and thrust of the propeller are totally supported by devices located in the fixed part of the thruster
- h = 1,22 where the impeller is fitted with key or shrink-fitted.

Q : As defined in [2.2.3].

The shafts are to be protected against corrosion by means of either a continuous liner or an oil-gland of an approved type, or by the nature of the material of the shaft.

2.3.2 Guide vanes, shaft support

a) Guide vanes and shaft supports, if any, are to be fitted in accordance with direction of flow. Trailing and leading edges are to be fitted with rounded profiles.

b) Fillet radius are generally not be less than the maximum local thickness of concerned element.Fatigue strength calculation is to be submitted.

2.3.3 Stator and impellers

a) Design is to take into account the loads developed in free going conditions and also in peculiar manoeuvres like crash stop.

b) Tip clearance is to take into account vibratory behaviours, displacements and any other expansion mode in all operating conditions of the water jet.

c) Fillet radii are generally not to be less than the maximum local thickness of concerned element.

d) There is to be no natural frequency of stator blades or rotor blades in the vicinity of the excitation frequencies due to hydrodynamic interaction between stator blades and rotor blades. Calculations are to be submitted for maximum speed and any currently used speed.

2.3.4 Nozzle and reversing devices

Design of nozzle and reversing devices are to take into account the loads developed in all operating conditions of the water jet, including transient loads.

2.3.5 Steering performance

Steering performance and emergency steering availability are to be at least equivalent to the requirements in Ch 1, Sec 11, [4.2] and Ch 1, Sec 11, [4.3].

2.4 Alarm, monitoring and control systems

2.4.1 Steering thruster controls

a) Controls for steering are to be provided from the wheelhouse, the machinery control station and locally.

b) Means are to be provided to stop any running thruster at each of the control stations.

c) A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

2.4.2 Alarm and monitoring equipment

For alarm and monitoring, see Ch 3, Sec 2.

3 Testing and certification

3.1 Material tests

3.1.1 Propulsion and steering thrusters

All materials intended for parts transmitting torque and for propeller/impeller blades are to be tested in accordance with the requirements of Ch 1, Sec 8, [4.1] in the presence of a Surveyor.

3.1.2 Transverse thrusters

Material testing for parts of athwartship thrusters does not need to be witnessed by a Surveyor, provided full test reports are made available to him.

3.2 Testing and inspection

3.2.1 Thrusters

Thrusters are to be inspected as per the applicable requirements in Ch 1, Sec 8, [4.2].

3.2.2 Prime movers

Prime movers are to be tested in accordance with the requirements applicable to the type of mover used.

3.3 Certification

3.3.1 Certification of thrusters

Thrusters are to be individually tested and certified by the Society.

3.3.2 Mass produced thrusters

Mass produced thrusters may be accepted within the framework of the type approval program of the Society.

SECTION 13 LIQUEFIED GAS INSTALLATIONS FOR DOMESTIC PURPOSES

1 General

1.1 Application

1.1.1 The requirements of this Section apply to permanently installed domestic liquefied gas installations on vessels.

1.1.2 Exceptions to these Rules are possible where they are permitted by the statutory Regulations in force in the area of service.

1.2 General provisions

1.2.1 On vessels intended to carry dangerous goods, liquefied gas installations are to comply also with the requirements dealing with fire and naked light developed in the different sections of Part D, Chapter 3.

1.2.2 Liquefied gas installations consist essentially of a supply unit comprising one or more gas receptacles, and of one or more reducing valves, a distribution system and a number of gas-consuming appliances.

1.2.3 Such installations may be operated only with commercial propane.

1.3 Documents for review

1.3.1 Diagrammatic drawings including the following information are to be submitted for review by the Society:

- service pressure
- size and nature of materials for piping
- capacity and other technical characteristics for accessories
- generally, all information allowing the verification of the requirements of the present Section.

2 Gas installations

2.1 General

2.1.1 Liquefied gas installations shall be suitable throughout for use with propane and shall be built and installed in accordance with best practice.

2.1.2 A liquefied gas installation may be used only for domestic purposes in the accommodation and the wheelhouse, and for corresponding purposes on passenger vessels.

2.1.3 There may be a number of separate installations on board. A single installation may not be used to serve accommodation areas separated by a hold or a fixed tank.

2.1.4 No part of a liquefied gas installation shall be located in the engine room.

2.2 Gas receptacles

2.2.1 Only receptacles with an approved content of between 5 and 35 kg are permitted.

In principle, in the case of passenger vessels, the use of receptacles with a larger content may be approved.

2.2.2 The gas receptacles must be permanently marked with the test pressure.

2.3 Supply unit

2.3.1 Supply units shall be installed on deck in a freestanding or wall cupboard located outside the accommodation area in a position such that it does not interfere with movement on board. They shall not, however, be installed against the fore or aft bulwark plating. The cupboard may be a wall cupboard set into the superstructure provided that it is gastight and can only be opened from outside the superstructure. It shall be so located that the distribution pipes leading to the gas consumption points are as short as possible.

2.3.2 No more receptacles may be in operation simultaneously than are necessary for the functioning of the installation. Several receptacles may be in operation only if an automatic reversing coupler is used. Up to four receptacles may be in operation per supply unit. The number of receptacles on board, including spare receptacles, shall not exceed six per installation.

2.3.3 Up to six receptacles may be in operation on passenger vessels with galleys or canteens for passengers. The number of receptacles on board, including spare receptacles, shall not exceed nine per installation.

2.3.4 Pressure regulators, or in the case of two-stage reduction the first pressure regulator, shall be fitted to a wall in the same cupboard as the receptacles.

2.3.5 Supply units shall be so installed that any leaking gas can escape from the cupboard into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition.

2.3.6 Cupboards shall be constructed of fire-resistant materials and shall be adequately ventilated by apertures in the top and bottom. Receptacles shall be placed upright in the cupboards in such a way that they cannot be overturned.

2.3.7 Cupboards shall be so built and placed that the temperature of the receptacles cannot exceed 50°C.

2.4 Pressure regulators

2.4.1 Gas-consuming appliances may be connected to receptacles only through a distribution system fitted with one or more pressure regulators to bring the gas pressure down to the utilisation pressure. The pressure may be reduced in one or two stages. All pressure regulators shall be set permanently at a pressure determined in accordance with [2.5].

2.4.2 The final pressure regulators shall be either fitted with or immediately followed by a device to protect the pipe automatically against excess pressure in the event of a malfunctioning of the pressure regulator. It shall be ensured that in the event of a leak in the protection device any leaking gas can escape into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition; if necessary, a special pipe shall be fitted for this purpose.

2.4.3 The protection devices and vents shall be protected against the entry of water.

2.5 Pressure

2.5.1 Where two-stage regulating systems are used, the mean pressure shall be not more than 2,5 bar above atmospheric pressure.

2.5.2 The pressure at the outlet from the last pressure regulator shall be not more than 0,05 bar above atmospheric pressure, with a tolerance of 10%.

2.6 Piping and flexible tubes

2.6.1 Pipes shall consist of fixed steel or copper tubing, in compliance with requirements of Ch 1, Sec 10.

However, pipes connecting with the receptacles shall be high-pressure flexible tubes or spiral tubes suitable for propane. Gas-consuming appliances may, if not permanently installed, be connected by means of suitable flexible tubes not more than 1 m long.

2.6.2 Pipes shall be able to withstand any stresses or corrosive action which may occur under normal operating conditions on board and their characteristics and layout shall be such that they ensure a satisfactory flow of gas at the appropriate pressure to the gas-consuming appliances.

2.6.3 Pipes shall have as few joints as possible. Both pipes and joints shall be gastight and shall remain gastight despite any vibration or expansion to which they may be subjected.

2.6.4 Pipes shall be readily accessible, properly fixed and protected at every point where they might be subject to impact or friction, particularly where they pass through steel bulkheads or metal walls. The entire outer surface of steel pipes shall be treated against corrosion.

2.6.5 Flexible pipes and their joints shall be able to withstand any stresses which may occur under normal operating conditions on board. They shall be installed in such a way that they are free of tension, cannot be heated excessively and can be inspected over their entire length.

2.7 Distribution system

2.7.1 It shall be possible to shut off the entire distribution system by means of a main valve which is at all times easily and rapidly accessible.

2.7.2 Each gas-consuming appliance shall be supplied by a separate branch of the distribution system, and each branch shall be controlled by a separate closing device.

2.7.3 Valves shall be fitted at points where they are protected from the weather and from impact.

2.7.4 An inspection joint shall be fitted after each pressure regulator. It shall be ensured using a closing device that in pressure tests the pressure regulator is not exposed to the test pressure.

2.8 Gas-consuming appliances

2.8.1 The only appliances that may be installed are propane-consuming appliances equipped with devices that effectively prevent the escape of gas in the event of either the flame or the pilot light being extinguished.

2.8.2 Appliances shall be so placed and connected that they cannot overturn or be accidentally moved and any risk of accidental wrenching of the connecting pipes is avoided.

2.8.3 Heating and water-heating appliances and refrigerators shall be connected to a flue for evacuating combustion gases into the open air.

2.8.4 The installation of gas-consuming appliances in the wheelhouse is permitted only if the wheelhouse is so constructed that no leaking gas can escape into the lower parts of the vessel, in particular through the penetrations for control lines to the engine room.

2.8.5 Gas-consuming appliances may be installed in sleeping quarters only if combustion takes place independently of the air in the quarters.

2.8.6 Gas-consuming appliances in which combustion depends on the air in the rooms in which they are located shall be installed in rooms which are sufficiently large.

3 Ventilation system

3.1 General

3.1.1 In rooms containing gas-consuming appliances in which combustion depends on the ambient air, fresh air shall be supplied and combustion gases evacuated by means of ventilation apertures of adequate dimensions, with a clear section of at least 150 cm^2 per aperture.

3.1.2 Ventilation apertures shall not have any closing device and shall not lead to sleeping quarters.

3.1.3 Evacuation devices shall be so designed as to ensure the safe evacuation of combustion gases. They shall be reliable in operation and made of non-combustible materials. Their operation shall not be affected by forced ventilation.

4 Tests and trials

4.1 Definition

4.1.1 A piping shall be considered gastight if, after sufficient time has elapsed for thermal balancing, no drop in the test pressure is noted during the following 10 minutes.

4.2 Testing conditions

4.2.1 The completed installation shall be subjected to tests defined in [4.2.2] to [4.2.8].

4.2.2 Medium-pressure pipes between the closing device, referred to in [2.7.4], of the first pressure regulator and the valves fitted before the final pressure regulator:

a) pressure test, carried out with air, an inert gas or a liquid at a pressure 20 bar above atmospheric pressure

b) gastightness test, carried out with air or an inert gas at a pressure 3,5 bar above atmospheric pressure.

4.2.3 Pipes at the service pressure between the closing device, referred to in [2.7.4], of the only pressure regulator or the final pressure regulator and the valves fitted before the gas-consuming appliances:

- tightness test, carried out with air or an inert gas at a pressure of 1 bar above atmospheric pressure.

4.2.4 Pipes situated between the closing device, referred to in [2.7.4], of the only pressure regulator or the final pressure regulator and the controls of the gas-consuming appliance:

- leak test at a pressure of 0,15 bar above atmospheric pressure.

4.2.5 In the tests referred to in [4.2.2] item b), [4.2.3] and [4.2.4], the pipes are deemed gastight if, after sufficient time to allow for equalisation with ambient temperature, no decrease in the test pressure is observed during a further 10 minute test period.

4.2.6 Receptacle connectors, piping and other fittings subjected to the pressure in the receptacles, and joints between pressure regulators and the distribution pipe:

- tightness test, carried out with a foaming substance, at the operating pressure.

4.2.7 All gas-consuming appliances shall be brought into service at the nominal capacity and shall be tested for satisfactory and undisturbed combustion at different capacity settings.

Flame failure devices shall be checked to ensure that they operate satisfactorily.

4.2.8 After the test referred to in [4.2.7], it shall be verified, in respect of each gas-consuming appliance connected to a flue, whether, after five minutes' operation at the nominal capacity, with windows and doors closed and the ventilation devices in operation, any combustion gases are escaping into the room through the air intake.

If there is a more than momentary escape of such gases, the cause shall immediately be detected and remedied. The appliance shall not be approved for use until all defects have been eliminated.

SECTION 14 TURBOCHARGERS

1 General

1.1 Application

1.1.1 These requirements are applicable for turbochargers with regard to design approval, type testing and certification and their matching on engines.

Turbochargers are to be type approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

1.1.2 The requirements escalate with the size of the turbochargers. The parameter for size is the engine power (at MCR) supplied by a group of cylinders served by the actual turbocharger, (e.g. for a V-engine with one turbocharger for each bank the size is half of the total engine power).

1.1.3 Turbochargers are categorised in two groups depending on served power by cylinder groups with:

- Category A: ≤ 1000 kW
- Category B: > 1000 kW

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to the Society the documents as such:

- On request for approval as described in Tab 1 for category A turbochargers
- For approval or information as described in Tab 2 for category B turbochargers

Table 1 : Documentation to be submitted for approval on request for Category A turbochargers

No.	Document
1	Containment test report
2	Cross sectional drawing with principal dimensions and names of components
3	Test program

Table 2 : Documentation to be submitted for Category B turbochargers

No	I/A **(1)**	Document
1	I	Cross sectional drawing with principal dimensions and materials of housing components for containment evaluation
2	A	Documentation of containment in the event of disc fracture
3	I	Operational data and limitation as: **(2)** • Maximum permissible operating speed (rpm) • Alarm level for over-speed • Maximum permissible exhaust gas temperature before turbine • Alarm level for exhaust gas temperature before turbine • Minimum lubrication oil inlet pressure • Lubrication oil inlet pressure low alarm set point • Maximum lubrication oil outlet temperature • Lubrication oil outlet temperature high alarm set point • Maximum permissible vibration levels, i.e. self- and externally generated vibration
4	A	Arrangement of lubrication system, all variants within a range.
5	I	Type test reports.
6	A	Test program

(1) A = to be submitted for review
I = to be submitted for information
(2) Alarm levels may be equal to permissible limits but shall not be reached when operating the engine at 110% power or at any approved intermittent overload beyond the 110%.

2 Design and construction

2.1 Materials

2.1.1 The requirements of [2.1.2] are to be complied with, as far as applicable, at the Society's discretion.

2.1.2 Approved materials

a) Turbocharger materials are to fulfil the requirements imposed by the operating conditions of the individual components. In the choice of materials, account is to be taken of effects such as creep, thermal fatigue, oxidation and corrosion to which individual components are subject when in service. Evidence of the suitability of the materials is to be supplied to the Society in the form of details of their chemical and mechanical properties and of the heat treatment applied. Where composite materials are used, their method of manufacture is to be described.

b) Turbine blades are to be built of corrosion and heat-resistant materials.

2.2 Design

2.2.1 The requirements of NR467, Pt C, Ch 1, Sec 5, [2] are to be complied with, as far as applicable, at the Society's discretion.

2.3 Monitoring

2.3.1 General

The general requirements given in Ch 3, Sec 2 apply.

3 Type tests, workshop inspection and testing, certification

3.1 Type tests

3.1.1 Requirements mentioned from [3.1.2] to [3.1.7] are applicable to Category B turbochargers.

3.1.2 The type test for a generic range of turbochargers may be carried out either on an engine (for which the turbocharger is foreseen) or in a test rig.

3.1.3 Turbochargers are to be subjected to at least 500 load cycles at the limits of operation. This test may be waived if the turbocharger together with the engine is subjected to this kind of low cycle testing, see NR467, Pt C, Ch 1, Sec 2, [4.1.4].

3.1.4 The suitability of the turbocharger for such kind of operation is to be preliminarily stated by the manufacturer.

3.1.5 The rotor vibration characteristics shall be measured and recorded in order to identify possible sub-synchronous vibrations and resonances.

3.1.6 The type test shall be completed by a hot running test at maximum permissible speed combined with maximum permissible temperature for at least one hour. After this test, the turbocharger shall be opened for examination, with focus on possible rubbing and the bearing conditions.

3.1.7 The extent of the surveyor's presence during the various parts of the type tests is left to the discretion of the Society.

3.2 Workshop inspections and testing

3.2.1 Category B turbochargers shall go through following inspections and testings, and the works' certificate (W) (see NR216 Materials and Welding, Ch 1, Sec 1, [4.2.3]) shall be produced:

- Chemical composition of material for the rotating parts
- Mechanical properties of the material of a representative specimen for the rotating parts and the casing
- UT and crack detection of rotating parts
- Dimensional inspection of rotating parts
- Rotor balancing
- Hydraulic testing of cooling spaces to 4 bars or 1.5 times maximum working pressure, whichever is higher
- Overspeed test of all compressor wheels for a duration of 3 minutes at either 20% above alarm level speed at room temperature or 10% above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The overspeed test may be waived for forged wheels that are individually controlled by an approved non-destructive method.

3.3 Certification

3.3.1 The manufacturer shall adhere to a certification scheme according to NR320 to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

For category B turbochargers, certification scheme for HBV product shall be selected. Each turbocharger shall be delivered with a works' certificate.

SECTION 15 TESTS ON BOARD

1 General

1.1 Application

1.1.1 This Section covers onboard tests, both at the moorings and during river trials. Such tests are additional to the workshop tests required in the other Sections of this Chapter.

1.2 Purpose of onboard tests

1.2.1 Onboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the onboard tests intended to be carried out by the shipyard is to be submitted to the Society.

For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded.

2 General requirements for onboard tests

2.1 Trials at the moorings

2.1.1 Trials at the moorings are to demonstrate the:

a) satisfactory operation of the machinery

b) quick and easy response to operational commands

c) protection of the various installations, as regards:
   - the protection of mechanical parts
   - the safeguards for personnel

d) accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or partly, after such repairs or alterations have been carried out.

2.2 River trials

2.2.1 Scope of the tests

River trials are to be conducted after the trials at the moorings and are to include:

a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions

b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative

c) detection of dangerous vibrations by taking the necessary readings when required

d) checks either deemed necessary for vessel classification or requested by the interested parties and which are possible only in the course of navigation.

2.2.2 Exemptions

Exemption from some of the river trials may be considered by the Society in the case of vessels having a sister vessel for which the satisfactory behavior in service is demonstrated.

Such exemption is, in any event, to be agreed upon by the interested parties and is subject to the satisfactory results of trials at the moorings to verify the safe and efficient operation of the propulsion system.

3 Onboard tests for machinery

3.1 Conditions of river trials

3.1.1 Degree of loading of vessels and convoys

During navigation tests, vessels intended to carry goods shall be loaded to at least 70% of their tonnage and loading, distributed in such a way as to ensure an horizontal attitude as far as possible.

3.1.2 Power of the machinery

a) The power developed by the propulsion machinery in the course of the river trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines, it is not to exceed the maximum continuous power for which the engine type concerned has been reviewed/approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.3 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the river trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by the Society.

   As an alternative, for reciprocating internal combustion engines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

   Other methods of determining the power may be considered by the Society on a case by case basis.

3.2 Navigation and manoeuvring tests

3.2.1 General

Vessels shall display adequate navigability and manoeuvrability. Self-propelled vessels shall meet the requirements set out in [3.2.2] to [3.2.7].

3.2.2 Navigation tests

Navigability and manoeuvrability shall be checked by means of navigation tests. Compliance with the requirements of [3.2.4] to [3.2.7] shall, in particular, be examined.

The Society may dispense with all or part of the tests where compliance with the navigability and manoeuvrability requirements is proven in another manner.

3.2.3 Test area

The navigation tests referred to in [3.2.2] shall be carried out on areas of waterways that have been designated by the Society.

Those test areas shall be situated on a stretch of flowing or standing water that is if possible straight, at least 2 km long and sufficiently wide and is equipped with highly-distinctive marks for determining the position of the vessel.

It shall be possible for the Surveyor to plot the hydrological data such as depth of water, width of navigable channel and average speed of the current in the navigation area as a function of the various water levels.

3.2.4 Stopping capacity

Vessels and convoys shall be able to stop facing downstream in good time while remaining adequately manoeuvrable.

Where the vessels are not longer than 86 m and not wider than 22,90 m, the stopping capacity mentioned above may be replaced by turning capacity.

The stopping capacity shall be proven by means of stopping manoeuvres carried out within a test area as referred to in [3.2.3] and turning capacity by turning manoeuvres in accordance with [3.2.7].

3.2.5 Astern trials

Where the stopping manoeuvre required in [3.2.4] is carried out in standing water, it shall be followed by a navigation test while going astern.

The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.

3.2.6 Capacity of taking evasive action

Vessels and convoys shall be able to take evasive action in good time. That capacity shall be proven by means of evasive manoeuvres carried out within a test area as referred to in [3.2.3].

3.2.7 Turning capacity

Vessels and convoys not exceeding 86 m in length or 22,90 m in breadth shall be able to turn in good time.

That turning capacity may be replaced by the stopping capacity referred to in [3.2.4].

The turning capacity shall be proven by means of turning manoeuvres against the current.

3.3 Tests of diesel engines

3.3.1 General

a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, trawling, etc.

b) Where the machinery installation is designed for special fuels, the ability of engines to burn such fuels is to be demonstrated.

3.3.2 Main propulsion engines driving fixed propellers

River trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 2 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 1 hour

c) operation at engine speed $n = 1{,}032\ n_0$ for 30 minutes

d) operation at minimum load speed

e) starting and reversing manoeuvres

f) operation in reverse direction of propeller rotation at a minimum engine speed of $n = 0{,}7\ n_0$ for 10 minutes

g) tests of the monitoring, alarm and safety systems

h) for engines fitted with independently driven blowers, emergency operation of the engine with the blowers inoperative.

Note 1: The test in c) is to be performed only where permitted by the engine adjustment.

Note 2: The test in f) may be performed during the dock or sea trials.

3.3.3 Main propulsion engines driving controllable pitch propellers or reversing gears

a) The scope of the sea trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of [3.3.2].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.4 Engines driving generators for propulsion

River trials of engines driving generators for propulsion are to include the following tests:

a) operation at 100% power (rated power) for at least 2 hours

b) operation at normal continuous cruise power for at least 1 hour

c) operation at 110% power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

e) starting manoeuvres

f) tests of the monitoring, alarm and safety systems.

Note 1: Test d) may be performed during the dock or sea trials.

Note 2: Tests a) to f) are to be performed at rated speed with a constant governor setting. The powers refer to the rated electrical powers of the driven generators.

3.3.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 2 hours. During the test, the set concerned is required to operate at its rated power for at least 1 hour.

b) It is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of onboard generating sets, account is to be taken of the times needed to actuate the generator's overload protection system.

3.4 Test of air starting system for main and auxiliary engines

3.4.1 The capability of the starting air system to charge the air receivers within one hour from atmospheric pressure to a pressure sufficient to ensure the number of starts required in Ch 1, Sec 10, [17.3.1] for main and auxiliaries engines is to demonstrated.

3.5 Tests of gears

3.5.1 Tests during river trials

During the river trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required by Ch 1, Sec 9, [3.5.1]
- test of the monitoring, alarm and safety systems.

3.5.2 Check of the tooth contact

a) Prior to the river trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

The tooth contact is to comply with Tab 1.

b) The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.

c) In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20000 N·m, the check of the tooth contact may be reduced at the Society's discretion.

Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

In any case, the teeth of the gears are to be examined by the Surveyor after the river trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

Table 1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
	across the whole face width	of the tooth working depth
Quenched and tempered, cut	70	40
Quenched and tempered, shaved or ground	90	40
Surface-hardened		

3.6 Tests of main propulsion shafting and propellers

3.6.1 Shafting alignment

Where alignment calculations are required to be submitted in pursuance of Ch 1, Sec 7, [3.3.1], the alignment conditions are to be checked on board as follows:

a) Shafting installation and intermediate bearing position, before and during assembling of the shafts

- optical check of the relative position of bushes after fitting
- check of the flanged coupling parameters (gap and sag)
- check of the centring of the shaft sealing glands.

b) Engine (or gearbox) installation, with floating vessel

- check of the engine (or gearbox) flanged coupling parameters (gap and sag)
- check of the crankshaft deflections before and after the connection of the engine with the shaft line, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine.

Note 1: The vessel is to be in the loading conditions defined in the alignment calculations.

c) Load on the bearings

- check of the intermediate bearing load by means of jack-up load measurements
- check of the bearing contact area by means of coating with an appropriate compound.

3.6.2 Shafting vibrations

Torsional vibration measurements are to be carried out where required by Ch 1, Sec 9. The type of the measuring equipment and the location of the measurement points are to be specified.

3.6.3 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.2].

3.6.4 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.6.5 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations is to be tested during the river trials.

3.7 Tests of piping systems

3.7.1 Hydrostatic tests of piping after assembly on board

a) When the hydrostatic tests of piping referred to in Ch 1, Sec 10, [20.4.2] and Ch 1, Sec 10, [20.4.3] are carried out on board, they may be carried out in conjunction with the leak tests required in [3.7.2].

b) Low pressure pipes, such as bilge or ballast pipes are to be tested, after fitting on board, under a pressure at least equal to the maximum pressure to which they can be subjected in service. Moreover, the parts of such pipes which pass, outside pipe tunnels, through compartments for ballast water, fresh water, fuel or liquid cargo, are to be fitted before the hydraulic test of the corresponding compartments.

c) Heating coils in oil fuel tanks or in liquid cargo tanks and fuel pipes are to be subjected, after fitting on board, to a hydraulic test under a pressure not less than 1,5 times the design pressure, with a minimum of 4 bars.

3.7.2 Leak tests

Except otherwise permitted by the Society, all piping systems are to be leak tested under operational conditions after completion on board.

3.7.3 Functional tests

During the river trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

3.7.4 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.8 Tests of steering gear

3.8.1 General

a) The steering gear is to be tested during the river trials under the conditions stated in [3.1] in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of Ch 1, Sec 11 are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

c) If the vessel cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by the Society. In such case, the vessel speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.8.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary steering gear with demonstration of the performances required by Ch 1, Sec 11, [2.3]

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the isolation of one power actuating system, checking the time for regaining steering capability

d) test of the hydraulic fluid refilling system

e) test of the alternative power supply

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the river trials.

Note 2: For small vessels, the Society may accept departures from the above list, in particular to take into account the actual design features of their steering gear.

Note 3: Azimuth thrusters are to be subjected to the above tests, as far as applicable.

3.9 Tests of windlasses

3.9.1 The working test of the windlass is to be carried out in the presence of a Surveyor.

3.9.2 The anchor equipment is to be tested during river trials. As a minimum requirement, this test is required to demonstrate that the conditions specified in Ch 1, Sec 5, [1.2.1] can be fulfilled.

4 Inspection of machinery after river trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the river trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to the Society.

4.2 Diesel engines

4.2.1

a) In general, for all diesel engines, the following items are to be verified:

- the deflection of the crankshafts
- the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the river trials.

Part C

Machinery, Electricity and Fire

Chapter 2

ELECTRICAL INSTALLATIONS

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SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 The requirements of this Chapter apply to electrical installations on vessels. In particular, they apply to the components of electrical installations for:

- primary essential services
- secondary essential services
- essential services for special purposes connected with vessels specifically intended for such purposes (e.g. cargo pumps on tankers, cargo refrigerating systems, air conditioning systems on passenger vessels)
- services for habitability.

The other parts of the installation are to be so designed as not to introduce any risks or malfunctions to the above services.

1.2 References to other regulations and standards

1.2.1 Besides these Rules, electrical equipment shall meet a standard approved by the Society, such as IEC and EN.

1.2.2 When referred to by the Society, publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards, are those currently in force at the date of agreement for vessel classification.

2 Documentation to be submitted

2.1

2.1.1 The documents listed in Tab 1 are to be submitted.

The list of documents requested is to be considered as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

3 Definitions

3.1 Essential services

3.1.1 Essential services are defined in Pt A, Ch 1, Sec 1, [1.3].

3.2 Earthing

3.2.1 The earth connection to the general mass of the hull of the vessel in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

3.3 Emergency condition

3.3.1 A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.

3.4 Hazardous areas

3.4.1 Areas in which an explosive atmosphere is or may be expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Note 1: An explosive gas atmosphere is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

3.4.2 Hazardous areas are classified in zones based upon the frequency and the duration of the occurrence of explosive atmosphere.

3.4.3 Hazardous areas for explosive gas atmosphere are classified in the following zones:

- Zone 0: an area in which an explosive gas atmosphere is present continuously or is present for long periods
- Zone 1: an area in which an explosive gas atmosphere is likely to occur in normal operation
- Zone 2: an area in which an explosive gas atmosphere is not likely to occur in normal operation and if it does occur, is likely to do only infrequently and will exist for a short period only.

3.5 Certified safe-type equipment

3.5.1 Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Documents to be submitted
1	A	General arrangement of electrical installation.
2	A	Single line diagram of main power and lighting systems.
3	I	Electrical power balance.
4	A	Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW).
5	A	Where the maximal short-circuit current on the main bus-bar is expected to exceed 50 kA for the main switchboard, justification of the main bus-bar and bracket strength related to induced electro-magnetic forces (except junction bars to the interrupting and protective devices).
6	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices.
7	A	Single line diagram and detailed diagram of the main switchboard.
8	A	Single line diagram and detailed diagram of the emergency switchboard, if any.
9	A	Diagram of the most important section boards or motor control centres (above 100 kW).
10	A	Diagram of the supply for monitoring and control systems of propulsion motors and generator prime movers.
11	A	Diagram of the supply, monitoring and control systems of the rudder propellers.
12	A	Diagram of the supply, monitoring and control systems of controllable pitch propellers.
13	A	Diagram of the general emergency alarm system, of the public address system and other intercommunication systems.
14	A	Detailed diagram of the navigation-light switchboard.
15	A	Diagram of the remote stop system (ventilation, fuel pump, fuel valves, etc.).
16	A	List of batteries including type and manufacturer, voltage and capacity, location and equipment and/or system(s) served, maintenance and replacement schedule (when used for essential and emergency services).
17	A **(2)**	Single line diagram.
18	A **(2)**	Principles of control system and its power supply.
19	A **(2)**	Alarm and monitoring system including: • list of alarms and monitoring points • power supply diagram.
20	A **(2)**	Safety system including: • list of monitored parameters for safety system • power supply diagram.
21	I **(2)**	Arrangements and details of the propulsion control consoles and panels.
22	I **(2)**	Arrangements and details of electrical coupling.
23	I **(2)**	Arrangements and details of the frequency converters together with the justification of their characteristics.
24	I **(2)**	Arrangements of the cooling system provided for the frequency converter and motor enclosure.
(1) A : To be submitted for approval I : To be submitted for information. **(2)** For electric propulsion installations.		

3.6 Limited explosion risk electrical apparatus

3.6.1 Limited explosion risk electrical apparatus means:

- an electrical apparatus which, during normal operation, does not cause sparks or exhibits surface temperatures which are above the required temperature class, including e.g.:
  - three-phase squirrel cage rotor motors
  - brushless generators with contactless excitation
  - fuses with an enclosed fuse element
  - contactless electronic apparatus, or
- an electrical apparatus with an enclosure protected against water jets (degree of protection IP55) which during normal operation does not exhibit surface temperatures which are above the required temperature class.

SECTION 2 GENERAL DESIGN REQUIREMENTS

1 Environmental conditions

1.1 General

1.1.1 The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

Different conditions may be accepted by the Society in the case of vessels intended for restricted service.

In particular, the conditions shown in the tables in this Article are to be taken into account.

Note 1: The environmental conditions are characterised by:

- one set of variables including climatic conditions (e.g. ambient air temperature and humidity), conditions dependent upon chemically active substances (e.g. salt mist) or mechanically active substances (e.g. dust or oil), mechanical conditions (e.g. vibrations or inclinations) and conditions dependent upon electromagnetic noise and interference, and
- another set of variables dependent mainly upon location on vessels, operational patterns and transient conditions.

1.2 Ambient air temperatures

1.2.1 All electrical machinery, appliances, cables and accessories are to be selected, designed and constructed for satisfactory performance under the ambient temperatures in Tab 1.

Where other conditions are likely, proper account shall be taken of these.

Table 1 : Ambient air temperature

Location	Temperature range, in °C	
Enclosed spaces - in general	0	+ 40
Enclosed spaces - tropical zone	0	+ 45
Fitted on machinery components, boilers, in spaces subject to higher or lower temperatures	According to specific local conditions	
Exposed decks - in general	– 20	+ 40
Exposed decks - tropical zone	– 20	+ 45

1.3 Humidity

1.3.1 The humidity ranges shown in Tab 2 are applicable in relation to the various locations of installation.

Table 2 : Humidity

Location	Humidity
General	95% up to 40°C 70% above 40°C
Air conditioned areas	Different values may be considered on a case-by-case basis

1.4 Water temperatures

All electrical machinery, appliances, cables and accessories are to be selected, designed and constructed for satisfactory performance under the ambient temperatures in Tab 3.

Where other conditions are likely, proper account shall be taken of these.

Table 3 : Water temperature

Coolant	Temperature range, in °C	
Water - in general	0	+ 25
Water - in tropical zone	0	+ 32

1.5 Inclinations

1.5.1 The inclinations applicable are those shown in Tab 4.

The Society may consider deviations from these angles of inclination taking into consideration the type, size and service conditions of the vessels.

Table 4 : Permanent inclination of vessel

Installations, components	Angle of inclination **(1)**	
	Athwartship	Fore and aft
Main and auxiliary machinery **(2)**	12°	5°

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) Higher angle values may be required depending on vessel operating conditions.

1.6 Vibrations

1.6.1 Electrical machines and appliances shall be so constructed and installed that they will not be damaged by the vibrations and shaking occurring in normal shipboard service.

1.6.2 The natural frequencies of foundations, fastenings and suspensions for machines, appliances and electrical components (including those inside appliances) shall not lie within the frequency range 5 - 100 Hz.

1.6.3 If, for reasons of design, the natural frequency has unavoidably to lie within the aforementioned frequency range, the accelerations are to be sufficiently damped to exclude the likelihood of malfunctions or damage.

2 Quality of power supply

2.1 General

2.1.1 All the electrical appliances used on board shall be so designed and constructed that they remain serviceable despite the voltage and frequency variations occurring in normal onboard service. Unless otherwise specified, considerations may be based on the variations shown in Tab 5.

Networks or sub-networks with greater voltage variations may be approved for consumers intended for operation with greater variations.

Table 5 : Voltage and frequency variations

	Variable	Variations	
		Permanent	Transient
General	Frequency Voltage	± 5% + 6% – 10%	± 10% 5s ± 20% 1,5s
Battery operation	Voltage	± 20%	–

2.1.2 In equipment with electronic frequency converters, the voltage waveform may deviate from that specified in Ch 2, Sec 3, [2.6.1] provided that measures are taken to ensure that this does not interfere with the operation of consumers or other equipment such as radio and navigation facilities.

If necessary, converters or similar means should be used for separation from the mains.

2.1.3 Harmonic distortion

The total harmonic distortion shall be less than or equal to 5%.

3 Electromagnetic susceptibility

3.1 General

3.1.1 For electronic type components such as sensors, alarm panels, automatic and remote control equipment, protective devices and speed regulators, the conducted and radiated disturbance levels to be assumed are those given in Part C, Chapter 3.

Note 1: See also IEC Publication 60533 - "Electromagnetic Compatibility of Electrical and Electronic Installations in ships.

3.1.2 Electrical and electronic equipment on the bridge and in the vicinity of the bridge, not required neither by the Rules and liable to cause electromagnetic disturbance, shall be of type which fulfill the test requirements of test specification NR467, Pt C, Ch 3, Sec 6, Tab 1, tests 19 and 20.

4 Materials

4.1 General

4.1.1 The materials used for the construction of electrical machines, cables and appliances shall be resistant to moist air and oil vapours. They shall not be hygroscopic and shall be flame-retardant. The dimensions of minimum creep distances and air clearances are to conform to IEC 60664-1 or EN 60664-1. Relaxations may be allowed for installations up to 50 V.

5 Protective measures

5.1 Protection against electric shock

5.1.1 Direct contact

Protection against direct contact includes all the measures designed to protect persons against the dangers arising from contact with live parts of electrical appliances. Live parts are deemed to be conductors and conductive parts of appliances which are live under normal operating conditions.

Electrical appliances shall be so designed that the person cannot touch or come dangerously close to live parts, in way of the determined operation.

Protection against direct contact may be dispensed with in the case of equipment using safety voltage.

In service spaces, live parts of the electrical appliances shall remain protected against accidental contact when doors and covers which can be opened without a key or tool are opened for operation purposes.

5.1.2 Indirect contact

Electrical appliances shall be made in such a way that persons are protected against dangerous contact voltages even in the event of an insulation failure.

For this purpose, the construction of the appliances shall incorporate one of the following protective measures:

- Protective earthing (see Ch 2, Sec 12, [2])
- Protective insulation (double insulation)
- Operation at very low voltages presenting no danger even in the event of a fault.

The additional usage of Residual Current Protective Devices is allowed except for steering and propulsion plant.

5.2 Protection against explosion hazard

5.2.1 General

Amount and ignition protection of approved electrical equipment in zone 0, zone 1 and zone 2 may be restricted in the different areas where they are used. The relevant current construction Rules have to be observed for this reason.

Regarding hazardous areas and approved electrical equipment on vessels for the carriage of dangerous goods, see Part D, Chapter 3.

For batteries room, see Ch 2, Sec 7.

5.2.2 Hazardous areas, zone 0

These areas include for instance the insides of tanks and piping with a combustible liquid with a flash point ≤ 60°C, or inflammable gases.

For electrical installations in these areas the permitted equipment that may be fitted is:

- intrinsically safe circuits Ex ia
- equipment specially approved for use in this zone by a test organisation recognised by the Society.

Cables in hazardous areas zone 0 shall be armoured or screened, or run inside a metal tube.

5.2.3 Hazardous areas, zone 1

These areas include e.g.:

- paint rooms
- storage battery rooms
- areas with machinery, tanks or piping for fuels with a flash point ≤ 60°C, or inflammable gases, see [5.2.6]
- ventilation trunks.

Areas subject to explosion hazard zone 1 also include tanks, vessels, heaters, pipelines etc. for liquids or fuels with a flash point > 60°C, if these liquids are heated to a temperature higher than 10°C below their flash point.

Electrical equipment shall not be installed or operated in areas subject to explosion hazard, with the exception of explosion-protected equipment of a type suitable for shipboard use. Electrical equipment is deemed to be explosion-protected, if they are manufactured to a recognized standard such as IEC 60079 publications or EN 50014-50020, and if they have been tested and approved by a testing authority recognized by the Society. Notes and restrictions at the certificate have to be observed.

Certified safe type equipment listed in Tab 6 is permitted.

Cables in hazardous areas zone 1 shall be armoured or screened, or run inside a metal tube.

Table 6 : Certified safe type equipment

Intrinsic safety	Ex i
Flameproof enclosure	Ex d
Pressurized apparatus	Ex p
Increased safety	Ex e
Special type of protection	Ex s
Oil immersion	Ex o
Encapsulation	Ex m
Sand filled	Ex q

5.2.4 Extended hazardous areas, zone 2

Areas directly adjoining zone 1 lacking gastight separation from one another are allocated to zone 2.

For equipment in these areas protective measures are to be taken which, depending on the type and purpose of the facility, could comprise e.g.:

- use of explosion-protected facilities, or
- use of facilities with type Ex n protection, or
- use of facilities which in operation do not cause any sparks and whose surfaces, which are accessible to the open air, do not attain any unacceptable temperatures, or
- facilities which in a simplified way are overpressure-encapsulated or are fumetight-encapsulated (minimum protection type IP 55) and whose surfaces do not attain any unacceptable temperatures.

5.2.5 Electrical equipment in paint rooms

In the above-mentioned rooms (zone 1) and in ventilation ducts supplying and exhausting these areas, electrical equipment shall be of certified type as defined in [5.2.3] and comply at least with II B, T3.

Switches, protective devices and motor switchgear for electrical equipment in these areas shall be of all-poles switchable type and shall preferably be fitted in the safe area.

Doors to paint rooms have to be gastight with self-closing devices without holding back means.

5.2.6 Electrical equipment in pipe tunnels

All equipment and devices in pipe tunnels containing fuel lines or adjoining fuel tanks shall be permanently installed irrespective of the flash point of the fuels. Where pipe tunnels directly adjoin tanks containing combustible liquids with a flash point ≤ 60°C, e.g. in ore or oil carriers, or where pipes inside these tunnels convey combustible liquids with a flash point ≤ 60°C, all the equipment and devices in pipe tunnels shall be certified explosion-protected in accordance with [5.2.3] (zone 1).

5.3 Protection against combustible dust hazard

5.3.1 Only lighting fittings with IP 55 protection, as a minimum requirement, may be used in areas where ignitable dusts may be deposited.

In continuous service, the surface temperature of horizontal surfaces and surfaces inclined up to 60° to the horizontal shall be at least 75 K below the glow temperature of a 5 mm thick layer of the dust.

6 Construction

6.1 General

6.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

6.1.2 The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also taking into account its arrangement on board.

6.1.3 Enclosures are to be of adequate mechanical strength and rigidity.

6.1.4 Enclosures for electrical equipment are generally to be of metal; other materials may be accepted for accessories such as connection boxes, socket-outlets, switches and luminaries. Other exemptions for enclosures or parts of enclosures not made of metal will be specially considered by the Society.

6.1.5 Cable entrance are not to impair the degree of protection of the relevant enclosure (see Tab 7).

6.1.6 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

6.1.7 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

6.2 Degree of protection of enclosures

6.2.1 The type of protection or enclosure of every machine and every other item or equipment shall be compatible with the site where it is installed. The particulars in Tab 7 are minimum requirements.

Table 7 : Minimum degrees of protection

Type of space	Minimum type of protection (in accordance with IEC Publication 60529)							
	Generators	Motors	Transformers	Switchboards, consoles, distribution boards	Measuring instruments	Switchgear	Installation material	Lamp fittings
Service spaces, machinery and steering gear spaces	IP 22	IP 22	IP 22	IP 22 **(1)**, **(2)**	IP 22	IP 22 **(1)**, **(2)**	IP 44	IP 22
Refrigerated holds		IP 44		IP 44		IP 44	IP 55	IP 55
Cargo holds		IP 55		IP 55		IP 55	IP 55	IP 55
Storage battery, paint storage and lamp room								IP 44 **(3)** and (EX)
Ventilating trunks (deck)		IP 44					IP 55	
Exposed deck, steering stations on open deck		IP 55		IP 55	IP 55	IP 55	IP 55	IP 55
Closed wheelhouse		IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
Accommodation and public rooms				IP 22			IP 20 IP 55 **(4)**	IP 20
Sanitary facilities and commissary spaces		IP 44	IP 44	IP 44			IP 55	IP 44

(1) IP 12 for appliances generating a large amount of heat.
(2) Where the class of protection is not provided by the appliance itself, the site at which it is installed must have the level of protection stated in the Table.
(3) Electrical appliance of certified safety, e.g. in accordance with IEC Publication 60079 or EN 50014-50020.
(4) Where laid behind ceiling.

SECTION 3 SYSTEM DESIGN

1 Supply systems and characteristics of the supply

1.1 Supply systems

1.1.1 As a general principle, systems listed in [1.1.2] to [1.1.4] are permitted.

1.1.2 For direct current and single-phase alternating current:

a) two conductors, one of which is earthed

b) single conductors with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)

c) two conductors insulated from the vessel's hull.

1.1.3 For 3-phase alternating current:

a) four conductors with earthed neutral and no hull return

b) three conductors insulated from the hull

c) three conductors with hull as neutral conductor, however, not in final subcircuits.

1.1.4 Other systems have to be approved by the Society in each case.

1.1.5 Systems using the hull as neutral conductor are not permitted:

a) on tankers (see Pt D, Ch 3, Sec 3, [8] and Pt D, Ch 3, Sec 2, [8])

b) on floating craft or vessels whose hull can be dismantled.

The power supply lines from one barge to another in pusher tug trains shall be insulated on all poles.

1.2 Characteristics of the supply

1.2.1 General

The use of standard voltages and frequencies is recommended.

Generators may have rated voltages up to 5% higher than the rated voltage of the consumers.

1.2.2 Maximum voltages

The operating voltages indicated in Tab 1 may not be exceeded.

In special installations (e.g. radio equipment and ignition equipment) higher voltages are permitted subject to compliance with the necessary safety measures.

Table 1 : Maximum permissible operating voltages

Type of installation	Maximum permissible operating voltage		
	DC	1-phase AC	3-phase AC
Power and heating installations including the relevant sockets	250 V	250 V	690 V
Lighting, communications, command and information installations including the relevant sockets	250 V	250 V	–
Sockets intended to supply portable devices used on open decks or within narrow or damp metal lockers, apart from boilers and tanks:			
• in general	50 V **(1)**	50 V **(1)**	–
• where a protective circuit-separation transformer only supplies one appliance	–	250 V **(2)**	–
• where protective-insulation (double insulation) appliances are used	250 V	250 V	–
• where ≤ 30 mA default current circuit breakers are used	–	250 V	690 V
Mobile power consumers such as electrical equipment for containers, motors, blowers and mobile pumps which are not normally moved during service and whose conducting parts which are open to physical contact are grounded by means of a grounding conductor that is incorporated into the connecting cable and which, in addition to that grounding conductor, are connected to the hull by their specific positioning or by an additional conductor	250 V	250 V	690 V
Sockets intended to supply portable appliances used inside boilers and tanks	50 V **(1)**	50 V **(1)**	–

(1) Where that voltage comes from higher voltage networks galvanic separation shall be used (safety transformer).
(2) All of the poles of the secondary circuit shall be insulated from the ground.

2 Sources of electrical power

2.1 General

2.1.1 Every power supply system on vessels shall comprise at least one main and one auxiliary power source.

2.2 Design

2.2.1 The power source may take the form of:

a) Two diesel sets

Special restrictions for the supply of steering gear systems are given in Ch 2, Sec 10, [1.4.8].

b) One diesel set and one power supply battery (in accordance with item c))

c) One generator driven by the main propulsion unit (shaft generator) is accepted as a main source provided a power supply battery is installed as the auxiliary source.

This design may be accepted if, in all sailing and manoeuvring conditions, including propeller being stopped, this generator is not less effective and reliable than an independent generating set.

The power supply battery shall be capable of supplying essential consumers for at least 30 minutes automatically and without intermediate recharging.

It shall be possible to recharge the battery with the means available on board even when the main engine is stationary, e.g. by using charging generators (lighting dynamos) driven by auxiliary machinery or by shore power via a battery charger.

d) Other energy generating systems can be permitted by the Society.

2.3 Power balance

2.3.1 A power balance for main and emergency system for the electrical plant shall be furnished as proof that the rating of the power source (generator, battery, solar panels, etc.) is sufficient.

2.3.2 The power requirements are to be determined for day/night running service and emergency supply, if any.

2.3.3 A table is to be compiled listing all the installed electrical consumers together with their individual power ratings:

a) Account is to be taken of the full power rating of those consumers permanently required for the operation of the vessel.

b) The installed capacity of consumers kept in reserve is to be listed. The consumption of those consumers which operate only following the failure of a unit of the same kind need not be included in the calculation.

c) The aggregate power consumption of all consumers intermittently connected to the supply is to be multiplied by a common simultaneity factor and the result added to the sum of the permanently connected consumers.

The simultaneity factor may be applied only once in the course of the calculation.

2.3.4 Consumers with a relatively high power consumption, such as the drive units of bow thrusters, are to be included in the calculation at their full rating even though they may be used only intermittently.

2.3.5 The sum of the loads represented by items a) and c), with due allowance for the battery charging capacity, is to be used when deciding the generator rating.

2.3.6 Unless some other standby capacity such as a floating battery is available, some spare capacity is to be designed into the system to cover short-lived peak loads like those caused by the automatic start-up of large motors.

2.4 Emergency power source on passenger vessels

2.4.1 For emergency power source on passenger vessels, see Pt D, Ch 1, Sec 6, [5.2].

2.5 DC generators

2.5.1 The following may be used to supply DC shipboard networks:

- regulated single or 3-phase AC generators connected to a rectifier
- compound-wound generators
- shunt generators with automatic voltage regulator.

2.5.2 Generators shall be designed so that, even with the battery disconnected, their voltage characteristic and harmonic content remain within the prescribed limits over the whole load range and they themselves suffer no damage. They should be so designed that a short circuit at the terminals produces a current not less than three times the rated current. They shall be able to withstand the sustained short-circuit current for 1 second without suffering damage. Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the vessel's network is assured at even lower sustained short-circuit currents, possibly in conjunction with a parallel-connected power supply battery.

The regulator characteristic of the generators shall ensure that connected power supply batteries are without fail fully charged over the whole load range and overcharging is avoided.

2.6 Single and 3-phase AC generators

2.6.1 Generator design

The apparent output of 3-phase generators shall be rated such that no unacceptable voltage dips occur in the shipboard supply as a result of the starting currents affecting normal operation. On no account may the start-up of the motor with the greatest starting current give rise to an undervoltage causing consumers already in service to cut out.

The waveform of the no-load phase-to-phase voltage should be sinusoidal as far as possible. The deviation from the sinusoidal fundamental wave should at no time be greater than 5% in relation to the peak value of the fundamental wave.

The root-mean-square (r.m.s.) values of the phase voltage with symmetrical loading shall not vary from each other by more than 0,5%.

If the neutral points of generators running in parallel are connected, the waveforms of the phase voltages should coincide as nearly as possible. The use of generators of the same type is recommended. As a general principle, it is necessary to ensure that the equalizing current determined by the harmonic content does not exceed 20% of the rated current of the machine with the lowest capacity.

The generators and their exciters are to be so designed that for two minutes the generator can be loaded with 150% of its rated current with an inductive power factor of 0,5 while approximately maintaining the rated voltage. Generators may suffer no damage as a result of a short-circuit and the short circuits which may occur in the supply network in later service. The design shall take account of the short time delay of the generator switches which is necessary to the selectivity of the system and during which the short-circuit current is sustained.

With voltage-regulated generators it is necessary to ensure that an input data failure cannot lead to unacceptable high terminal voltages.

2.6.2 Conditions

Under balanced load conditions, 3-phase alternators and their exciters are required to meet the following conditions:

a) Steady conditions

   When the alternator is operated with the associated prime mover, the voltage shall not deviate from the rated value by more than ± 2,5% from no-load up to the rated output and at the rated power factor after the transient reactions have ceased. For this purpose the prime mover shall be set to its rated speed at rated output.

b) Transient control conditions

   With the generator running at rated speed and rated voltage, the voltage shall not deviate below 85% or above 120% of its rated value as the result of the sudden connection or disconnection of balanced loads with a specified current and power factor. It shall regulate within the limits stated in item a) in not more than 1,5 seconds. Under test conditions, the generator may in this connection be driven at practically constant speed, e.g. by a suitable electric motor.

   Unless the client specifies particular load changes, the above requirements are to be satisfied under the following conditions:

   - the idling generator, excited to its rated voltage, is to be suddenly connected to a load equal to 60% of its rated current with a (lagging) power factor not greater than 0,4
   - once steady-state control conditions have been attained, the load is to be suddenly disconnected.

c) Sustained short-circuit current

   The sustained short-circuit current at a single, two or 3-phase terminal short shall not be less than three times the rated current. The generator and its exciter shall be able to carry the sustained short-circuit current for a period of one second without suffering damage.

   Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the vessel's network is assured at even lower sustained short-circuit currents.

2.6.3 Three-phase AC generators for parallel operation

Where generators of the same output are run in parallel with the active load shared equally, the reactive power of each machine shall not deviate from its percentage share by more than 10% relative to its rated reactive power.

Where the generators differ in output, the deviation from the proportional share within the aforementioned load range shall not exceed the smaller of the following values, assuming proportionally equal sharing of the active load:

a) 10% of the rated reactive power of the largest machine

b) 25% of the rated reactive power of the smallest machine.

2.7 Generator prime movers

2.7.1 Design and control

The design and control of generator prime movers are to conform to Ch 1, Sec 2.

2.7.2 Parallel operation

The governing characteristics of prime movers in the case of single or 3-phase alternator sets of the same output operating in parallel shall ensure that, over the range from 20% to 100% of the total active power, the share of each machine does not deviate from its proportionate share by more than 15% of its rated active power.

Where the units are differently rated, the deviation from the proportionate share within the load range stated shall not exceed the lesser of the following values:

a) 15% of the rated active power of the largest machine

b) 25% of the rated active power of the smallest machine.

2.7.3 Cyclic irregularity

The permissible cyclic irregularity is to be agreed upon between the prime mover and generator manufacturers. The following is to be ensured:

a) faultless parallel operation of 3-phase generators

b) regular or irregular load variations shall not give rise to fluctuations in active power output exceeding 10% of the rated output of the machine concerned

c) practically non-flicker lighting at all working speeds.

2.8 Special rules

2.8.1 Notwithstanding the conditions set out above, other speed and control characteristics may be approved for generators with outputs of up to 10 kW (kVA) provided that troublefree operation remains assured.

Where generators are backed up by floating batteries it is necessary to ensure that the absence of the battery voltage cannot damage the generators and controllers.

3 Distribution

3.1 Subdivision of the distribution network

3.1.1 Consumers are to be arranged in sections or consumer groups. The following main groups are to be supplied separately:

- lighting circuits
- power plants
- heating plants
- navigation, communication, command and alarm system.

3.2 Hull return

3.2.1 In systems using hull return, the final subcircuits for space heating and lighting are to be insulated on all poles.

3.2.2 The earth for the hull return connection is to be formed by connecting the earth busbar in the main or subsidiary distribution board to the vessel's hull.

3.2.3 The earth connection shall be located in an easily accessible position so that it can easily be tested and disconnected for the purpose of testing the insulation of the circuit.

3.2.4 Earth connections shall be at least equal in cross-section of the supply leads. Bare leads may not be used. Casings and their retaining bolts may not be used for the earth return or for connecting the return lead to the vessel's hull.

3.2.5 The connecting surface of the cable lug shall be metallically clean. The cable lug is to be tinned. The terminal screws are to be made of brass and are to be compatible with the cable cross-sections. The smallest permissible size is M 6.

3.3 Final subcircuits

3.3.1 Final lighting subcircuits and plug socket circuits within the accommodation and day rooms are to be fitted with fuses rated for not more than 16 A. The load on each lighting subcircuit shall not exceed 10 A.

The number of lighting points supplied by a final sub-circuit shall not exceed the numbers given in Tab 2.

Table 2 : Maximum number of lighting points

Voltage	Maximum number of lighting points
up to 55 V	10
from 56 V to 120 V	14
from 121 V to 250 V	24

3.3.2 Plug sockets (outlets) are to be connected to separate circuits wherever possible.

Final subcircuits for lighting in accommodation spaces may, as far as practicable, include socket outlets.

In that case, each socket outlet counts for 2 lighting points.

3.3.3 In main machinery spaces and other important service spaces and control stations, the lighting shall be supplied by at least two different circuits.

The lamps are to be so arranged that adequate lighting is maintained even if one of the circuits fails.

3.4 Navigation lights and signal lamps

3.4.1 The switchboard for navigation lights and signal lamps shall be mounted in the wheelhouse and shall be supplied by a separate cable from the main switchboard, if no change-over to a separate feeder is provided.

3.4.2 Navigation light, each shall be individually supplied, protected and controlled from the navigation lights switchboard.

3.4.3 The navigation lights switchboard may be enlarged to provide connections for other signal lamps. No other consumers may be connected to this switchboard.

3.4.4 A number of locally grouped signal lamps may be jointly supplied, controlled and monitored provided that the monitoring system indicates or signals the failure of even one such lamp.

3.4.5 The switchboard is to be fitted with a device which indicates or signals the extinction of a navigation light. Where pilot lamps are used as indicators, special precautions shall be taken to ensure that the navigation light is not extinguished if the pilot lamp burns out.

3.4.6 Navigation lights shall be designed for the standard voltages: 24 V, 110 V or 220 V.

3.4.7 The voltage at the lamp socket shall not permanently deviate by more than 5% above or below the standard voltages mentioned in [3.4.6].

3.5 Shore connection

3.5.1 General

Shore line terminal containers are to be connected to the main switchboard by a permanently laid cable.

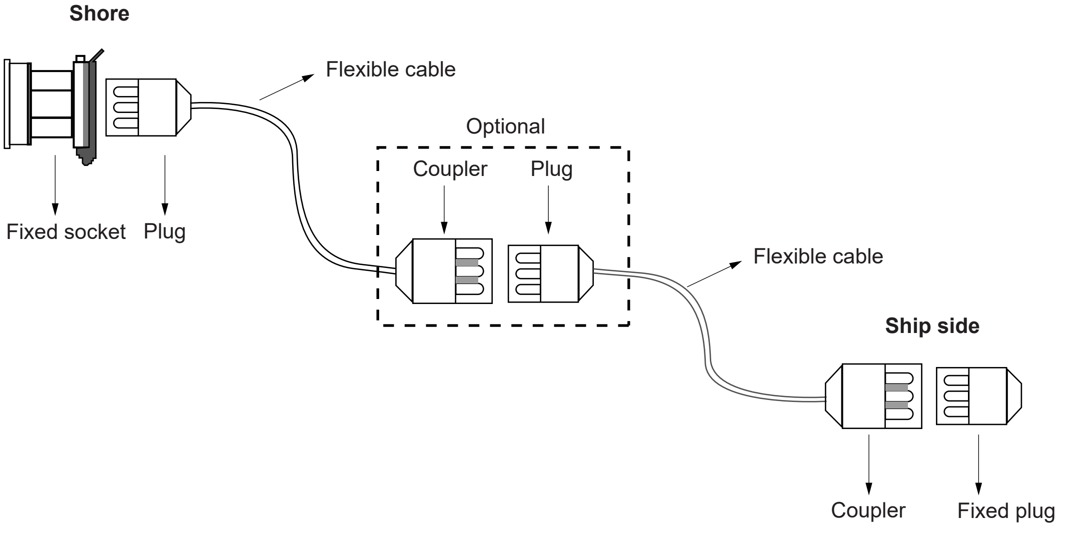
Consequences of mooring breaks on the shore connection are to be considered. It shall not lead to critical damages on the installation.

3.5.2 Connection equipment

The shore connection is to be protected at the main switchboard by a switch or contactor with control switch and fuses or a power circuit breaker with overload protection. Switch, contactor or power circuit breaker are to be interlocked with the generator circuit in such a way as to prevent the vessel's generator operating in parallel with the shore mains.

When using plug-type shore connectors with a current rating of more than 16 A, an interlocking (mechanical or electrical) with a switching device is to be provided ensuring that a connection / disconnection is not possible when the plug is "live".

Figure 1 : Shore connection



In mechanical interlocking, a mechanical lock ensures that the switch associated with the socket is closed only when the plug has been fully engaged and the plug can be disconnected only when the switch is opened again. Electrical interlocking is achieved by supplying the coil of an upstream contactor by means of additional wires and pilot contacts throughout the circuit. Short-circuit protection at the connection can then be dispensed with.

In order to prevent contact with live parts, plug-type shore connectors are to be designed as appliance connectors comprising a coupler plug mounted on board and a coupler socket supplied from the shore, as indicated in Fig 1.

With a connecting voltage of more than 50 V a provision is to be made for connecting the vessel's hull to earth. The connection point shall be marked.

On vessels with DC-power system with hull return the negative pole of the shore side power source shall be connected to the vessel's hull.

The main switchboard is to be equipped with an indicator showing whether the shore connection cable is live.

Instruments shall be available for comparing the polarity of a DC power supply or the phase sequence of a 3-phase power supply from the shore with that of the vessel's network. The installation of a phase change overswitch is recommended.

The following details are to be given on a data plate in the shore line terminal box:

- kind of current, rated voltage and frequency for alternating current
- the concerning measures are to be taken for the shore connection.

To reduce the load on the terminals, the shore line is to be provided with a tension relief device.

Only flexible, oil-resistant and flame retardant cables are to be used as feeder cables.

3.6 Power supply to other vessels

3.6.1 A separate junction box is to be provided in the case of supplying power to other vessels. The branch is to be fitted with fuses and an on-load switch or with a power circuit breaker with overcurrent and short-circuit protection. Where voltages of more than 50 V and/or currents of more than 16 A are transmitted, it is necessary to ensure that connection and disconnection can only be made in the dead condition. Where a connecting line carrying a voltage of more than 50 V is wrenched out of its connector, it shall immediately be deenergized by a forcing circuit. The same applies to a rupture of the connecting cable.

Vessel hulls have to be conductively connected.

Facilities have to be provided to allow this.

Connecting cable suspensions shall be tension-relieved.

SECTION 4 ROTATING MACHINES

1 Construction

1.1 General

1.1.1 Unless otherwise stated in the following Rules, all motors and generators shall conform to a standard accepted by the Society.

1.1.2 In conjunction with the protective equipment to be provided, generators shall be capable of withstanding the dynamic and thermal stresses produced by a short circuit. All machines are to be so designed and constructed that the permissible temperature rises stated in Tab 1 are not exceeded.

The insulation classes have to correspond to the ratings IEC 60085.

In the case of laminated insulations, the highest temperature permitted for each individual insulating material shall not be exceeded.

All windings shall be effectively protected against the effects of moist or salty air and oil vapours.

On DC machines, the commutating pole windings are to be connected symmetrically to the armature, wherever possible. Anti-interference capacitors are to be connected directly to the armature terminals. Anti-interference capacitors on generators shall have built-in cutouts.

1.1.3 The carbon brushes shall be compatible with the slipring and commutator materials and, in the case of the latter, with the commutating conditions.

The working position of the brushholder is to be clearly marked.

1.1.4 The terminals shall be located in an easily accessible position and shall be dimensioned to suit the cross-section of the cables to be connected. The terminals are to be clearly marked.

The class of protection shall match that of the machine and shall be at least IP 44.

Exceptions to this Rule may be permitted for machines with a working voltage of 50 V or less.

1.1.5 The manufacturer shall provide every generator and motor with a name and data plate containing the machine's serial number and all essential operating data.

1.1.6 Commutators, sliprings and, wherever possible, windings shall be easily accessible for the purposes of inspection, maintenance and repair. On larger machines with plain bearings it shall be possible to check the air gap.

2 Testing of electrical machines

2.1 Workshop certificates

2.1.1 For generators and electrical motors with rated power less than 50 kVA or 50 kW, which have not been tested in the presence of a Surveyor, workshop certificates are to be submitted.

2.2 Scope of tests

2.2.1 Temperature rise test (heat test)

a) A heat test shall be performed until the steady-state temperature corresponding to the required mode of operation is reached. The steady-state temperature pass for reached when the temperature rises by not more than 2 K per hour.

   Machines with separate cooling fans, air filters and heat exchangers shall be tested together with this equipment. The heat run shall be completed with the determination of the temperature rise. The maximum permissible values shown in Tab 1 shall not be exceeded.

b) An extrapolation of the measured values to the disconnection time (t = 0) is not necessary if the reading takes place within the following periods:
   - up to 50 kVA/kW 30 s
   - over 50 up to 200 kVA/kW 90 s
   - over 200 up to 5000 kVA/kW 120 s

c) Heat tests on machines of identical construction made not more than 3 years previously can be recognized.

   The referenced temperature rise shall be at least 10% lower than that listed in Tab 1.

The following tests shall be carried out at approximately normal operating temperatures.

2.2.2 Load characteristics

On generators the voltage and on motors the speed is measured as a function of the applied load.

2.2.3 Overload test

a) For generators:

   1,5 times the rated current for two minutes

b) For standard motors:

   1,6 times the rated torque for 15 seconds. During the test, the motor speed may not drop below its pull out speed

c) For windlass motors:

   1,6 times the rated torque for 2 minutes. Overload tests already performed on motors of identical construction may be recognized.

   The current of the operating stage corresponding to twice the rated torque shall be measured and indicated on the rating plate.

Table 1 : Permitted temperature-rises of air cooled machines at an ambient temperature of 40°C (difference values in K)

<table>
<tr><th rowspan="2">No.</th><th rowspan="2" colspan="2">Machinery component</th><th rowspan="2">Method of measurement **(1)**</th><th colspan="5">Insulation class</th></tr>
<tr><th>A</th><th>E</th><th>B</th><th>F **(2)**</th><th>H **(2)**</th></tr>
<tr><td>1</td><td colspan="2">AC windings of machines</td><td>R</td><td>60</td><td>75</td><td>80</td><td>105</td><td>125</td></tr>
<tr><td>2</td><td colspan="2">Commutator windings</td><td>R</td><td>60</td><td>75</td><td>80</td><td>105</td><td>125</td></tr>
<tr><td>3</td><td colspan="2">Field windings of AC and DC machines with DC excitation, other than those specified under 4</td><td>R</td><td>60</td><td>75</td><td>80</td><td>105</td><td>125</td></tr>
<tr><td rowspan="4">4</td><td colspan="2">a) Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors</td><td>R</td><td>–</td><td>–</td><td>90</td><td>110</td><td>130</td></tr>
<tr><td colspan="2">b) Stationary field windings of DC machines having more than one layer</td><td>R</td><td>60</td><td>75</td><td>80</td><td>105</td><td>125</td></tr>
<tr><td colspan="2">c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer</td><td>R
Th</td><td>60</td><td>75</td><td>80</td><td>100</td><td>120</td></tr>
<tr><td colspan="2">d) Single-layer field windings of AC and DC machines with exposed bare or varnished metal surfaces and single-layer compensation windings of DC machines</td><td>R
Th</td><td>60</td><td>80</td><td>90</td><td>110</td><td>130</td></tr>
<tr><td>5</td><td colspan="2">Permanently short-circuited, insulated windings</td><td>Th</td><td>60</td><td>75</td><td>80</td><td>100</td><td>120</td></tr>
<tr><td>6</td><td colspan="2">Permanently short-circuited, uninsulated windings</td><td rowspan="2" colspan="6">The temperature rises of these parts shall in no case reach such values that there is a risk of injury to any insulation or other material on adjacent parts or to the item itself</td></tr>
<tr><td>7</td><td colspan="2">Iron cores and other parts not in contact with windings</td></tr>
<tr><td>8</td><td colspan="2">Iron cores and other parts in contact with windings</td><td>Th</td><td>60</td><td>75</td><td>80</td><td>100</td><td>120</td></tr>
<tr><td>9</td><td colspan="2">Commutators and slip rings, open or closed</td><td>Th</td><td>60</td><td>70</td><td>80</td><td>90</td><td>110</td></tr>
<tr><td>10</td><td>Plain bearings</td><td>measured in the lower bearing shell or in the oil sump after shutdown</td><td></td><td colspan="5">50</td></tr>
<tr><td rowspan="2">11</td><td>Roller bearings</td><td rowspan="2">measured in the lubrication nipple bore or near the outer bearing seat</td><td rowspan="2"></td><td colspan="5">50</td></tr>
<tr><td>Roller bearings with special grease</td><td colspan="5">80</td></tr>
<tr><td>12</td><td>Surface temperature</td><td></td><td></td><td colspan="5">Reference 40 **(3)**</td></tr>
<tr><td colspan="9">**(1)** R = resistance method
Th = thermometer method.
(2) The values may need correction in the case of high-voltage AC windings.
(3) Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidentally touched and there is a risk of burns (above 80°C), the Society reserves the right to request means of protection, such as a handrail, to prevent accidental contacts.</td></tr>
</table>

2.2.4 Short-circuit test on 3-phase AC generators

a) On all synchronous generators, the steady short-circuit current shall be determined with the exciter unit in operation (see Ch 2, Sec 3, [2.6.2], item c).

b) A short-circuit withstand test may be demanded:

- to determine the reactances
- if there is any concern regarding mechanical and electrical strength.

Synchronous generators which have undergone a short-circuit withstand test shall be thoroughly examined after the test for any damage.

2.2.5 High-voltage test (winding test)

a) The test voltage shall be as shown in Tab 2.

It shall be applied for one minute for each single test. The voltage test shall be carried out between the windings and the machine housing, the machine housing being connected to the windings not involved in the test. This test shall be performed only on new, fully assembled machines fitted with all their working parts. The test voltage shall be a practically sinusoidal AC voltage at system frequency.

The maximum anticipated no-load voltage or the maximum system voltage is to be used as reference in determining the test voltage.

b) Any repetition of the voltage test which may be necessary shall be performed at only 80% of the nominal test voltage specified in Tab 2.

Table 2 : Test voltages for the winding test

No.	Machine or machinery component		Test voltage (r.m.s) dependent on rated voltage U of the subject winding, in V
1	Insulated windings of rotating machines of output less than 1 kW (kVA), and of rated voltages less than 100 V with the exception of those in items 3 to 6		2U + 500
2	Insulated windings of rotating machines with the exception of those in item 1 and items 3 to 6		2U + 1000, with a minimum of 1500
3	Separately excited field windings of DC machines		1000 + twice the maximum excitation voltage but not less than 1500
4	Field windings of synchronous generators, synchronous motors and rotary phase converters:		
	a)	Rated field voltage up to 500 V over 500 V	 10 times the rated voltage, with a minimum of 1500 4000 + twice rated field voltage
	b)	When a machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of the winding	10 times the rated field voltage, minimum 1500, maximum 3500
	c)	When a machine is intended to be started either with the field winding connected across a resistance of value equal to or more than ten times the resistance of the winding, or with the field windings on open-circuit with or without a field dividing switch	1000 + twice the maximum value of the r.m.s. voltage, which can occur under the specified starting conditions, between the terminals of the field winding, or in the case of a sectionalized field winding between the terminals of any section, with a minimum of 1500
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheostatic starting)		
	a)	For non-reversing motors or motors reversible from standstill only	1000 + twice the open-circuit standstill voltage as measured between slip rings or secondary terminals with rated voltage applied to the primary windings
	b)	For motors to be reversed or braked by reversing the primary supply while the motor is running	1000 + four times the open circuit secondary voltage as defined in item 5 a)
6	Exciters		
	a)	Apart from the exceptions in b) and c)	as for the windings to which they are connected
	b)	Exception 1: Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting	twice rated exciter voltage + 1000, with a minimum of 1500
	c)	Exception 2: Separately excited field windings of exciters	as under item 3

2.2.6 Overspeed test

As proof of mechanical strength, a two minute overspeed test is to be carried out as follows:

a) For generators with their own drive:

at 1,2 times the rated speed

b) For generators coupled to the main propulsion system:

at 1,25 times the rated speed

c) For constant-speed motors:

at 1,2 times the no-load speed

d) For variable-speed motors:

at 1,2 times the maximum no-load speed

e) For motors with series characteristics:

at 1,2 times the maximum speed shown on the name plate, but at least at 1,5 times the rated speed.

The overspeed test may be dispensed with in the case of squirrelcage induction motors.

2.2.7 Measurement of insulation resistance

Measurement of insulation resistance is to be performed, wherever possible, on the machine at service temperature at the end of the test schedule. The test is to be carried out using a DC voltage of at least 500 V. The minimum insulation resistance shall be not less than 1 Megohm.

2.3 Testing in the presence of a Surveyor

2.3.1 All electrical machines are to be tested at the manufacturer's works. When test procedure is not specified, requirements of IEC 60034 apply.

2.3.2 All generators and electrical motors with an output of 50 kVA or 50 kW and over are to be of type approved and tested at the manufacturer's works in the presence of a Surveyor.

The Society reserves the right to stipulate that a works test be performed on new types of machines which are to be installed for the first time on a vessel with class or where there are special grounds for specifying such a test.

Individual tests may be replaced by type tests.

SECTION 5 TRANSFORMERS

1 General

1.1 General requirements

1.1.1 Transformers are to be installed in well ventilated locations or spaces. Transformers with exposed live parts are to be installed in special spaces accessible only to the responsible personnel. The installation of liquid-cooled transformers requires the Society's special approval.

1.1.2 As a general principle, the primary and secondary windings of transformers are to be separated electrically. For the adjustment of the secondary voltage, taps are to be provided corresponding to ± 2,5% of the rated voltage.

Starting transformers are excepted from this rule.

1.1.3 Power transformers have to be tested according to IEC 60076.

Transformers with a power rating of 50 kVA or more are to undergo a test at the manufacturer's works in the presence of a Surveyor.

Individual tests may be replaced by One's Own Responsibility Test made by the manufacturer.

1.1.4 The manufacturer is to fit to transformers/reactors a name and date plate containing the serial number of the unit and all essential operating data.

SECTION 6 SEMICONDUCTOR CONVERTERS

1 Constructional and operational requirements

1.1 Construction

1.1.1 Semiconductor converters are generally to comply with the requirements for switchgear assemblies (see Ch 2, Sec 8).

1.1.2 The design of semi-conductor converters is to comply with the requirements of IEC Publication 60146-1-1 with applicable requirements modified to suit marine installations like e.g. environmental requirements stated in Ch 2, Sec 2.

1.1.3 The design of semi-conductor converters for power supply is to comply with the requirements of IEC 62040 serie (see [2]).

1.1.4 The design of semi-conductor converters for motor drives is to comply with the requirements of IEC 61800 serie.

1.1.5 The monitoring and control circuits are generally to comply with the requirements of Part C, Chapter 3.

1.1.6 For liquid-cooled converters the following provisions are to be satisfied:

- liquid is to be non-toxic and of low flammability
- drip trays or other suitable means are to be provided to contain any liquid leakages
- the resistivity of the cooling fluid in direct contact with semiconductor or other current carrying parts is to be monitored and an alarm initiated if the resistivity is outside the specified limits.

1.1.7 Where forced cooling is used, the temperature of the heated cooling medium is to be monitored.

If the temperature exceeds a preset value an alarm is to be given and the shutdown of the converter is to be activated.

1.1.8 Where forced (air or liquid) cooling is provided, it is to be so arranged that the converter cannot be or remain loaded unless effective cooling is maintained.

Alternatively, other effective means of protection against overtemperature may be provided.

1.1.9 Stacks of semiconductor elements, and other equipment such as fuses, or control and firing circuit boards etc., are to be so arranged that they can be removed from equipment without dismantling the complete unit.

1.1.10 Semiconductor converters are to be rated for the required duty having regard to the peak loads, system transient and overvoltage and to be dimensioned so as to withstand the maximum short-circuit currents foreseen at the point of installation for the time necessary to trip the protection of the circuits they supply.

1.2 Protection

1.2.1 Semiconductor elements are to be protected against short-circuit by means of devices suitable for the point of installation in the network.

1.2.2 Overcurrent or overvoltage protection is to be installed to protect the converter. When the semiconductor converter is designed to work as an inverter supplying the network in transient periods, precautions necessary to limit the current are to be taken.

1.2.3 Semiconductor converters are not to cause distortion in the voltage wave form of the power supply at levels exceeding the voltage wave form tolerances at the other user input terminals (see Ch 2, Sec 2, [2.1.3]).

1.2.4 An alarm is to be provided for tripping of protective devices against overvoltages and overcurrents in electric propulsion converters and for converters for the emergency source of power.

1.3 Parallel operation with other power sources

1.3.1 For converters arranged to operate in parallel with other power sources, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1.4 Temperature rise

1.4.1 The permissible limit of temperature rise of the enclosure of the semiconductors is to be assessed on the basis of an ambient air temperature of 45°C or sea water temperature of 32°C for water-cooled elements, taking into account its specified maximum permissible temperature value.

1.4.2 The value of the maximum permissible temperature of the elements at the point where this can be measured (point of reference) is to be stated by the manufacturer.

1.4.3 The value of the mean rated current of the semiconductor element is to be stated by the manufacturer.

1.5 Insulation test

1.5.1 The test procedure is that specified in IEC Publication 60146.

1.5.2 The effective value of the test voltage for the insulation test is to be as shown in Tab 1.

Table 1 : Test voltages for high voltage test on static converters

$\frac{U_m}{\sqrt{2}} = U$ in V **(1)**	Test voltage, in V
$U \le 60$	600
$60 < U \le 90$	900
$90 < U$	2 U + 1000 (at least 2000)
(1) U_m: highest crest value to be expected between any pair of terminals.	

2 Requirements for uninterruptible power system (UPS) units as alternative and/or transitional power

2.1 Definitions

2.1.1 Uninterruptible power system (UPS)

Combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure (see IEC Publication 62040).

2.1.2 Off line UPS unit

A UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

2.1.3 Line interactive UPS unit

An off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

2.1.4 On line UPS unit

A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

2.2 Design and construction

2.2.1 UPS units are to be constructed in accordance with IEC 62040, or an acceptable and relevant national or international standard.

2.2.2 The operation of the UPS is not to depend upon external services.

2.2.3 The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

2.2.4 An external bypass is to be provided.

2.2.5 The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for:

- power supply failure (voltage and frequency) to the connected load
- earth fault
- operation of battery protective device
- when the battery is being discharged
- when the bypass is in operation for on-line UPS units.

2.3 Location

2.3.1 The UPS unit is to be suitably located for use in an emergency.

2.3.2 UPS units utilising valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of IEC 62040 or an acceptable and relevant national or international standard.

2.4 Performance

2.4.1 The output power is to be maintained for the duration required for the connected equipment.

2.4.2 No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity.

2.4.3 The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

2.4.4 On restoration of the input power, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

3 Testing

3.1 General

3.1.1 Converters intended for essential services are to be subjected to the tests stated in [3.2].

3.1.2 The manufacturer is to issue a test report giving information on the construction, type, serial number and all technical data relevant to the converter, as well as the results of the tests required.

3.1.3 In the case of converters which are completely identical in rating and in all other constructional details, it will be acceptable for the rated current test and temperature rise measurement stipulated in [3.2] not to be repeated.

3.1.4 The tests and, if appropriate, manufacture of converters of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

3.2 Tests on converters

3.2.1 Converters are to be subjected to tests in accordance with Tab 2.

Type tests are the tests to be carried out on a prototype converter or the first of a batch of converters, and routine tests are the tests to be carried out on subsequent converters of a particular type.

3.2.2 The electronic components of the converters are to be constructed to withstand the tests required in Ch 3, Sec 6.

3.2.3 Final approval of converters is to include complete function tests after installation on board, performed with all ship's systems in operation and in all characteristic load conditions.

3.3 Additional testing and survey for uninterruptible power system (UPS) units as alternative and/or transitional power

3.3.1 UPS units of 50 kVA and over are to be surveyed by the Society during manufacturing and testing.

3.3.2 Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum the following tests:

- functionality, including operation of alarms
- ventilation rate
- battery capacity.

3.3.3 Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

Table 2 : Tests to be carried out on static converters

No	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Light load function test to verify all basic and auxiliary functions	X	X
3	Rated current test	X	
4	Temperature rise measurement	X	
5	Insulation test (dielectric strength test and insulation resistance measurement)	X	X
6	Protection of the converters in case of failure of forced cooling system	X	X

(1) Type test on prototype converter or test on at least the first batch of converters.
(2) The certificates of converters routine tested are to contain the manufacturer's serial number of the converter which has been type tested and the test result.
(3) A visual examination is to be made of the converter to ensure, as far as practicable, that it complies with technical documentation.

SECTION 7 STORAGE BATTERIES AND CHARGERS

1 General

1.1 Application

1.1.1 These regulations apply to permanently installed storage batteries.

1.1.2 Storage batteries may be of the Lead-acid or Nickel-Cadmium type, due consideration being given to the suitability for any specific application.

1.1.3 Other types of storage batteries of satisfactorily proven design may be accepted provided they are suitable for vessels use to the satisfaction of the Society.

1.1.4 Storage batteries have to be in compliance with and tested according to recognised standards, e.g.:

- IEC 60896-11 or IEC 60896-21,22, for Lead-acid batteries
- IEC 60622, IEC 60623 or IEC 62259, for Nickel-Cadmium batteries.

1.1.5 For storage batteries location, see Ch 2, Sec 11, [4].

2 Design and construction of cells

2.1 General

2.1.1 Cells shall be so designed that they retain their normal operation at inclination of up to 15° and no electrolyte leaks out at inclination of up to 40°. Cells should be combined in cabinets, containers or racks if the weight of single cells allows this.

The weight of a battery or battery element shall not exceed 100 kg.

3 Data plate and operation instructions

3.1 General requirements

3.1.1 Each battery or battery element shall be marked with maker's name and type of battery, containing all relevant data for operation.

3.1.2 For each type of battery an operation manual shall be delivered. It shall contain all informations for proper maintenance and operation.

4 Installation

4.1 General requirements

4.1.1 Storage batteries are to be installed in such a way that they are accessible for cell replacement, inspection, testing, topping-up and cleaning.

The installation of batteries in the accommodation area, in cargo holds and wheelhouses is not permissible. Gastight batteries can be seen as an exception, e.g. in case of internal power source of emergency lighting fittings.

4.1.2 Storage batteries are not to be installed in locations where they are exposed to unacceptably high or low temperatures, spray or other effects liable to impair their serviceability or reduce their life essentially. They are to be installed in such a way, that adjacent equipment is not damaged by the effects of escaping electrolyte vapours.

4.1.3 Lead-acid batteries and alkaline storage batteries are not to be installed in the same room or in the immediate vicinity of each other.

4.1.4 Measures are to be taken to prevent storage batteries from shifting. The braces used shall not impede ventilation.

4.1.5 For the installation of storage batteries the total power of associated charger has to be considered.

The charging power is to be calculated from the maximum current of the battery charger and the rated voltage of the battery.

For automatic IU-charging, the charging power may be calculated as stated under Ch 2, Sec 11, [4.2.3].

5 Battery room equipment

5.1 General requirements

5.1.1 Only explosion protected lamps, switches, fan motors and space heating appliances shall be installed in Battery Rooms. The following minimum requirements shall be observed:

- explosion group II C
- temperature class T 1.

Other electrical equipment is permitted only with the special approval of the Society.

5.1.2 Where leakage is possible, the inner walls of Battery rooms, cabinets and containers shall be protected against the injurious effects of the electrolyte.

6 Starter batteries

6.1 General requirements

6.1.1 Storage batteries for starting internal combustion engines shall be designed to have sufficient capacity for at least six starting operations in 30 minutes without intermediate recharging.

6.1.2 Starter batteries shall be capable of being recharged with the means available on board and may only be used to start engines and supply energy to the monitoring systems allocated to them.

6.1.3 Starting internal combustion engines with the vessel's supply battery is permitted only in emergencies.

6.1.4 Wherever possible storage batteries used for starting and preheating internal combustion engines are to be located close to the machines.

7 Rating of storage battery chargers

7.1 General requirements

7.1.1 Charging equipment shall be so rated that discharged storage batteries can be charged to 80% of their rated capacity within a period not greater than 15 hours without exceeding the maximum permissible charging currents.

Only automatic chargers shall be used with charging characteristic adapted to the type of batteries.

If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120% of the rated voltage. The power demand of the consumers shall be considered for the selection of the chargers.

7.2 Tests on chargers

7.2.1 Battery chargers are to be subjected to tests in manufacturer's work in accordance with Tab 1.

Type tests are the tests to be carried out on a prototype charger or the first of a batch of chargers, and routine tests are the tests to be carried out on subsequent chargers of a particular type.

7.2.2 Battery charger's with rating power of 2 kW upwards have to be tested in manufacturer's work in the presence of the Society's Surveyor.

Table 1 : Tests to be carried out on battery chargers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Functional tests (current and voltage regulation, quick, slow, floating charge, alarms)	X	X
3	Temperature rise measurement	X	
4	Insulation test (dielectric strength test and insulation resistance measurement)	X	X

(1) Type test on prototype battery charger or test on at least the first batch of battery chargers.
(2) The certificates of battery chargers routine tested are to contain the manufacturer's serial number of the battery charger which has been type tested and the test result.
(3) A visual examination is to be made of the battery charger to ensure, as far as practicable, that it complies with technical documentation.

SECTION 8 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

1 Switchboards

1.1 General rules

1.1.1 Switchboards shall contain all the gear, switches, fuses and instruments necessary for operating and protecting the generators and main power distribution systems. They shall be clearly, easily and safely accessible for the purposes of maintenance, repair or renewal.

1.1.2 Built-in gear, instruments and operating equipment are to be indelibly marked. The current ratings of fuses and the response values of protective devices are to be indicated.

1.1.3 The replacement of fuse elements shall be possible without removing panels or covers. Different voltages and types of current are to be clearly indicated.

1.1.4 Where switchgear or fuses carrying a voltage of more than 50 V are located behind doors, the live parts of appliances mounted on the door (switches, pilot lights, instruments) shall be protected against being touched by accident (see Ch 2, Sec 2, [5.1]).

1.1.5 Busbars and bare connections shall be made of copper. Even under adverse operating conditions, their temperature rise may not exceed 40°C. Busbars are to be fastened and secured in such a way that they are able to withstand the mechanical stresses produced by the greatest possible short-circuit currents.

1.1.6 All screwed joints and connections are to be secured against spontaneous loosening. Screws up to M 4 size may be secured with lacquer or enamel.

1.1.7 With the exception of the connections between switchgear and outgoing terminals, switchboards may only contain lines with cross-sections of up to 50 mm^2. If larger cross-sections are required, a main busbar system is to be provided for connecting generators and consumers.

1.1.8 The power feed for the control of consumers is to be picked up on the consumer side downstream of the main fuses. Exceptions will be permitted only in special cases.

1.1.9 Where fuses and switches are used, the sequence shall be busbar - fuse - switch.

1.1.10 Neutral conductors in 3-phase systems shall have at least half the cross-section of the outer conductors. For line cross-sections of up to 16 mm^2, neutral conductors shall have the full cross-section of the outer conductors. Equalizer lines for 3-phase alternator exciters shall be designed to carry half the exciting current of the largest alternator and shall be laid separately from other lines.

1.1.11 The smallest permissible cross-section for wiring inside the switchboard, including measuring wires and control lines, is generally 0,5 mm^2. Smaller cross-sections are allowed only in automation and telecommunication equipment and for data bus/data cables. Lines without fuse protection from the main busbar to fuses and protective switches shall be as short as possible not longer than 1 m. They may not be laid and fastened together with other lines.

Shunt circuits within the switchboard shall be laid separately from other lines and shall generally not be protected by fuses.

Important control lines shall be laid and protected in such a way they cannot be damaged by arcing due to switching operations or, as far as possible, short-circuits.

1.1.12 It shall be possible to observe meters and indicators and to operate the switchgear from the front of the switchboard with the doors closed.

1.1.13 Operating handles shall generally not be located less than 300 mm above floor level. The operating handles of generator switches are to be located at a distance of at least 800 mm from the floor.

1.2 Distribution boards

1.2.1 The Rules set out in [1.1] apply in analogous manner.

1.2.2 Where a number of distribution boards are supplied via a common feeder cable without intermediate protection, the busbars and the connecting terminals shall be dimensioned to withstand the total load.

1.2.3 Distribution circuits shall be protected in accordance with [3.1] and [3.9] against damage due to short-circuit and overload. Final subcircuits with fuses rated at more than 63 A shall be fitted with on-load switches. On-load switches may be dispensed with in final subcircuits with fuses rated up to 63 A provided that each connected consumer can be disconnected by a switch located nearby.

1.2.4 Distribution boards for the supply of mobile consumers, e.g. container plug sockets shall be individually supplied from the distribution board and shall be individually fused and individually disconnectable.

A pilot light or voltmeter is to be provided to show whether the distribution board is live.

1.2.5 Motor switchgear shall be accessible for the purposes of inspection and repair without the need to disconnect other important circuits.

Mechanical devices, ammeters or indicator lights shall show whether the motor is switched on.

Motor switchgear units or their control switches are normally to be located close to their respective motors. Where for operational reasons they are placed out of sight of the motor, personnel working on the motor shall be provided with means of protecting themselves against the unauthorized switching on of the motor.

Motors shall be disconnected on all poles as a matter of principle.

1.3 Switchboard design assessment

1.3.1 The design assessment of switchboards may be carried out:

- either for a specific unit (DA), or
- using type approval procedure (TA).

1.4 Switchboard testing

1.4.1 Before being installed on board, every switchboard together with all its equipment is to be subjected to tests at the manufacturer's works.

1.4.2 A test at the manufacturer's works in the presence of a Society Surveyor is to be carried out on main switchboards for a connected generator output of more than 100 kW/kVA, and on all switchboards for emergency generator sets. The Society reserves the right to call for a works test on other switchboards where there are special reasons for this.

1.4.3 Operational test

As far as possible, the proper operation of the equipment is to be checked in accordance with the design.

1.4.4 High-voltage test

High-voltage test is to be performed for a period of one minute at the test voltage shown in Tab 1.

Measuring instruments and other ancillary equipment may be disconnected during the test.

Table 1 : Test voltages for main circuits

Rated insulation voltage Ui (V)	Test voltage A.C. (r.m.s) (V)
Ui ≤ 60	1000
60 < Ui ≤ 300	2000
300 < Ui ≤ 690	2500

1.4.5 Insulation resistance measurement

Insulation resistance measurement is to be performed using at least 500 V DC. For the purpose of this test, large switchboards may be divided into a number of test sections. The insulation resistance of each section shall be at least 1 MΩ.

2 Switchgear

2.1 General

2.1.1 As a general principle, switchgear shall be type approved, designed and constructed in accordance with standard IEC, EN or to other standards recognized by the Society.

2.2 Selection of switchgear

2.2.1 Switchgear is to be selected not merely by reference to its rated current but also on the basis of its thermal and dynamic strength and its making and breaking capacity.

On-load breakers shall be designed to carry at least the rated current of the series-connected fuse.

Circuit breakers shall act on all live conductors simultaneously. It shall be clearly apparent whether the breaker is in the open or closed position.

Installation switches in lighting systems up to 16 A are exempted from this rule.

2.3 Power circuit breaker

2.3.1 Power circuit breakers are to be provided with trip-free release. Their rated making and breaking capacity shall be sufficient to make or break short-circuit currents at the installation site.

2.4 Fuses

2.4.1 The fuse elements or cartridges shall have an enclosed fusion space. They shall be made of a ceramic material or a material recognized by the Society as equivalent. The fuse element shall be embedded in a heat-absorbing material.

2.4.2 It shall be possible to replace the fuse elements or cartridges without exposing the attendant to the danger of touching live components or suffering burns. Where grip-type fuses are used, a detachable grip is permissible.

3 Switchgear, protective and monitoring equipment

3.1 General

3.1.1 Generators, power consumers and circuits shall be protected in each one of their non-earthed poles or conductors against damage due to overload or short-circuit. In insulated DC and single-phase AC circuits and in insulated 3-phase circuits with balanced load, the overload protection may be dispensed with in one conductor.

3.1.2 The protective devices are to be coordinated in such a way that, in the event of a fault, only the defective circuit is disconnected and the supply to the sound circuits is maintained.

3.1.3 All non-earthed poles shall be connected and disconnected simultaneously. In earthed systems, lines are to contain neither switches nor fuses in their earthed pole or conductor.

3.2 Equipment for 3-phase AC generators

3.2.1 Switchgear and protective devices for individual operation 3-phase AC generators are to be provided with 3-pole power circuit breakers with delayed-action overcurrent trip and short-delayed short-circuit trip to obtain selectivity. This protective equipment is to be designed as follows:

a) The overload trip, which is to be set at an overcurrent of between 10% and 50%, shall open the power circuit breaker with a maximum time delay of two minutes.

   A setting of more than 50% overcurrent may be approved if required by the operating conditions and compatible with the generator or primemover design.

b) The short-circuit trip is to be set at an overcurrent of more than 50% but less than the sustained short-circuit current. It shall operate with a short delay of up to about 500 ms adjusted to suit the selectivity of the system.

c) On generators rated at less than 50 kVA, fuses and contactors or on-load switches may be used provided that the requirements of a) and b) are satisfied in an analogous manner. For this purpose the contactors shall also have a delayed drop-out.

   The contactors are to be designed for at least twice the rated generator current.

3.2.2 Switchgear and protective devices for parallel operation

The following equipment is to be provided in addition to the switchgear and protective devices specified in [3.2.1].

a) 3-phase AC generators rated at 50 kVA and above shall be provided with reverse-power protection with a time delay of 2 to 5 seconds.

   The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4% to 10% of the rated current for diesel-driven generators. The protection should, wherever possible, be set to 50% of the prime mover trailing power. A voltage drop to 60% of the rated voltage shall not render the reverse-power protection ineffective within the specified range.

b) The generator switches shall be fitted with undervoltage protection which prevents the contact assemblies from closing when the generator is deenergized. If the voltage drops to between 70% and 35% of the rated voltage, the generator switch shall open automatically. Undervoltage trips shall have a short time delay matched to the short-circuit trip called for in [3.2.1], item b).

c) A synchronizing device is to be fitted. Where automatic synchronizing equipment is fitted, provision shall also be made for manual independent synchronization.

d) In the case of parallel operating generators with individual output rating of more than 50 kVA, protection is to be provided against the effects of paralleling the generators when in phase opposition.

   For example, the following may be used for this purpose:

   - a reactor which limits to a permissible degree the electrical and mechanical stresses arising from faulty synchronization. It is to be disconnected when the generator switch is closed, or
   - a synchronizing interlock which allows the generator switch to cut in only up to an angular deviation of 45° (electrical) maximum, and also blocks the connection in case of too large a difference frequency. The permissible difference frequency depends on the characteristics of the generator switch and its drive and shall not generally exceed 1 Hz.

3.3 Equipment for DC generators

3.3.1 Switchgear and protective devices for individual operation

a) DC generators are generally to be provided with power circuit breakers with delayed-action overcurrent trip and short-delayed short-circuit trip to obtain selectivity. The switchgear and protective devices are to conform to [3.2.1] (for individual operation) with the difference that the short-circuit trip is to have a short time delay of up to 200 ms.

b) A polarity-reversing facility, if necessary.

3.3.2 Switchgear and protective devices for parallel operation

The following equipment is to be provided in addition to the switchgear and protective devices specified in [3.3.1]:

a) DC generators equipped for parallel operation with each other or with a storage battery shall be fitted with reverse-current protection with no-delay action or with a short delay of up to 1 second.

   The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4% to 10% of the rated output for diesel-driven generators.

b) Undervoltage protection as described in [3.2.2], item b) for parallel operation.

c) In the case of compound-wound generators, the power circuit breaker shall be provided with an equalizer circuit contact assembly which, on making, closes simultaneously with, or in advance of, the contacts of the power circuit breaker and, on breaking, opens simultaneously with, or after, the contacts of the power circuit breaker, and is designed to carry at least half the rated current.

3.4 Special rules

3.4.1 On-load switches, power circuit breakers and, generally speaking, reverse-current cutouts can be dispensed with in the case of generators with outputs of up to 10 kW (kVA) and a voltage of 50 V or less which, because of their control equipment, do not need to be subjected to switching operations in service. Further exemptions may be allowed depending on the design of the equipment.

3.5 Disconnection of non-essential consumers

3.5.1 It is recommended that a device be installed which, when the generator reaches its rated output, emits a warning signal after about 5 s and automatically cuts off consumers whose temporary disconnection will not jeopardize the safety of the vessel and its machinery installation. The disconnection of the loads may be effected in one or more steps. The automatic disconnection of non-essential consumers is mandatory on larger passenger vessels and on vessels with automated engine operation.

3.6 Measuring and monitoring equipment

3.6.1 The measuring error of switchboard instruments may not exceed 1,5% of the scale terminal value. Directionally sensitive instruments are to be used for DC generators and storage batteries.

The scale of voltmeters shall cover at least 120% of the rated voltage, that of ammeters at least 130% of the maximum amperage to be expected in continuous operation. Ammeters are to be designed to avoid damage due to motor starting currents.

The scale of watt meters shall cover at least 120% of the rated power. For generators operating in parallel, the scale shall also cover at least 12% of the reverse power. In the case of power meters with only one current path, the measurement shall be performed in the same phase on all generators. Where the total power input to all consumers connected to one phase reaches more than 10% of the output of the smallest alternator, the power meters shall be equipped with multiple movements to register also the unbalanced load on the outer conductors.

Frequency meters are to be capable of registering deviations of down to ± 5 Hz from the rated frequency.

The main switchboard (main distribution board) is to be provided with ammeters for major consumers, unless these are mounted at the consumers themselves. One instrument may be used for more than one circuit. The rated currents are to be marked on the instrument scales, or on a separate panel in the case of multi-circuit instruments with changeover switch. The rated service values are to be marked in red on the scales of all instruments.

Appropriate digital means of measuring and monitoring equipment is acceptable taking into account above mentioned scales for voltage, current, power and frequency measurement.

3.6.2 Generator measuring and monitoring equipment

a) Each DC generator is to be provided with:
   - 1 voltmeter
   - 1 ammeter
   - 1 blue pilot light (generator live).

   Where circuit breakers are used, the following additional lights are to be provided:
   - 1 green pilot light (circuit breaker closed)
   - 1 red pilot light (circuit breaker open).

b) Battery
   - 1 centre zero ammeter.

c) Bus-bar
   - 1 voltmeter.

d) Each 3-phase AC generator is to be provided with:
   - 1 voltmeter, where necessary capable of switching to the other generators
   - 1 ammeter, connectable to each phase conductor
   - 1 wattmeter (active power meter) for generators with outputs of 50 kVA and over
   - 1 frequency meter, where necessary capable of switching to the other generators
   - Pilot lights as specified in item a) for DC generator.

3.6.3 Special rules

Instead of the ammeter and the blue pilot light specified in item b), a charging pilot light may be provided for installations with an output of up to 10 kW/kVA and a voltage ≤ 50 V.

3.6.4 Protection of generator monitoring and control circuits

The following circuits are to be supplied by the generator direct and are to be individually fused (using fusible cutouts):

- generator protective relay and generator switch undervoltage trip
- measuring instruments
- synchronizing equipment
- pilot lights
- speed adjuster
- electrical generator switch drive
- automatic power supply system (measuring voltage).

3.6.5 Earth fault indication

Every non-earthed primary or secondary system is to be equipped with devices for checking the insulation resistance against vessel's hull.

Where filament lamps are used as indicators, their power input may not exceed 15 W. The lamps may be earthed only during testing by means of a pushbutton switch.

An insulation monitoring system may be dispensed with in the case of secondary circuits such as control circuits.

3.6.6 Insulation monitoring equipment

Where insulation monitoring devices are used, they shall provide a continuous indication of the insulation resistance and shall trip an alarm if the insulation resistance of the network drops below 100 Ω per volt of the network voltage.

With a full earth fault the measuring current may not exceed 30 mA.

3.7 Transformer protection

3.7.1 The windings of transformers shall be protected against short circuit and overload by multi-pole power circuit breakers or by fuses and on-load switches in accordance with the above Rules. Transformers for parallel operation shall be fitted with isolating switches on the secondary side.

Overload protection primary side may be dispensed with where it is protected on the secondary side.

3.8 Motor protection

3.8.1 Motors rated at more than 1 kW shall be individually protected against overloads and short circuits.

For steering gear motors see Ch 2, Sec 10, [1].

It is permissible to provide common short-circuit protection for a motor and its own individual supply cable.

The protective devices shall be suited to the particular operating modes of the motors concerned and shall provide reliable thermal protection in the event of overloads.

If the current-time characteristic of the overload protection is not compatible with the starting characteristics of a motor, the overload protection may be disabled during start-up. The short-circuit protection shall remain operative.

The switchgear of motors whose simultaneous restarting on restoration of the voltage after a power failure might endanger the operation of the installation shall be fitted with a facility which:

- interrupts the circuit in response to a voltage drop or power failure and prevents automatic restarting, or
- causes the motor to start up again automatically without any inadmissible starting current on restoration of the voltage. Where necessary, the automatic restarting of a number of motors is to be staggered in time.

The undervoltage protection shall work reliable between 70% and 35% of the rated voltage.

3.9 Circuit protection

3.9.1 Every distribution circuit shall be protected against damage due to overloads and short circuits by means of multi-pole power circuit breakers or fuses in accordance with [3.8]. Final subcircuits supplying power to a consumer fitted with its own overload protection may be provided with only short-circuit protection at the feed point. Under continuous service conditions fuses for this purpose may be two stages higher than for the rated service of the consumer in question; for short-period and intermittent service, the rated current of the fuse may not be greater than 160% of the rated consumer current. The corresponding switches are to be designed for the rated amperage of the fuse.

For steering gear circuits see Ch 2, Sec 10, [1]. Automatic cutouts and protective motor switches shall, where necessary, be backed up by the series-connected fuses specified by the manufacturer. In the case of important consumers, automatic cutouts without selectively staggered disconnecting delay may not be arranged in series.

3.10 Storage battery protection

3.10.1 Batteries, except starter batteries, shall be provided with short-circuit protection situated near the batteries, but not in battery's cabinet or container. Emergency batteries supplying essential services may only be provided with short-circuit protection sufficient for their cables. The value of the fuses may be two stages higher than the corresponding values for the rated cable current shown in Ch 2, Sec 9, Tab 2 and Ch 2, Sec 9, Tab 3, column 3, or of power circuit breakers with suitably adjusted short-circuit protection.

3.11 Protection of measuring instruments, pilot lights and control circuits

3.11.1 Indicators, measuring instruments and pilot lights are to be protected by fuses. Pilot lights with operating voltage over 24 V are to be fused separately from control circuits in every case so that a short circuit in the lamp does not cause failure of the control circuits. Pilot lights connected via short-circuit-proof transformers may be fused jointly with control circuits.

3.12 Exciter circuits

3.12.1 Exciter circuits and similar circuits whose failure might endanger the operation of essential systems may not be protected, or may be protected only against short circuits.

3.13 Emergency disconnecting switches

3.13.1 Oil burner equipment, fuel pumps, boiler fans, separators, machinery space and pump room ventilators shall be provided with an individual emergency disconnecting switch located at a central position outside the machinery space unless other means are available for rapidly interrupting the fuel and air supply outside the room in which the equipment is installed.

4 Control and starting equipment

4.1 Operating direction of handwheels and levers

4.1.1 Handwheels and levers of starters and drum controllers not intended for reversing are to be arranged to turn clockwise for starting the motors. Motor speed and generator voltage control is to be so effected that clockwise rotation increases the speed/voltage. The linear movement of handles upwards or to the right shall produce the same effect as clockwise rotation.

4.2 Hand-operated controllers, resistors

4.2.1 The temperatures of handles and other parts which have to be touched in order to operate equipment may not exceed the following values in service:

- metal parts: 50°C
- insulating material: 60°C.

Resistor casings whose temperature is liable to exceed 60°C are to be so mounted that they cannot be touched by accident.

The temperature rise of the air flowing from the casing may not exceed 165°C in the case of resistors integral to starters and controllers or 190°C for separately mounted resistors.

SECTION 9 CABLES

1 General

1.1

1.1.1 All electrical cables and insulated wiring used on board are to be of type approved. As a general principle, the use of the types of cables and wires according to IEC 60092 is permitted. In addition, equivalent cables and lines may be approved by the Society.

1.1.2 Except for lighting and space heating, only cables with multi-strand conductors are to be used.

1.1.3 The voltage rating of a cable may not be less than the rated working voltage of the relevant circuit.

In insulated distribution systems the outer conductor voltage of the system is to be deemed to be the rated voltage of the cable between a conductor and the vessel's hull, because in the event of a fault, e.g. outer conductor shorting to earth, this voltage may occur for a prolonged period between an intact outer conductor and the vessel's hull.

2 Choice of cables

2.1 Temperatures

2.1.1 In positions liable to be subjected to high ambient temperatures, only cables whose permissible temperature is at least 10 K above the maximum ambient temperature to be expected may be used. A correction factor is to be applied to the permissible loading (see Tab 1).

Cables on diesel engines, heaters etc. liable to be exposed to high temperatures are to be routed so that they are protected against excessive external heating. If this is not possible, oil-resistant cables with high heat resistance are to be used. Cables not previously used are to be submitted to the Society for approval before installation.

2.2 Fire resistance

2.2.1 Cables and insulated wires shall be flame-retardant (IEC 60332) and self-extinguishing.

2.3 Cable sheaths

2.3.1 On open decks, in damp or wet rooms, in service rooms and wherever condensation or harmful vapours (oil vapours) may occur, only cables with impermeable sheaths resistant to the environmental influences may be used.

PVC (polyvinyl chloride), CSP (chlorosulphonated polyethylene) and PCP (polychloroprene) sheaths are deemed to fall into this category, although they are unsuitable for long-term immersion in liquids.

Table 1 : Correction factors for cables in higher ambient temperatures

Maximum permissible conductor operating temperature		Ambient temperature				
		40°C	45°C	50°C	60°C	70°C
60°C	see Tab 2	1,00	0,87	0,71	–	–
85°C	see Tab 3	1,00	0,94	0,89	0,74	0,57

2.4 Movable connections

2.4.1 Machines or equipment mounted on rubber or spring vibration absorbers are to be connected via cables or wires with sufficient flexibility.

Mobile equipment is in all cases to be supplied by heavy, flame-retardant and oil-resistant rubber-sheathed flexible cords such as HO7RN-F-CENELEC HD 22 or equivalent.

For working voltages above 50 V, the movable connecting cables or wires for non-double-insulated equipment shall include an earthed conductor, which is to be specifically marked.

In spaces in the accommodation area, lightweight flexible cords are also permitted.

3 Determination of conductor cross-sections

3.1 General requirements

3.1.1 The sizes of cables and wires are to conform to the details in Tab 2 and Tab 3, unless other conductor cross-sections are necessitated by the permissible voltage drop for particular equipment items (see [3.1.3]) or by the elevated ambient temperature or by a special permissible working temperature (see also [3.2.1]). See Tab 1 for the correction factor.

3.1.2 Parallel cables may be calculated with the sum of their permissible loads and may be fused in common provided that the current is equally shared between all the parallel cables.

In every case, only cables of the same cross-sectional area and length shall be used as parallel cables.

3.1.3 The cross-section of cables and wires is to be determined not only by reference to the permissible current load but also according to the permissible voltage drop. The voltage drop between the main switchboard and the most unfavourable point of the system under consideration may not exceed 5% for lighting or 7% for power and heating circuits. In the case of transient loads, caused for example by start-ups, it is necessary to ensure that the voltage drop in the cable does not occasion any malfunction of the system.

Table 2 : Current rating of cables with a maximum permissible conductor temperature of 60°C at an ambient temperature of 40°C

1	2	3	4	5	6	7
Nominal cross-section of the copper conductor (mm^2)	Continuous service		Short time service S 2 = 30 min.		Short time service S 2 = 60 min.	
	Max. permissible current (A)	Rated fuse current (A)	Max. permissible current (A)	Rated fuse current (A)	Max. permissible current (A)	Rated fuse current (A)
Single-core cables						
1,0	9	10	10	10	10	10
1,5	14	16	15	15	15	15
2,5	19	20	20	20	20	20
4	26	25	28	25	28	25
6	34	36	36	36	36	36
10	46	50	49	50	49	50
16	62	63	66	63	66	63
25	82	80	87	80	87	80
35	101	100	108	100	107	100
50	126	125	136	160	134	160
70	156	160	171	160	165	160
95	189	160	217	224	202	200
120	219	224	251	250	234	224
150	251	250	294	300	271	250
185	287	250	353	315	311	300
240	337	315	420	–	371	–
300	388	355	500	–	435	–
Two-core cables						
1,0	8	6	9	10	9	10
1,5	11	10	12	16	12	16
2,5	17	16	18	20	18	20
4	22	20	23	25	23	25
6	29	25	31	25	31	25
10	39	36	41	36	41	36
16	53	50	60	63	56	63
25	70	63	83	80	75	80
Three or four-core cables						
1,0	6	6	7	10	7	10
1,5	9	10	10	10	10	10
2,5	14	16	15	16	15	16
4	18	20	19	20	19	20
6	24	25	25	25	25	25
10	32	36	36	36	34	36
16	43	36	50	50	46	50
25	57	50	70	63	60	63
35	71	63	88	80	75	80
50	89	80	115	100	100	100
70	109	100	151	125	125	125
95	132	125	194	200	161	160
120	153	160	234	225	161	200
5 to 24-core cables 1,5 mm^2						
5	8	6				
7	7	6				
10	6	6				
12	6	6				
14	6	6				
16	6	6				
19	5	4				
24	5	4				

Table 3 : Current rating of cables with a maximum permissible conductor temperature of 85°C at an ambient temperature of 40°C

1	2	3	4	5	6	7
Nominal cross-section of the copper conductor (mm²)	Continuous service		Short time service S 2 = 30 min.		Short time service S 2 = 60 min.	
	Max. permissible current (A)	Rated fuse current (A)	Max. permissible current (A)	Rated fuse current (A)	Max. permissible current (A)	Rated fuse current (A)
Single-core cables						
1,0	17	16	18	16	18	20
1,5	22	20	23	20	23	20
2,5	30	25	32	25	32	36
4	40	36	42	36	42	50
6	52	50	55	50	55	63
10	72	63	76	63	76	80
16	96	100	102	100	102	100
25	127	125	135	125	135	160
35	157	160	168	160	166	224
50	196	200	212	224	208	250
70	241	224	264	300	255	300
95	292	300	327	315	311	315
120	338	315	387	–	362	–
150	389	400	455	–	420	–
185	443	425	532	–	481	–
240	522	500	650	–	574	–
300	600	630	765	–	672	–
Two-core cables						
1,0	14	10	15	16	15	16
1,5	19	20	20	20	20	20
2,5	26	25	28	25	28	25
4	34	36	36	36	36	36
6	44	36	47	50	47	50
10	61	63	65	63	65	63
16	82	80	93	100	87	100
25	108	100	127	125	115	125
Three or four-core cables						
1,0	12	10	13	16	13	16
1,5	15	16	16	16	16	16
2,5	21	20	22	25	22	25
4	28	25	30	36	30	36
6	36	36	38	36	38	36
10	50	50	56	63	53	50
16	67	63	75	80	71	63
25	89	80	110	100	96	80
35	110	100	138	125	120	100
50	137	125	178	160	153	125
70	169	160	235	224	194	160
95	205	200	300	300	250	250
120	237	224	365	315	296	300
5 to 24-core cables 1,5 mm²						
5	13	10				
7	11	10				
10	10	10				
12	10	10				
14	9	6				
16	9	6				
19	8	6				
24	8	6				

3.2 Minimum cross-sections

3.2.1 The minimum cross-section of permanently laid cables and wires in power, heating, lighting systems and control circuits for power plants shall be 1,0 mm^2; in control circuits of safety systems 0,75 mm^2; in automation and telecommunication equipment 0,5 mm^2; in telecommunication systems not relevant to the safety of the vessel and for data bus/data cables 0,2 mm^2.

Within accommodation and day rooms, flexible leads with a conductor cross-section of 0,75 mm^2 and over may also be used for the mobile connection of appliances with a current input of up to 6 A.

3.3 Hull return conductors

3.3.1 See Ch 2, Sec 3, [3.2]

3.4 Protective earth wires

3.4.1 See Ch 2, Sec 12, [2]

3.5 Neutral conductors of 3-phase systems

3.5.1 The cross-section of neutral conductors of 3-phase systems is to equal at least half that of the outer conductors. Where the cross-section of the outer conductors is 16 mm^2 or less, the cross-section of the neutral conductor shall equal that of the outer conductors.

4 Cable overload protection

4.1 General requirements

4.1.1 All cables and wires with the exception of hull return, neutral and earthing conductors are to be fitted with fuses in accordance with Tab 2 and Tab 3.

4.1.2 Where protection is afforded by power circuit breakers with overcurrent and short-circuit trip, the overcurrent trip is to be set in accordance with the maximum permissible current loads shown in Tab 2 and Tab 3. The short-circuit trip shall be set to 4-6 times the indicated amperages.

For short-circuit protection, see also Ch 2, Sec 8, [3.9].

4.1.3 The exciter conductors of DC motors and DC generators operating in parallel may not be fitted with fuses except in the case of special installations. The exciter conductors of individually connected DC generators and 3-phase synchronous machines may be fused only where there are special grounds for doing so, e.g. where the cables are run through several of the vessel's main vertical zones.

5 Identification

5.1 General

5.1.1 Each cable is to have clear means of identification so that the manufacturer can be determined.

5.1.2 Fire non propagating cables are to be clearly labelled with indication of the standard according to which this characteristic has been verified and, if applicable, of the category to which they correspond.

SECTION 10 MISCELLANEOUS EQUIPMENT

1 Steering gear

1.1 General requirements

1.1.1 As a general principle, two steering gears, as constructionally independent as possible, are to be provided, i.e.:

- 1 main and 1 auxiliary steering gear system
- 2 main steering gear systems.

1.2 Definitions

1.2.1 Main steering gear system

The main steering gear system comprises all the system components needed to steer the vessel under normal design conditions.

1.2.2 Auxiliary steering gear system

The auxiliary steering gear system generally comprises equipment which, if the main steering gear system malfunctions, is able to assume its duty with reduced or equal capacity.

1.3 Design features

1.3.1 In general, all parts of main and auxiliary steering gears shall be designed in conformity with Ch 1, Sec 11.

1.3.2 The rated output of the electrical machinery is to be related to the maximum torque of the steering gear. For hydraulic steering gears, the rated output of the drive motors is to be determined by reference to the maximum pump delivery against the maximum pressure produced by the steering gear (safety valve setting) with due allowance for pump efficiency.

The stalling torque of the motor shall equal at least 1,6 times the rated torque.

Steering gear drive units shall comply at least with the following modes of operation:

a) Steering gears with intermitted power demand

   S 6: 25% for converters and motors of electrohydraulic steering gears

   S 3: 40% for motors of electromechanical steering gears

b) For steering gears with a constant power demand the machines are to be designed for continuous service S 1.

1.3.3 With power-driven steering gears, the auxiliary drive shall be largely independent of the main drive so that a failure in one system does not render the other one inoperative.

1.4 System requirements

1.4.1 Basically, systems may be differentiated as follows:

a) hydraulically driven main steering gear with electrohydraulic auxiliary steering gear

b) electrohydraulic main steering gear comprising two equivalent rudder drives

c) hydraulic main and auxiliary steering gear systems.

1.4.2 Electrical and electrohydraulic power unit shall be supplied via separate cable. The necessary fuse junctions and switchgear devices are to be housed in separate switch containers. If installed together in switchboards, they are to be suitably isolated from the feeder panels of other consumers.

1.4.3 The systems are to be so designed that each drive unit can be put into operation either individually or jointly from the wheelhouse. The feed for the remote control of the motor switchgear shall be taken from the appropriate supply fuse.

1.4.4 Where a system is supplied from a battery, a voltage monitor is to be fitted which acts with a time delay to trip a visual and audible alarm signal on the bridge if the supply voltage drops more than 10%.

1.4.5 If the auxiliary steering gear is supplied from a battery, the latter shall be capable of sustaining the supply for 30 minutes without intermediate recharging.

1.4.6 The changeover from the main to the auxiliary steering gear system shall be able to be effected within 5 seconds.

1.4.7 Following a power failure, the steering gear drive systems shall automatically re-start as soon as the power supply is restored.

1.4.8 If the steering gear is operated only by electrically driven power units or electrohydraulic power units, then at least one of the power units or rudder drives shall, in the event of failure of the vessel's network, be automatically supplied by a battery until an auxiliary diesel set has been started and has taken over the power supply.

The battery is not required, in case that the standby auxiliary diesel set starts automatically and takes over the power supply within 5 seconds after black-out.

1.4.9 Installations other than that described require the Society's special approval.

1.5 Protective equipment

1.5.1 The control circuits and motors of steering gear systems are to be protected against short circuits only.

1.5.2 Where fuses are used, their rated current is to be two stages higher than that corresponding to the rated current of the motors. However, in the case of motors for intermittent service, the value shall not be greater than 160% of their rated current.

1.5.3 Where power circuit breakers are used, their short-circuit quick release device shall be set at not more than 10 times the rated current of the electric drive motor.

Thermal trips are to be disabled or are to be set to twice the rated current of the motor.

1.5.4 Control circuits shall be fused for at least twice the maximum circuit current rating.

They are to be located on the load side of the main fuse of the electrical drive concerned.

1.5.5 The protective devices are to be coordinated in such a way that in the event of a fault, only the defective circuit is disconnected while the supply to the intact circuits is maintained.

All non-earthed poles are to be fitted with fuses and are to be connected and disconnected simultaneously.

1.5.6 On relays and magnetic valves rectifiers or capacitors in parallel are to be fitted to quench arcs.

1.6 Indicating and monitoring equipment

1.6.1 As a general principle, separate indicators or monitors, as appropriate, are to be provided which respond to the operative/inoperative state of the control circuits, a drop in potential below the supply voltage (in the case of battery supply) and an inadmissible fall in the hydraulic oil level in the compensating tank.

1.6.2 A failure of the control voltage and any departure from the limit values prescribed for safe operation shall trip a visual and audible signal in the wheelhouse. It shall be possible to cancel the audible signal. The cancellation of an audible alarm shall not prevent the signalling of a fault affecting the other working parts of the steering gear systems.

1.6.3 Operative signals and alarms:

a) 1 green indicator light each for the main and auxiliary steering gears (or for each main steering gear, where applicable) showing that the equipment is operative

b) 1 red indicator light for the main and auxiliary steering gears to signal a failure or a fault

c) 1 red indicator light responding to a drop in potential of 10% below the rated network voltage. The signal response is to be subjected to a time delay in order to bridge voltage dips caused by starting operations (where a system is supplied by a battery).

1.6.4 In addition, 3-phase AC systems are to be provided with yellow indicator light signalling overload and phase failure.

The phase failure monitor may be dispensed with if the system is supplied exclusively via power circuit breakers. The overload alarm may be dispensed with for drive systems used exclusively for inching duty. The alarm may also be combined with other steering gear alarms.

Where bimetallic relays are used to signal overloading of the motors, these are to be set at 0,7 times the rated current of the motor.

1.7 Rudder control

1.7.1 It shall be possible to control the main and auxiliary steering gears from the main steering station.

The controls are to be so arranged that the rudder angle cannot be altered unintentionally.

1.7.2 Where more than one power drive is installed, the wheelhouse is to be provided with at least two mutually independent steering gear control systems.

Separate cables and lines are to be provided for these control systems.

The mutual independence of the steering gear control systems may not be impaired by the fitting of additional equipment such as autopilot systems.

1.7.3 A common selector switch is to be provided for switching from one control system to another.

1.8 Auto pilot systems

1.8.1 An indicator light showing that the auto pilot is operative has to be installed.

A failure of the control voltage and a deviation of the rated rpm of the gyro shall trip a visual and audible alarm.

The auto pilot system and its associated alarms have to be supplied separately from each other.

1.9 Rudder angle indicator

1.9.1 The actual position of the rudder shall be clearly indicated in the wheelhouse and at every steering station. In the case of electrical or hydraulic control systems, the rudder angle shall be indicated by a device (rudder angle transmitter) which is independent of the control system and actuated either by the rudderstock itself or by parts rigidly connected to it.

The system shall have a separate power supply and the indication shall be continuous.

Additionally installed transmitters for position indicators of autopilot systems shall have a separate power supply and shall be electrically isolated from the above mentioned system.

2 Lateral thrust propellers and active rudder systems

2.1 General

2.1.1 The short-circuit protection of the supply is to conform to [1.5].

2.2 Drives

2.2.1 Active rudder systems are to be rated for continuous service.

Lateral thrust propeller systems are to be rated in accordance with the vessel's operating conditions, but at least for short-term duty (S 2 - 30 min).

Lateral thrust propellers and active rudder systems are to be protected against short circuits and overloads. The overload protection is to be so designed that in the event of an overload a warning is first given followed by a reduction of the output or the shutdown of the system should the overload persist.

Motors for short-term duty shall be monitored for critical winding temperature. An exceeding of temperature limits shall be alarmed. If the maximum permissible temperature is reached the output shall be automatically reduced or the motor shall be switched off.

2.3 Monitoring

2.3.1 The wheelhouse is to be equipped with the monitors and indicators described in [2.3.2] to [2.3.6].

2.3.2 A blue indicator light signalling that the system is operative.

2.3.3 A yellow indicator light for signalling an overload.

2.3.4 Depending on the type of system, further indicators are to be provided for signalling operational level and the desired direction of movement of the vessel.

2.3.5 The controls of lateral thrust propeller systems shall take the form of pushbuttons or levers. The operating direction shall correspond to the desired direction of movement of the vessel. The electrical control system shall be fed from the supply to the main drive.

2.3.6 Where fuses are used for short-circuit protection, a phase monitor shall ensure that the system cannot be started up in the event of a phase failure.

3 Lighting installations

3.1 General

3.1.1 Lighting installations are to be designed in compliance with the following requirements:

- Ch 2, Sec 3, [1.2], for voltages and frequencies
- Ch 2, Sec 3, [3.3], for final subcircuits
- Ch 2, Sec 3, [3.4], for navigation lights
- Ch 2, Sec 8, [1.1.4], for protective measures.

For additional requirements regarding lighting installations on passenger vessels, see Pt D, Ch 1, Sec 6, [5.3].

3.2 Design of lighting installations

3.2.1 The number of lamps and their distribution shall be such as to ensure satisfactory illumination.

3.2.2 In machinery and service spaces, service passageways, cargo holds and commissary spaces, lighting fixtures are to be provided which are sufficiently robust for this application. The lighting fixtures shall be fitted with impact resistant covers.

3.2.3 Wherever possible, separate circuits are to be provided for plug sockets.

3.2.4 The use of normal shore type light fittings is permitted in accommodation, day rooms and commissary spaces provided that they comply with [3.3].

3.3 Design of lighting fixtures

3.3.1 Lighting fixtures shall have a base which reflects and dissipates the heat produced by the light source. The mountings used shall provide a gap of at least 5 mm to allow cooling air to circulate between the base of the fixture and a combustible surface to which it is fastened.

Lighting likely to be exposed to more than ordinary risk of mechanical damage shall be protected against such damage or to be of a special robust construction.

3.3.2 The temperature of lighting fixtures should not exceed 60°C where they can be touched easily.

3.3.3 Heat-resistant leads are to be used for the internal wiring of lamp-holders.

3.3.4 Metal lighting fixtures shall be fitted with an earthing screw in the casing or base. All metal parts inside a lighting fixture are to be conductively connected to each other.

The connecting terminals shall be directly fastened to the lighting fixture.

3.3.5 Every lighting fixture shall be permanently marked with the maximum permissible wattage of the lamps to be fitted.

3.4 Mounting of lighting fixtures

3.4.1 All lighting fixtures are to be mounted in such a way that combustible structural elements such as wood etc. will not be ignited by the heat produced and the lighting fixtures themselves are not exposed to damage.

3.4.2 In bathrooms and shower rooms lighting fixtures shall be mounted in accordance with IEC.

3.5 Lighting in cargo holds

3.5.1 Where a lighting system is permanently installed, each final subcircuit or each section is to be equipped with switches having clearly marked settings or with pilot lamps showing whether the system is switched on. The switches are to be located outside the holds in positions where they are only accessible to authorized personnel.

The lighting fixtures are to be fitted with sufficiently robust wire guards or impact-resistant covers.

Their method of mounting is to ensure that they cannot be damaged while work is in progress.

For explosion protection see also Ch 2, Sec 2, [5.2].

3.6 Lighting of engine rooms

3.6.1 The lighting equipment of engine rooms is to be distributed on two or more circuits so that there still remains sufficient lighting to enable work to continue if there is failure of a circuit.

4 Electric heating appliances

4.1 General

4.1.1 The use of portable, unsecured heating and cooking appliances is not permitted except for appliances which are under constant supervision when in use, e.g. soldering irons, flat irons and appliances where special precautions are taken to prevent the build-up of heat to ignition temperature (e.g. electric cushions and blankets).

4.1.2 The installation and use of electric heaters is not allowed in spaces where easily flammable gases or vapours may accumulate or in which ignitable dust may be deposited.

4.2 Space heaters

4.2.1 Arrangement of heaters

No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

Where heaters are fitted in the bulkhead lining, a trough made of non-combustible material (see Ch 4, Sec 1, [2.14] for definition) shall be mounted behind each heater in such a way as to prevent the accumulation of heat behind the lining.

Only waterproof heaters according to IEC 60335 may be used in washrooms, bathrooms and other damp spaces as well as in machinery spaces.

4.2.2 Enclosures

Heater enclosures are to be so designed that no objects can be deposited on them and air can circulate freely round the heating elements.

4.2.3 Thermal design of heaters

Electrical space heaters are to be so designed that, at an ambient temperature of 20°C, the temperature of the outer jacket or cover and the temperature of the air flowing from the heater do not exceed 95°C.

For the maximum permissible temperature of control components and their immediate vicinity, see Ch 2, Sec 8, [4.2.1].

4.2.4 Electrical equipment of heaters

Only heating elements with sheathed or ceramic-encased coils may be used.

To prevent the build-up of heat leading to excessive temperature rises, every heater is to be equipped with thermal protection which interrupts the current as soon as the maximum permissible heater temperature is exceeded. Automatic restarting shall be prevented.

Self regulating material in heating elements may be dispensed with.

The operating switches shall disconnect all live conductors when in the off position. The off position and the positions for the various operating levels shall be clearly marked on the switches.

Every space heater shall normally be connected to a separate circuit. However, a number of small space heaters may be connected to a common circuit provided that their total current input does not exceed 16 A.

4.3 Oil and water heaters

4.3.1 See Ch 1, Sec 3.

4.4 Electric ranges and cooking equipment

4.4.1 Cooking plates

Only enclosed-type cooking plates may be used.

4.4.2 switches

The switches of the individual cooking plates shall disconnect all live conductors when in the off position. The switch steps shall be clearly marked.

Switches and other control elements shall be so fitted that they are not exposed to radiant heat from the cooking plates or heating elements. The maximum permissible temperature limits specified in Ch 2, Sec 8, [4.2.1] are applicable.

SECTION 11 LOCATION

1 General

1.1 Location

1.1.1 The degree of protection of the enclosures and the environmental categories of the equipment are to be appropriate to the spaces or areas in which they are located; see Ch 2, Sec 2, [6.2].

1.2 Areas with a risk of explosion

1.2.1 Except where the installation of equipment for explosive gas atmosphere is provided for by the Rules, electrical equipment is not to be installed where flammable gases or vapours are liable to accumulate; see Ch 2, Sec 2, [5.2].

2 Distribution boards

2.1 Distribution boards for cargo spaces and similar spaces

2.1.1 Distribution boards containing multipole switches for the control of power and lighting circuits in bunkers and cargo spaces are to be situated outside such spaces.

2.2 Distribution board for navigation lights

2.2.1 The distribution board for navigation lights is to be placed in an accessible position in the wheelhouse.

3 Cable runs

3.1 General

3.1.1 Cable runs are to be so selected that cables can, wherever possible, be laid in straight lines and are not exposed to mechanical damage. Continuous cable runs shall not be routed along the shell plating and its frames.

3.1.2 Sources of heat such as boilers, hot pipes etc. shall be by-passed to avoid exceeding the permissible end temperature of the cable conductors. Where this is not possible, the cables are to be shielded from radiant heat.

3.1.3 Where, for safety reasons, an installation is provided with double feeder cables, these are to be laid as far apart as possible.

Cable runs are to be protected against corrosion.

3.1.4 For the installation of cables in the vicinity of radio equipment or of cables belonging to electronic control and monitoring systems, steps are to be taken in order to limit the effects of unwanted electromagnetic interference (see Ch 2, Sec 2, [3]).

4 Storage batteries

4.1 General

4.1.1 Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration. They are to be installed in such a way that no damage may be caused to surrounding appliances by the vapours generated.

4.1.2 Storage batteries are to be suitably housed, and compartments (rooms, lockers or boxes) used primarily for their accommodation are to be properly constructed and efficiently ventilated so as to prevent accumulation of flammable gas.

4.1.3 Starter batteries are to be located as close as practicable to the engine or engines served.

4.1.4 Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, locker, box), unless of valve-regulated sealed type.

4.2 Ventilation

4.2.1 General requirements

All battery installations in rooms, cabinets and containers shall be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

Gastight NiCd-, NiMH- or Li- batteries may not be ventilated.

4.2.2 Batteries installed in switchboards - charging power up to 0,2 kW

Lead batteries with charging power up to 0,2 kW may be installed without separation to the switchgear, if:

a) the batteries are of valve regulated type (VRL), provided with solid electrolyte, and
b) the switchboards are not closed completely (IP 2X will be suitable), and
c) the charger is an automatic IU-charger with a maximum continuous charging voltage of 2,3 V/cell and rated power is limited on 0,2 kW.

4.2.3 Ventilated spaces - batteries charging power up to 2 kW

Batteries with charging power up to 2 kW may be installed in ventilated cabinets or containers arranged itself in ventilated rooms (except in rooms according to [4.1.1] and [4.1.2]). The unenclosed installation (IP 12) in well ventilated positions in machinery spaces is permitted. The charging power P, in W, for automatic IU-charging should be calculated as follows:

$P = U\ I$

where:

U : Rated battery voltage, in V

I : Charging current, in A:

- for Pb-batteries: I = 8 C / 100
- for NiCd-batteries: I = 16 C / 100

C : Rated battery capacity, in Ah.

Battery's gassing voltage shall not be exceeded. If several battery sets are be used, the sum of charging power has to be calculated.

The room free air volume V, in m^3, should be calculated depending on battery size, as follows:

V = 2,5 Q

where:

Q : Air quantity, in m^3/h, equal to:

Q = 0,25 f I n

n : Number of battery-cells in series connection

f : Taken equal to:

- f = 0,03 for lead batteries (VRL) with solid electrolyte
- f = 0,11 for batteries with fluid electrolyte

If several battery sets will be installed in one room, the sum of air quantity shall be calculated.

The air ducts for natural ventilation shall have a cross-section A, in cm^2, as follows, assuming an air speed of 0,5 m/s:

A = 5,6 Q

The required minimum cross-sections of ventilation ducts are shown in Tab 1.

Small air ducts and dimensions of air inlet and outlet openings should be calculated based on lower air speed (≤ 0,5m/s).

Table 1 : Minimum cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU- charging)			
Battery charging power (W)	Minimum cross-section, in cm^2		
	Lead battery solid electrolyte VRL	Lead battery fluid electrolyte	Nickel-Cadmium battery
P < 500	40	60	80
500 ≤ P < 1000	60	80	120
1000 ≤ P < 1500	80	120	180
1500 ≤ P < 2000	80	160	240
2000 ≤ P < 3000	80	240	forced ventilation
P ≥ 3000	forced ventilation		

4.2.4 Ventilated rooms - charging power more than 2 kW

If the charging power of batteries exceeds 2 kW, it has to be installed either in closed cabinets, containers or a battery room to be ventilated to the open deck. Lead batteries up to 3 kW still may be ventilated by natural ventilation.

Battery rooms are to exhaust to open deck area. It should be used forced ventilation.

Doors to battery rooms have to be gastight with self-closing devices without holding back means.

4.2.5 Ventilation requirements

Ventilation inlet and outlet openings shall be so arranged to ensure that fresh air flows over the surface of the storage battery.

The air inlet openings shall be arranged below and air outlet openings shall be arranged above.

If batteries are installed in several floors, the free distance between them shall be at least 50 mm.

Devices which obstruct the free passage of air, e.g. fire dampers and safety screens, shall not be mounted in the ventilation inlet and outlet ducts. If necessary, weathertight closures shall be carried out otherwise.

Air ducts for natural ventilation shall lead to the open deck directly. Openings shall be at least 0,9 m above the cabinet/ container. The inclination of air ducts shall not exceed 45° from vertical.

4.2.6 Forced ventilation

If natural ventilation is not sufficient or required cross-sections of ducts according to Tab 1 are too big, forced ventilation shall be provided. The air quantity Q shall be calculated according to [4.2.3]. The air speed shall not exceed 4 m/s.

Where storage batteries are charged automatically, with automatic start of the fan at the beginning of the charging, arrangements shall be made for the ventilation to continue for at least 1 h after completion of charging.

Wherever possible, forced ventilation exhaust fans shall be used. The fan motors shall be either explosion-proof and resistant to electrolyte or, preferably, located outside of the endangered area.

The fan impellers shall be made of a material which does not create sparks on contact with the housing, and dissipates static charges.

The ventilation systems shall be independent of the ventilation systems serving other rooms.

Air ducts for forced ventilation shall be resistant to electrolyte and shall lead to the open deck.

4.3 Warning signs

4.3.1 At doors or openings of battery rooms, cabinets or containers warning notices have to be mounted drawing attention to the explosion hazard in those areas and that smoking and handling of open flames are prohibited.

SECTION 12 INSTALLATION

1 General

1.1 Protection against injury or damage caused by electrical equipment

1.1.1 All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.

1.1.2 All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.

1.1.3 For protective earthing as a precaution against indirect contact, see [2].

1.1.4 Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

1.2 Protection against damage to electrical equipment

1.2.1 Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, steam, oil or oil vapours.

1.2.2 The air supply for internal ventilation of electrical equipment is to be as clean and dry as practicable; cooling air for internal ventilation is not to be drawn from below the floor plates in engine and/or boiler rooms.

1.2.3 Equipment is to be so mounted that its enclosing arrangements and the functioning of the built-in equipment will not be affected by distortions, vibrations and movements of the ship's structure or by other damage liable to occur.

1.2.4 If electrical fittings, not of aluminium, are attached to aluminium, suitable provision is to be made to prevent galvanic corrosion.

1.3 Accessibility

1.3.1 Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts (see [6.1]).

2 Protective earthing

2.1 Parts to be earthed

2.1.1 Metal casings and all metal parts accessible to touch which are not live in normal operation but may become so in the event of a fault are to be earthed except where their mounting already provides a conductive connection to the vessel's hull.

2.1.2 Special earthing may be dispend with in the case of:

a) metal parts insulated by a non-conductor from the dead or earthed parts
b) bearings of electrical machines which are insulated to prevent currents flowing between them and the shaft
c) electrical equipment whose service voltage does not exceed 50 V.

2.2 Methods of earthing

2.2.1 Where machines and equipment are earthed to the hull via their mountings, care is to be taken to ensure good conductivity by clean metal contact faces at the mounting. Where the stipulated earth is not provided via the mountings of machinery and equipment, a special earthing conductor is to be fitted for this purpose.

2.2.2 For the earthing of metal sheaths, armouring and cable braiding, see [7.9].

Protection shall be provided by an additional cable, an additional lead or an additional core in the power cable.

Metal cable armouring may not be used as an earthing conductor.

2.2.3 A conductor normally carrying current may not be used simultaneously as an earthing conductor and may not be connected with the latter by a common connection to the vessel's hull.

2.2.4 The cross-section of the earthing conductor shall be at least in accordance with Tab 1.

2.2.5 Electrical equipment in the area subject to explosion hazard is in every case to be fitted with an earthing conductor irrespective of the type of mounting used.

Table 1 : Cross-section of earthing conductors

Cross-section of main conductors (mm^2)	Minimum cross-section of earthing conductor (mm^2)	
	Earthing conductor incorporated in the cable	Earthing conductor separated from the cable
0,5 up to 4	equal to the main conductor	4
> 4 up to 16	equal to the main conductor	equal to the main conductor
> 16 up to 35	16	16
> 35 up to 120	equal to the half main conductor	equal to the half main conductor
> 120	70	70

2.3 Earthing connections

2.3.1 The connections of earthing conductors to the metal parts to be earthed and to the vessel's hull are to be made with care and are to be protected against corrosion.

3 Installation material

3.1 Design and mounting

3.1.1 Installation appliances shall be adequately protected against mechanical damage and shall be made of corrosion-resistant materials.

Where appliances with casings of brass or other copper alloys are fixed to aluminium surfaces, they shall be insulated from the latter to protect them against corrosion.

3.1.2 The cable entries of the appliances shall be of a size compatible with the cables to be connected and shall be selected to suit the type of cable concerned.

3.1.3 The space inside appliances shall be sufficient to enable insulated conductors to be connected without having to make sharp bends. Corners, edges and projections shall be well rounded.

3.1.4 Mobile appliances are to be provided with means of relieving tension in the cable so that the conductors are not subjected to tensile load.

3.1.5 Terminals, screws and washers shall be made of brass or another corrosion-resistant material.

3.2 Plug connections and switches

3.2.1 The live contact components of sockets (outlets) and plugs shall be so enclosed that they cannot be touched under any circumstances, even during insertion of the plug.

3.2.2 The sockets for amperages over 16 A shall be interlocked with a switch in such a way that the plug can be neither inserted nor withdrawn as long as the socket contact sleeves are live.

3.2.3 Where a vessel is provided with sockets for a variety of distribution systems differing in voltage or frequency, use is to be made of sockets and plugs which cannot be confused in order to ensure that an appliance cannot be connected to a socket belonging to the wrong system.

3.2.4 Plug connections shall conform to the required class of enclosure irrespective of whether or not the plug is in or out.

3.2.5 Wherever possible, appliances are to be so designed and mounted that the plugs are inserted from below.

3.2.6 Apart from the sockets standardized and specifically approved for use in shipbuilding practice, accommodation and day rooms may also be provided with sockets designed for use on shore provided that they are mounted in a dry position.

3.2.7 Only sockets with a permissible operating voltage in accordance with Ch 2, Sec 3, Tab 1 are allowed in washrooms and bathrooms. No sockets or switches may be fitted in shower cubicles, shower cabinets or close to bathtubs. Exempted from this rule are razor sockets with an isolating transformer.

3.2.8 Switches shall simultaneously connect and disconnect all the non-earthed conductors of a circuit. Single-pole disconnection is permitted only in the accommodation area for the switches of lighting circuits not carrying more than 16 A.

3.2.9 No plug connections are normally to be provided in cargo holds.

Where power sockets are essential in special cases, e.g. for supplying power to refrigerated containers, they are to be supplied from their own subdistribution boards with fused outlet switches which can be centrally disconnected and are located outside the cargo holds.

The subdistribution boards shall be provided with devices indicating when they are live and which outlets are connected/disconnected.

Sockets may only be installed at locations which give adequate protection against mechanical damage.

4 Rotating machines

4.1

4.1.1 Every rotating machine is preferably to be installed with the shaft in the fore-and-aft direction. Where a rotating machine of 100 kW and over is installed athwartship, or vertically, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in Ch 2, Sec 2, Tab 4.

5 Semiconductor converters

5.1 Semiconductor power converters

5.1.1 Naturally air-cooled semiconductor converters are to be installed such that the circulation of air to and from the stacks or enclosures is not impeded and that the temperature of the cooling inlet air to converter stacks does not exceed the ambient temperature for which the stacks are specified.

6 Switchgear and controlgear assemblies

6.1 Main switchboards

6.1.1 Switchboards are to be installed in easily accessible and adequately ventilated spaces in which no flammable gases can gather. They are to be protected against water and mechanical damage.

Switchboards on the floorplates over the bilges shall be closed from below.

Pipes and air trunks are to be so arranged that any leakage does not endanger the switchgear. Where the routing of pipes and trunks close to switchboards cannot be avoided, they are to have no flanged or screwed joints in this section.

Cabinets and recesses for housing switchboards shall be made of non-combustible material (see Ch 4, Sec 1, [2.14] for definition) or shall be protected by a metal or other fireproof lining. The doors of cabinets and recesses are to bear a notice drawing attention to the switchboard installed therein. A service passageway at least 0,6 m wide is to be provided in front of switchboards.

6.1.2 A service passageway of not less than 0,5 m behind the switchboard is called for only when required by its construction or maintenance.

6.1.3 In the case of voltages over 50 V, insulating gratings or mats shall be placed behind the switchboards and in front of their control sides. No live parts may be mounted on the front side of switchboards.

Parts located to the rear of an open switchboard and carrying voltages of more than 50 V shall be protected against contact up to a height of 0,3 m.

7 Cables

7.1 Cable laying

7.1.1 Cables from generators and all cables going out from the main or emergency switchboard up to the distribution boards or the power consumers themselves shall be laid undivided and in a single length. The same applies to all connecting cables in essential systems. Exemptions are subject to the Society's express approval (e.g. for vessel extensions or barrier containers at the movable cable loop below the wheelhouse).

For elastically mounted machinery and equipment, adequate freedom of movement shall be ensured by compensation bends.

7.1.2 In DC systems without hull return multi-core cables are to be used for the smaller cross-sections. When using single-core cables for large cross-sections, the outgoing and return lines shall be laid as close as possible to each other over their entire length to avoid stray magnetic fields.

7.1.3 In 3-phase systems without hull return, 3-core cables are to be used for 3-phase connections; and 4-core cables are to be used for circuits with charged neutral. The use of a 3-core cable and a separate neutral conductor is only permissible if the current in the latter does not exceed 20 A.

7.1.4 In single or 3-phase AC systems, single-core cables carrying a current above 20 A are to be avoided. If such a method of installation cannot be avoided, the measures to be taken are to be agreed with the Society.

7.1.5 Cables whose maximum permissible temperature of the conductor differ by more than 5 K from each other may be laid in a common bundle only if the permissible loadings of the lowest-capacity type are taken as the basis for all cables.

7.1.6 Should it be impossible to use multi-core cables in accordance with [7.1.3] in single or 3-phase AC systems because of the connection difficulties associated with high power ratings, approval may be given for the laying of single-core cables and wires subject to compliance with special requirements which are to be agreed with the Society in each case.

7.1.7 Tab 2 indicates the minimum internal radius of curvature of cable bends according to the type and outside diameter of the cable concerned.

Table 2 : Minimum internal radius of curvature

Outer diameter D of cable (mm)	Cables without metal sheath or braid	Cables with metal sheath or braid
$D \leq 25$	4 D	6 D
$D > 25$	6 D	6 D

7.2 Fastening of cables and wires

7.2.1 Cables are to be fastened to trays or carriers. Individually run cables are to be fixed with clips.

7.2.2 Cables and wires are to be fastened with clips, straps or bindings made of galvanized steel strip, copper or brass strip.

Other established fastenings approved by the Society may also be used.

Cadmium coated or galvanized steel screws and galvanized clips or fastenings of other suitable materials are to be used for fixing cables to aluminium surfaces.

Clips used for mineral-insulated copper-sheathed cables shall be made of copper alloy if in electrical contact with the cable-sheath.

7.3 Tension relief

7.3.1 Cables are to be fastened in such a way that any tensile loads are kept within the permissible limits. This is particularly applicable to cables with a small cross-section and to those installed in vertical trays or vertical ducts.

7.4 Protection against mechanical damage

7.4.1 Cables in cargo holds, on deck and in locations where they are particularly exposed to the danger of mechanical damage, including especially cables laid up to a height of 500 mm above floor, are to be provided with additional protection in form of sheaths or ducts.

Cable coverings are to be conductively connected to the vessel's hull.

7.5 Laying of cables and wires in metal conduits or enclosed ducts

7.5.1 Conduits and ducts shall be smooth on the inside and shall have ends shaped to avoid damaging the cable covering or sheath. They are to be provided with drainage holes measuring at least 10 mm in diameter.

Bores and bending radii shall be such as to enable the cables to be inserted without difficulty.

7.5.2 Cables may only occupy up to a maximum of 40% of the clear cross-section of conduits and ducts, the aggregate cross-section of the cables being the sum of the individual cross-sections calculated from the cable diameters.

7.5.3 Extensive cable ducts and conduits are to be fitted with inspection and draw containers.

7.6 Laying of cables and wires in non-metal conduits or enclosed ducts

7.6.1 The conduits or ducts shall be made of flame-retardant material.

7.7 Bulkheads and deck penetrations

7.7.1 Where cables pass through bulkheads or decks, the cable penetrations shall not impair the mechanical strength, watertightness or fire resistance of the bulkheads and decks concerned.

7.7.2 Cable lead-throughs in watertight bulkheads or decks are to take the form of individual gland-type lead-throughs or, in the case of cable bundles, collective lead-throughs of a type approved by the Society. Sealing may be effect with casting resins or elastic plugs.

If casting resin is used, the cables shall be run and encased in the resin over a length of at least 150 mm inside the lead-through.

7.8 Cables in refrigerated spaces

7.8.1 Cables may be laid neither in nor directly upon the thermal insulation of these spaces. They are to be installed on perforated metal plates or spacing clips clear of the covering of the insulating layer. Excepted from this are individual cables with plastic outer sheathing, which may be laid directly on the insulation covering.

7.9 Cable laying to wheelhouses using extending cable feeds (movable loops)

7.9.1 The following points are to be specially considered when selecting and laying the cables for variable-height wheelhouse and control platforms:

- choice of cable types possessing the necessary flexibility and resistance to oil and to high and low temperatures (e.g. HO7RN-F)
- use of increased bending radii at locations subject to severe mechanical loads
- cable attachment using metal cable straps or clips
- suitable protection against mechanical damage.

7.10 Cables junctions and branches

7.10.1 Branches from cables and wires may only be made inside containers.

7.10.2 Junction and distribution containers shall be located in easily accessible positions and shall be clearly marked.

7.10.3 As a general principle, only one circuit shall be led through any one box. Should it be necessary to lead a larger number of circuits through one box, the terminals are to be so arranged that similar circuits are adjacent to each other. The terminals for dissimilar systems or for systems with different working voltages are to be separated from each other by partitions. All terminals are to be clearly and indelibly marked. A terminal connection diagram is to be mounted on the box cover.

7.10.4 It is necessary to effect the continuous conductive connection of all metal cable sheaths, particularly inside cable distribution and junction containers.

Metal cable sheaths, armouring, screening and shielding shall normally be conductively connected to the vessel's hull at both ends. In the case of single-core cables in single phase AC systems, only one end is to be earthed. The earthing at one end only of cables and wires in electronic systems is recommended.

8 Various appliances

8.1 Lighting fittings

8.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

Note 1: Where the temperature of terminals of lighting fittings exceeds the maximum conductor temperature permitted for the supplied cable (see Ch 2, Sec 9, [3.1]), special installation arrangements, such as terminal boxes thermally insulated from the light source, are to be provided.

8.1.2 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

8.1.3 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

8.1.4 Emergency lights are to be marked for easy identification.

8.2 Heating appliances

8.2.1 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

Note 1: To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself.

8.2.2 Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

8.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

8.3 Heating cables and tapes or other heating elements

8.3.1 Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials.

Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

SECTION 13 ELECTRICAL PROPULSION PLANTS

1 General

1.1

1.1.1 A vessel has an electrical main propulsion plant if the main drive to the propeller is provided by at least one electrical propulsion motor.

1.1.2 If a propulsion plant has only one propulsion motor and the vessel has no additional propulsion system which ensures sufficient propulsive power, this plant shall be so structured that following a fault in the static converter or in the regulation- and control system at least a limited propulsion capability remains.

1.1.3 Auxiliary propulsion plants are additionally propulsion systems.

1.1.4 The engines driving the generators for the electrical propulsion plant are main engines. Motors driving the propeller shaft are propulsion motors.

1.1.5 If electrical main propulsion plants are supplied from the vessel's general mains, this Section applies also to the generators and the associated switchgear. For auxiliary propulsion plants, the requirements of this Section are to be met correspondingly.

2 Drives

2.1 Basis for dimensioning

2.1.1 The electrical machinery and plants must, in accordance with their service and operating conditions, be designed for short periods of overload and for the effect of manoeuvres.

2.1.2 The lubrication of machinery and shafting shall be designed to be adequate for the entire speed range of rotation in both directions including towing.

2.2 Main engines

2.2.1 The main engines must also conform to the requirements of Part C, Chapter 1, Machinery and systems.

2.2.2 The diesel governors must allow safe operation over the whole speed range and under all running and manoeuvring conditions, this for both, single operation and parallel operation.

2.2.3 The main engines shall be so constructed that under the consideration of the plant conception they can absorb the reverse power arising during reversing manoeuvres.

2.3 Propulsion motors

2.3.1 The propulsion motors must also conform to the requirements of Ch 2, Sec 1 to Ch 2, Sec 12.

2.3.2 The effects of the harmonics of currents and voltages is to be taken into consideration for the design of the propulsion motors.

2.3.3 The winding insulation shall be designed to withstand the overvoltages which may arise from manoeuvres switching operations.

2.3.4 Machines with forced ventilation shall be so dimensioned that in case of ventilation failure a limited operation is still possible. Versions deviating from this principle require an agreement with the Society.

2.3.5 Electrical propulsion motors must be able to withstand without damage a short circuit at their terminals and in the system under rated operating conditions until the protection devices respond.

3 Static converter installations

3.1

3.1.1 Power-electronic equipment must also conform to the requirements of Ch 3, Sec 4, [2].

3.1.2 Static converters must be designed for the load to be expected under all operating and manoeuvring conditions, including overloads and short circuits.

3.1.3 If static converters are separately cooled, the plant must be capable to continue operation at reduced power level if the cooling system fails.

3.1.4 The circuits for main power supply and exciter equipment must be supplied directly from the switchboard and shall be separate for each motor and each winding.

3.1.5 Exciter circuits whose failure can endanger the operation shall only be protected against short circuit.

3.1.6 The static converters must be easily accessible for inspection, repair and maintenance.

4 Control stations

4.1

4.1.1 Should the remote control system fail, local operation must be possible. Changeover must be possible within a reasonably short time. This operation can be made, e.g. from the control cabinet of the propulsion plant. Voice communication with the bridge shall be provided.

4.1.2 The main control station on the bridge shall be provided with an emergency stop device independent of the operating elements of the main control system. Also an emergency stop device in the engine room shall be provided.

4.1.3 All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

4.1.4 A defect in a system for synchronizing or in a position equalization device for control operating levers of several control stations shall not result in the failure of the remote control from the main control position.

5 Vessel's mains

5.1

5.1.1 It must be possible to connect and disconnect generators without interrupting the propeller drive.

5.1.2 If a power management system is available, the automatic stop of main engines during manoeuvring shall be prevented.

6 Control and regulating

6.1

6.1.1 If computer systems are used, the requirements of Ch 3, Sec 3 shall be observed.

6.1.2 An automatic power limitation of the propulsion motors must ensure that the vessel mains will not be overloaded.

6.1.3 The reverse power during reversing or speed-reducing manoeuvres shall be limited to the acceptable maximum values.

7 Protection of the plant

7.1

7.1.1 Automatic stop of the propulsion plant, which impairs the vessel's manoeuvring capability, shall be limited to such failures which would result in serious damage within the plant.

7.1.2 Protection devices must be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring.

7.1.3 Defects in reducing and stopping devices shall not impair the limited operation in accordance with [1.1.2].

7.1.4 In the event of failure of an actual or reference value it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will be not reversed or dangerous operating conditions arise. The same applies to failure of the power supply for control and regulating.

7.1.5 The following additional protection equipment shall be provided:

- where drives uncontrolled can be mechanically blocked, they must be provided with protection devices which prevents damage to the plant
- overspeed protection
- protection against overcurrent and short circuit
- differential protection and earth fault monitoring for propulsion motors with an output of more than 1500 kW.

7.1.6 The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition must remain recognizable even after switching-off.

8 Measuring, indicating, monitoring and alarms equipment

8.1 General

8.1.1 Failures in measuring, monitoring and indicating equipment must not cause a failure of control and regulating.

8.2 Measuring equipment and indicators

8.2.1 Propulsion motors and generators shall be provided with at least the measuring equipment and indicators at control stations in compliance with [8.2.2] and [8.2.3].

8.2.2 The following equipment shall be provided at local control station:

- ammeter and voltmeter for each supply and each load component
- ammeter and voltmeter for each exciter circuit
- revolution indicator for each shaft
- plant ready for switching on
- plant ready for operation
- plant disturbed
- power reduced
- control from the bridge
- control from local control station.

8.2.3 The following equipment shall be provided at main control station on the bridge:

- revolution indicator per shaft
- indication of the power remaining available for the propulsion plant in relation to the total available vessel's main power; the indication of remaining power may be omitted in the case of power management system
- plant ready for switching on
- plant ready for operation
- plant disturbed
- power reduced
- request to reduce
- control from the bridge
- control from the local control station.

8.3 Monitoring equipment

8.3.1 Abnormal values of the different parameters of the following equipment should trigger an alarm which has been signalled optically and audibly:

a) monitoring of the ventilators and temperatures of the cooling air for forced-ventilation of machines, transformers and static converters
b) monitoring of the flow rate and leakage of coolants of machines and static converters with closed cooling systems
c) instead of the monitoring of air flow and flow rate (items a) and b)) of machines and transformers, winding-temperature monitoring can be provided
d) for machines above 1500 kW, temperature monitoring for the stator windings and the bearings
e) pressure or flow monitoring for the lubricating oil of friction bearings (except in the case of ring)
f) insulation resistance in the case of unearthed networks.

8.4 Power reduction

8.4.1 In the case abnormal operating power may be automatically reduced, this information is to be indicated at the propulsion control position.

9 Cables and cable installation

9.1 General

9.1.1 The cable network for electrical propulsion plants must comply with the requirements of Ch 2, Sec 9. If there is more than one propulsion unit, the cables of any one unit shall, as far as is practicable, be run over their entire length separately from the cables of the other units.

10 Testing and trials

10.1 General

10.1.1 A quality assurance plan has to be submitted to the Society.

10.1.2 Tests of machines, static converters, switchgear, equipment and cables shall be carried out at the maker's works in accordance with applicable requirements of this Chapter.

10.1.3 Shaft material for generators and propulsion motors

Tests of steel and Iron materials, shall be made by a shaft material test as for vessel's shafting.

10.1.4 The testing of other important forgings and castings for electrical main propulsion plants, e.g. rotors and pole shoe bolts, shall be agreed with the Society.

10.2 Tests after installation

10.2.1 Newly-constructed or enlarged plants require testing and trials on board.

The scope of the trials is to be agreed with the Society.

10.2.2 Dock trial

For scope and extent of dock trials, see Ch 2, Sec 14, [4.1.6].

10.2.3 River trial

For river trial programme, see Ch 2, Sec 14, [5.2].

SECTION 14 TESTING

1 General

1.1

1.1.1 The tests are divided into:

- tests during construction
- tests during commissioning
- tests during trial voyages.

2 Type approvals

2.1 General

2.1.1 The installations, equipment and assemblies mentioned in [2.1.5] are subject to mandatory type approval.

2.1.2 Type tests shall be carried out in the presence of Society's Surveyor either in the manufacturer's works or, by agreement, in suitable institutions.

2.1.3 Type tests are carried out according to the Society's Rules for approval of equipment.

2.1.4 Type tested installations, apparatuses and assemblies shall be used within the scope of valid construction Rules only. The suitability for the subject application shall be ensured.

2.1.5 Installations, equipment and assemblies subject to type approval

The following installations, equipment and assemblies are subject to type approval:

a) generators, power ≥ 50 kW/kVA

b) electrical machines, power ≥ 50 kW/kVA

c) transformers, power ≥ 50 kW/kVA

d) storage batteries

e) storage battery chargers, power ≥ 2 kW

f) switchgear

g) cables and insulated wires

h) control, monitoring, alarm and safety systems

i) power electronics, power ≥ 50 kW/kVA

j) computer systems: class 3, class 4 and class 5.

2.2 Exceptions

2.2.1 Instead of the stipulated type approvals in well-founded cases routine tests in the presence of a Surveyor may be carried out. An agreement with the Society prior to testing is required.

3 Tests during construction

3.1

3.1.1 During the period of construction of the vessel, the installations shall be checked for conformity with the documents reviewed/approved by the Society and with the Rules for construction.

3.1.2 Test certificates for tests which have already been performed shall be presented to the Surveyor on request.

3.1.3 Protective measures

a) protection against foreign bodies and water

b) protection against electric shock, such as protective earthing, protective separation or other measures as stated in Ch 2, Sec 8, [1.1.4]

c) measures of explosion protection.

3.1.4 Testing of the cable network

Inspection and testing of cable installation and cable routing with regard to:

a) acceptability of cable routing with regard to:
   - separation of cable routes
   - fire safety
   - reliable supply of emergency consumers (where applicable)

b) selection and fixation of cables

c) construction of bulkhead and deck penetrations

d) insulation resistance measurement.

4 Testing during commissioning of the electrical equipment

4.1

4.1.1 General

Proofs are required of the satisfactory condition and proper operation of the main and emergency power supply systems, the steering gear and the aids of manoeuvring, as well as of all the other installations specified in the Rules for construction.

Unless already required in the Rules for construction, the tests to be performed shall be agreed with the Society's Surveyor in accordance with the specific characteristics of the subject equipment.

4.1.2 Generators

A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on appropriate form.

4.1.3 Storage batteries

The following shall be tested:

a) installation of storage batteries

b) ventilation of battery rooms, cupboards/containers, and cross-sections of ventilation ducts

c) storage-battery charging equipment

d) the required caution labels and information plates.

4.1.4 Switchgear

The following items shall be tested under observance of:

a) accessibility for operation and maintenance

b) protection against the ingress of water and oil from ducts and pipes in the vicinity of the switchboards, and sufficient ventilation

c) equipment of main and emergency switchboards with insulated handrails, gratings and insulating floor coverings

d) correct settings and operation of protection devices and interlocks.

The Society reserves the right to demand the proof of selective arrangement of the vessel supply system.

4.1.5 Power plants

The following items shall be tested:

a) Motor drives together with the driven machines, which shall, wherever possible, be subjected to the most severe anticipated operating conditions

   This test shall include a check of the settings of the motors' short-circuit and overcurrent protection devices

b) The emergency remote stops of equipment such as engine room fans and boiler blowers

c) Closed loop controls, open loop controls and all electric safety devices.

4.1.6 Electrical propulsion plant

Functioning of the propulsion plant shall be proved by a dock trial before navigation trials.

At least the following trials/measurements shall be carried out in the presence of the Society Surveyor:

- start-up, loading and unloading of the main and propulsion motors in accordance with the design of the plant and a check of regulation, control and switchgear
- verification of propeller speed variation and all associated equipment
- verification of protection, monitoring and indicating/alarm equipment including the interlocks for sufficient functioning
- verification of insulation condition of the main-propulsion circuits.

5 Testing during trial voyages

5.1 General

5.1.1 Proof is required that the power supply meets the requirements under the various operating conditions of the vessel. All components of the system must function satisfactorily under service conditions, i.e. at all main engine speeds and during all manoeuvres.

5.2 Electrical propulsion plant

5.2.1 Trial programme

The trial programme shall at least include:

a) Continuous operation of the vessel at full propulsion load until the entire propulsion plant has reached steady-state temperatures.

   The trials shall be carried out at rated engine speed and with an unchanged governor setting:

   - at 100% power output (rated power): at least 2 hours
   - with the propeller running astern during the dock test or during the river trial at a minimum speed of at least 70% of the rated propeller speed: 10 minutes.

b) Reversal of the plant out of the steady-state condition from full power ahead to full power astern and maintaining of this setting until at least the vessel has lost all speed. Characteristic values such as speed, system currents and voltages, and the load sharing of the generators, shall be recorded. If necessary, oscillograms shall be made

c) Performance of typical manoeuvres

d) Checking of the machinery and plant in all operating conditions

e) Checking of the network qualities in the vessel's propulsion network and mains.

Part C
Machinery, Electricity and Fire

Chapter 3
AUTOMATION

SECTION 1 GENERAL REQUIREMENTS

SECTION 2 DESIGN REQUIREMENTS

SECTION 3 COMPUTER BASED SYSTEMS

SECTION 4 CONSTRUCTIONAL REQUIREMENTS

SECTION 5 INSTALLATIONS REQUIREMENTS

SECTION 6 TESTING

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Field of application

1.1.1 The following requirements apply to automation systems, installed on all vessels, intended for essential services as defined in Pt A, Ch 1, Sec 1, [1.3]. They also apply to systems required in Part C, Chapter 1 and Part C, Chapter 2, installed on all vessels.

1.1.2 This chapter is intended to avoid that failures or malfunctions of automation systems associated with essential and non-essential services cause danger to other essential services.

1.1.3 Requirements for unattended machinery spaces and for additional notations are specified in Pt D, Ch 2, Sec 8.

1.2 Regulations and standards

1.2.1 The regulations and standards applicable are those defined in Ch 2, Sec 1.

1.3 Definitions

1.3.1 Unless otherwise stated, the terms used in this chapter have the definitions laid down in Ch 2, Sec 1 or in the IEC standards. The following definitions also apply:

- Alarm indicator is an indicator which gives a visible and/or audible warning upon the appearance of one or more faults to advise the operator that his attention is required.
- Alarm system is a system intended to give a signal in the event of abnormal running condition.
- Application software is a software performing tasks specific to the actual configuration of the computer based system and supported by the basic software.
- Automatic control is the control of an operation without direct or indirect human intervention, in response to the occurrence of predetermined conditions.
- Automation systems are systems including control systems and monitoring systems.
- Basic software is the minimum software, which includes firmware and middleware, required to support the application software.
- Cold standby system is a duplicated system with a manual commutation or manual replacement of cards which are live and non-operational. The duplicated system is to be able to achieve the operation of the main system with identical performance, and be operational within 10 minutes.
- Control station is a group of control and monitoring devices by means of which an operator can control and verify the performance of equipment.
- Control system is a system by which an intentional action is exerted on an apparatus to attain given purposes.
- Fail safe is a design property of an item in which the specified failure mode is predominantly in a safe direction with regard to the safety of the ship, as a primary concern.
- Full redundant is used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function and operate simultaneously.
- Hot standby system is used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function, one of which is in operation while the other is on standby with an automatic change-over switch.
- Instrumentation is a sensor or monitoring element.
- Local control is control of an operation at a point on or adjacent to the controlled switching device.
- Monitoring system is a system designed to observe the correct operation of the equipment by detecting incorrect functioning (measure of variables compared with specified value).
- Safety system is a system intended to limit the consequence of failure and is activated automatically when an abnormal condition appears.
- Redundancy is the existence of more than one means for performing a required function.
- Remote control is the control from a distance of apparatus by means of an electrical or other link.
- Inspection of components (only hardware) from sub-suppliers: proof that components and/or sub-assemblies conform to specification.
- Quality control in production: evidence of quality assurance measures on production.
- Final test reports: reports from testing of the finished product and documentation of the test results.
- Hardware description:
  - system block diagram, showing the arrangement, input and output devices and interconnections
  - connection diagrams
  - details of input and output devices
  - details of power supplies.

- Failure analysis for safety related functions only (e.g. FMEA): the analysis is to be carried out using appropriate means, e.g.:
  - fault tree analysis
  - risk analysis
  - FMEA or FMECA.

  The purpose is to demonstrate that for single failures, systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by the Society.

1.4 General

1.4.1 The automation systems and components, as indicated in Ch 2, Sec 14, [2], are to be chosen from among the list of type approved products.

They are to be approved on the basis of the applicable requirements of these Rules and in particular those stated in this Chapter.

Case by case approval may also be granted at the discretion of the Society, based on submission of adequate documentation and subject to the satisfactory outcome of any required tests.

1.4.2 Control, alarm and safety systems are to be based on the fail-to-safety principle.

1.4.3 Failure of automation systems is to generate an alarm.

1.4.4 Detailed indication, alarm and safety requirements regarding automation systems for individual machinery and installations are to be found in Ch 3, Sec 2, Tab 1 andPt D, Ch 2, Sec 8, Tab 2.

Each row of these tables is to correspond to one independent sensor.

2 Documentation

2.1 General

2.1.1 Before the actual construction is commenced, the Manufacturer, Designer or Shipbuilder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in this Section.

The list of documents requested is to be considered as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Plans are to include all the data necessary for their interpretation, verification and approval.

2.2 Documents to be submitted

2.2.1 The documents listed in Tab 1 are to be submitted.

2.3 Documents for type approval of equipment

2.3.1 Documents to be submitted for type approval of equipment are listed hereafter:

- a request for type approval from the manufacturer or his authorized representative
- the technical specification and drawings depicting the system, its components, characteristics, working principle, installation and conditions of use and documents related to computer based system, if any.
- any test reports previously prepared by specialized laboratories.

Table 1 : Documentation to be submitted

No	I/A **(1)**	Documentation
1	I	The general specification for the automation of the vessel
2	A	The detailed specification of the essential service systems
3	A	The list of components used in the automation circuits, and references (Manufacturer, type, etc.)
4	I	Instruction manuals
5	I	Test procedures for control, alarm and safety systems
6	A	A general diagram showing the monitoring and/or control positions for the various installations, with an indication of the means of access and the means of communication between the positions as well as with the engineers
7	A	The diagrams of the supply circuits of automation systems, identifying the power source
8	A	The list of monitored parameters for alarm/monitoring and safety systems
9	A	Diagram of the engineers' alarm system
10	I	List of computerized systems
11	A / I	Documentation related to computer based system, if any
12	I	Software Registry
(1) A = to be submitted for approval; I = to be submitted for information.		

2.3.2 Modifications

Modifications are to be documented by the manufacturer. Subsequent significant modifications to the software and hardware for systems of categories II and III are to be submitted for approval.

Note 1: A significant modification is a modification which influences the functionality and/or the safety of the system.

3 Environmental and supply conditions

3.1 General

3.1.1 The automation system is to operate correctly when the power supply is within the range specified in Ch 3, Sec 2, [2].

3.1.2 Environmental conditions

The automation system is to be designed to operate satisfactorily in the environment in which it is located. The environmental conditions are described in Ch 2, Sec 2, [1].

3.1.3 Failure behaviour

The automation system is to have non-critical behaviour in the event of power supply failure, faults or restoration of operating condition following a fault. If a redundant power supply is used, it must be taken from an independent source.

3.2 Power supply conditions

3.2.1 Electrical power supply

The conditions of power supply to be considered are defined in Ch 2, Sec 2, [2].

3.2.2 Pneumatic power supply

For pneumatic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 10, [17].

3.2.3 Hydraulic power supply

For hydraulic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 10, [14].

4 Materials and construction

4.1 General

4.1.1 The choice of materials and components is to be made according to the environmental and operating conditions in order to maintain the proper function of the equipment.

4.1.2 The design and construction of the automation equipment is to take into account the environmental and operating conditions in order to maintain the proper function of the equipment.

4.2 Type approved components

4.2.1 See Ch 2, Sec 14, [2].

5 Alterations and additions

5.1

5.1.1 When an alteration or addition to an approved system is proposed, plans are to be submitted and approved by the Society before the work of alteration or addition is commenced.

5.1.2 A test program for verification and validation of correct operation is to be made available.

5.1.3 Where the modifications may affect compliance with the rules, they are to be carried out under survey and the installation and testing are to be to the Surveyor’s satisfaction.

SECTION 2 DESIGN REQUIREMENTS

1 General

1.1 General requirements

1.1.1 The design of safety measures, open and closed loop controls and monitoring of equipment must limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

1.1.2 Where appropriate, the following basic requirements shall be observed:

- compatibility with the environmental and operating conditions
- compliance with accuracy requirements
- recognizability and constancy of the parameter settings, limiting and actual values
- compatibility of the measuring, open and closed loop controls and monitoring systems with the process and its special requirements
- immunity of system elements to reactive effects in overall system operation
- non-critical behaviour in the event of power failure, restoration and of faults
- unambiguous operation
- maintainability, the ability to recognize faults and test capability
- reproducibility of values.

1.1.3 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

1.1.4 If dangers to persons or the safety of the vessel arising from normal operation or from faults or malfunctions in machinery or plant, or in control, monitoring and measuring systems, cannot be ruled out, safety devices or safety measures are required.

1.1.5 If dangers to machinery and systems arising from faults or malfunctions in control, monitoring and measuring systems cannot be ruled out, protective devices or protective measures are required.

1.1.6 Where mechanical systems or equipment are either completely or partly replaced by electric / electronic equipment, the requirements relating to mechanical systems and electric/electronic equipment shall be met accordingly.

1.2 Design and construction

1.2.1 Machinery alarm systems, protection and safety systems, together with open and closed loop control systems for essential equipment shall be constructed in such a way that faults and malfunctions affect only the directly involved function. This also applies to measuring facilities.

1.2.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities must be provided to permit independent manual operation.

Manual operation shall override all remote and automatical control.

1.2.3 In the event of disturbances automatically switched off plants shall not be released for restarting until having been manually unlocked.

1.3 Application of computer systems

1.3.1 If computer systems are used, Ch 3, Sec 3 has to be observed.

1.4 Maintenance

1.4.1 Access must be provided to systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps etc. are to be provided to allow functional checks to be carried out and faults to be located.

1.4.2 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

1.4.3 Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign must be fitted to indicate the risk.

1.4.4 Circuit boards and plug-in connections must be protected against unintentional mixing up. Alternatively they must be clearly marked to show where they belong to.

2 Power supply of automation systems

2.1

2.1.1 Automation systems are to be arranged with an automatic change-over to a continuously available stand-by power supply in case of loss of normal power source.

2.1.2 The capacity of the stand-by power supply is to be sufficient to allow the normal operation of the automation systems for at least half an hour.

2.1.3 Failure of any power supply to an automation system is to generate an audible and visual alarm.

2.1.4 Power supplies are to be protected against short circuit and overload for each independent automation system.

Power supplies are to be isolated.

3 Control systems

3.1 General

3.1.1 In the case of failure, the control systems used for essential services are to remain in the last position they had before the failure, unless otherwise specified by these Rules.

3.2 Local control

3.2.1 Each system is to be able to be operated manually from a position located so as to enable visual control of operation. For detailed instrumentation for each system, refer to Part C, Chapter 1 and Part C, Chapter 2.

3.2.2 Local control systems is to be self-contained and not depend on other systems or external communication links for its intended operation.

3.2.3 When local control is selected, any control signal(s) from the remote control system is to be ignored.

3.3 Remote control systems

3.3.1 When several remote control stations are provided, control of machinery is to be possible at one station at a time. At each location, an indicator showing which location is in control is to be provided.

3.3.2 Remote control is to be provided with the necessary instrumentation, in each remote control station, to allow effective control (correct function of the system, indication of control station in operation, alarm display).

3.3.3 When transferring the control location, no significant alteration of the controlled equipment is to occur. Transfer of control is to be protected by an audible warning and acknowledged by the receiving remote control location. The main remote control location is to be able to take control without acknowledgment.

3.3.4 Failure in remote control systems is not to prevent local operation.

3.4 Automatic control systems

3.4.1 Automatic control is to be stable in the range of the controller in normal working conditions.

3.4.2 Automatic control is to have instrumentation to verify the correct function of the system.

3.4.3 For machinery systems which due to their complexity requires continuous automatic control, manual control of the individual Equipment Under Control may not be feasible. In such cases, local means are to be provided to both monitor the concerned process- and to enable/disable any automatic functions / modes (a typical example is the gas supply system to a gas fuelled engine).

4 Machinery control and monitoring installations

4.1 Open loop control

4.1.1 Main engines and essential equipment shall be provided with effective means for the control of its operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems, see also [1.1.2].

4.1.2 Control equipment must have built-in protection features where incorrect operation would result in serious damage or in the loss of essential functions.

4.1.3 The consequences of control commands must be indicated at the respective control station.

4.1.4 Controls shall correspond with regard to their position and direction of operation to the system being controlled respective to the direction of motion of the vessel.

4.1.5 It shall be possible to control the essential equipment at or near to the equipment concerned.

4.1.6 Where controls are possible from several control stations, the following shall be observed:

- Competitive commands shall be prevented by suitable interlocks. The control station in operation must be recognizable as such.
- Taking over of command shall only be possible with the authorization of the user of the control station which is in operation.
- Precautions shall be taken to prevent changes to desired values due to a change-over in control station.

4.1.7 Open loop control for speed and power of main engines are subject to mandatory type testing.

4.2 Closed loop control

4.2.1 Closed loop control shall keep the process variables under normal conditions within the specified limits.

4.2.2 Closed loop controls must maintain the specified reaction over the full control range. Anticipated variations of the parameters must be considered during the planning.

4.2.3 Defects in a control loop shall not impair the function of operationally essential control loops.

4.2.4 The power supply of operationally essential control loops shall be monitored and power failure must be signalled by an alarm.

4.2.5 Closed loop control for speed and power of main engines are subject to mandatory type testing.

4.3 Integration of systems for essential equipment

4.3.1 The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

4.3.2 A defect in one of the subsystems (individual module, unit or subsystem) of the integrated system shall not affect the function of other subsystems.

4.3.3 Any failure in the transfer of data of autonomous subsystems which are linked together shall not impair their independent function.

4.3.4 Essential equipment must also be capable of being operated independently of integrated systems.

4.4 Control of machinery installations

4.4.1 Machinery installations are to be equipped with monitoring equipment as detailed in Tab 1.

Table 1 : Control and monitoring of machinery installations

Symbol convention H = High, HH = Very high, L = Low I = Individual alarm, G = Group alarm		Monitoring				
Identification of system parameter		Alarms	Indication local	Alarms wheelhouse **(1)**	Indication wheelhouse	Shut down
MAIN ENGINE						
Engine speed	All engines		X			
	Engine power > 220kW	HH	X	G		X
Shaft revolution indicator			X			
Lubricating oil pressure		L	X	G		
Lubricating oil temperature		H	X	G		
Fresh cooling water system inlet pressure **(2)**		L	X	G		
Fresh cooling water system outlet temperature **(2)**		H	X	G		
Fuel oil temperature for engines running on HFO		L	X	G		
Exhaust gas temperature (single cylinder when the dimensions permit)			X			
Starting air pressure		L	X	G	X	
Charge air pressure			X			
Control air pressure			X			
Exhaust gas temperature at turbocharger inlet/outlet (where the dimensions permit)			X			
Manual emergency stop of propulsion		X	X			X **(3)**
Fault in the electronic governor		X	X	G		
REDUCTION GEAR						
Tank level			X			
Lubricating oil temperature			X			
Lubricating oil pressure			X			
AUXILIARY MACHINE **(4)**						
Engine speed	All engines		X			
	Engine power > 220 kW	HH	X	G		X
Low pressure cooling water system **(2)**		L	X	G		
Fresh cooling water system outlet temperature **(2)**		H	X	G		
Lubricating oil pressure		L	X	G		
Fault in the electronic governor		X	X	G		
DIESEL BOW THRUSTER **(4)**						
Engine speed	All engines		X			
	Engine power > 220 kW	HH	X	G		X
Low pressure cooling water system **(2)**		L	X	G		
Fresh cooling water system outlet temperature **(2)**		H	X	G		
Direction of propulsion			X			
Lubricating oil pressure		L	X	G		
Lubricating oil temperature			X			
Fault in the electronic governor		X	X	G		

Symbol convention H = High, HH = Very high, L = Low I = Individual alarm, G = Group alarm	Monitoring				
Identification of system parameter	Alarms	Indication local	Alarms wheelhouse **(1)**	Indication wheelhouse	Shut down
PROPULSION					
Propulsion remote control ready		X			
Pitch control		X			
ELECTRICITY					
Earth fault (when insulated network)	X	X	G		
Main supply power failure	X	X	G		
FUEL OIL TANKS					
Fuel oil level in service tank or tanks supplying directly services essential for safety or navigation	L	X	G		
STEERING GEAR					
Rudder angle indicator		X		X	
Level of each hydraulic fluid	L	X	I	X	
Indication that electric motor of each power unit is running		X		X	
Failure of rate of turn control	X		I	X	
Overload failure	X	X	I	X	
Phase failure	X	X	I	X	
Loss of power supply	X	X	I	X	
Loss of control supply	X	X	I	X	
STEAM BOILER					
Water level	L+H	X			
	LL				X
Circulation stopped (when forced circulation boiler)	X				X
Flame failure	X				X
Temperature in boiler	H				
Steam pressure	HH	X			X
THERMAL OIL					
Thermal fluid temperature heater outlet	H	X			X **(5)**
Thermal fluid pressure pump discharge	H	X			X
Thermal fluid flow through heating element	L	X			
	LL				X **(5)**
Expansion tank level	L	X			
	LL				X **(6)**
Expansion tank temperature	H				
Forced draft fan stopped	X				X
Burner flame failure	X				X
Flue gas temperature heater outlet	H				
	HH				X **(6)**
FIRE					
Fire detection	X			X	
Fire manual call point	X			X	
Automatic fixed fire extinguishing system activation, if fitted	X			X	
FLOODING					
Level of machinery space bilges/drain wells	X			X	

Symbol convention H = High, HH = Very high, L = Low I = Individual alarm, G = Group alarm	Monitoring				
Identification of system parameter	Alarms	Indication local	Alarms wheelhouse **(1)**	Indication wheelhouse	Shut down
ALARM SYSTEM					
Alarm system power supply failure	X	X		X	

(1) Group of alarms are to be detailed in the machinery space or control room (if any).
(2) A combination of level indication/alarm in expansion tank and indication/alarm cooling water temperature can be considered as equivalent with consent of the Society.
(3) Openings of clutches can, with the consent of the Society, be considered as equivalent.
(4) Exemptions can be given for diesel engines with a power of 50 kW and below.
(5) Shut-off of heat input only.
(6) Stop of fluid flow and shut-off of heat input.

4.4.2 The remote control shall be capable to control speed, direction of thrust, and as appropriate torque or propeller pitch without restriction under all navigating and operating conditions.

4.4.3 Single lever control is to be preferred for remote control systems. Lever movement shall be in accordance to the desired course of the vessel. Commands entered into the remote control system from the wheelhouse must be recognizable at all control stations.

4.4.4 The remote control system shall carry out commands which are ordered, including emergency manoeuvres, in accordance with the propulsion plant manufacturer's specifications.

Where critical speed ranges are incorporated, their quick passing is to be guaranteed and a reference input within them have to be inhibited.

4.4.5 With each new command, stored commands must be erased and replaced by the new input.

4.4.6 In the case of set speed stages, a facility must be provided to change the speed in the individual stages.

4.4.7 An overload limitation facility is to be provided for the propulsion machinery.

4.4.8 It must be possible to stop the propeller thrust from the wheelhouse independently of the remote control system.

4.4.9 Following emergency manual shutdown or automatic shutdown of the main propulsion plant, a restart shall only be possible via the stop position of the command entry.

4.4.10 The failure of the remote control system and of the control power shall not result in any sudden change in the propulsion power nor in the speed and direction of rotation of the propeller. In individual cases, the Society may approve other failure conditions, whereby it is assumed that:

- there is no increase in vessel's speed
- there is no course change
- no unintentional start-up processes are initiated.

Local control must be possible from local control positions. The local control positions are to be independent from remote control of propulsion machinery and continue to operate 15 minutes after a blackout.

4.4.11 The failure of the remote control system and of the control power is to be signalled by an alarm.

4.4.12 Wheelhouse and engine room are to be fitted with indicators indicating that the remote control system is operative. The wheelhouse and the machinery space are to be provided with indicators showing:

- propeller speed and direction of rotation
- pitch of controllable pitch propeller.

4.4.13 Remote control systems for main propulsion plants are subject to mandatory type approval.

4.4.14 The transfer of control between the wheelhouse and machinery space shall be possible only in the machinery area.

4.4.15 It shall be ensured that control is only possible from one control station at any time. Transfer of command from one control station to another shall only be possible when the respective control levers are in the same position and when a signal to accept the transfer is given from the selected control station. A display at each control station shall indicate whether the control station in question is in operation.

4.4.16 Each local control position, including partial control (e.g. local control of controllable pitch propellers or clutches) is to be provided with means of communication with the remote control position.

5 Alarm systems

5.1 General requirements

5.1.1 Alarm systems shall indicate unacceptable deviations from operating figures optically and audibly. The operative state of the system is to be indicated in the wheelhouse and on the equipment.

5.1.2 Optical signals shall be individually indicated. The meaning of the individual indications must be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal must remain visible until the fault has been eliminated. It must be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

5.1.3 Alarm systems shall be designed according to the closed-circuit principle or the monitored open circuit principle. Equivalent monitoring principles are permitted.

5.1.4 The power supply shall be monitored and a failure shall cause an alarm. Test facilities are required for the operation of light displays.

The alarm system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

5.2 Alarm functions

5.2.1 Alarm activation

Alarms are to be activated when abnormal conditions appear in the machinery, which need the intervention of personnel on duty, and on the automatic change-over, when standby machines are installed.

An existing alarm is not to prevent the indication of any further fault.

5.2.2 Acknowledgement of alarms

It must be possible to acknowledge audible signals. The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes.

Alarms must be discernible under all operating conditions. Where this cannot be achieved, for example due to the noise level, additional optical signals, e.g. flashing lights must be installed.

Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

5.2.3 Time delay of alarm

Alarm delays shall be kept within such time limits that any risk to the monitored system is prevented if the limit value is exceeded.

5.2.4 Pressure alarms

Pressure alarms may in general not be delayed by more than 2 s. Level alarms are to be delayed sufficiently to ensure that the alarm is not tripped by brief fluctuations in level.

5.2.5 A failure of the power supply or disconnection of the system shall not alter the limit value settings at which a fault is signalled.

5.2.6 The fault signalling systems of main engines with engine-driven pumps are to be so designed that variations in operating parameters due to manoeuvres do not trip the alarm.

5.2.7 It is recommended that input devices approved by the Society should be used.

5.2.8 It is recommended that the alarm signals should be automatically suppressed when the main engine and auxiliaries are taken out of service.

5.3 Alarms arrangements

5.3.1 Alarms are to be given at manned location in the machinery control position, if any, or in the wheelhouse and are to take the form of individual visual displays and collective audible signals. The audible alarm shall sound throughout the whole machinery space, at manned location in the machinery control position and at the wheelhouse. If this cannot be ensured because of the noise level, additional visual alarms such as flash signals shall be installed.

5.3.2 Simultaneously with a collective alarm signal, an acknowledgeable audible alarm shall be given at manned location in the machinery control position and in the wheelhouse which, following acknowledge, shall be available for further signals. It must be possible to stop audible signals independently of acknowledging the visual signal. Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the concerned process is been given.

5.3.3 Where the alarm system contents individual visual displays in the machinery space, the visual fault signals in the wheelhouse may be arranged in at least three groups as collective alarms in accordance with their urgency, if this is necessary due to the scope of the plant:

- Group 1: alarms signalling faults which require immediate shutdown of the main engine (red light)
- Group 2: alarms signalling faults which require a reduction in power of the main engine (red light)
- Group 3: alarms signalling faults which do not require Group 1 or Group 2 measures (yellow light).

6 Safety devices and systems

6.1 Safety devices

6.1.1 The design of safety devices shall be as simple as possible and must be reliable and inevitable in operation. Proven safety devices which are not depending on a power source are to be preferred.

6.1.2 The suitability and function of safety devices must be demonstrated in the given application.

6.1.3 Safety devices shall be designed so that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, vessel or machinery.

These faults and also the tripping of safety devices shall be signalled by an alarm.

6.1.4 The adjustment facilities for safety devices shall be designed so that the last setting can be detected.

6.1.5 Where auxiliary energy is needed for the function of safety devices, this has to be monitored and a failure has to be alarmed.

6.2 Safety systems

6.2.1 Safety systems shall be independent of open and closed loop control and alarm systems. Faults in one system shall not affect other systems.

Deviations from this requirement may be allowed for redundant equipment where this would entail no risk to human life and where vessel safety would not be compromised.

6.2.2 Safety systems shall be assigned to systems which need protection.

6.2.3 Where safety systems are provided with overriding arrangements, these shall be protected against unintentional operation. The actuation of overriding arrangements shall be indicated and recorded.

6.2.4 The monitored open-circuit principle shall be used for safety systems. Alternatively, the closed circuit principle shall be applied where the provisions of national Regulations demand it. (e.g. boiler and oil fired systems).

Equivalent monitoring principles are permitted. Faults, and also the tripping of safety systems shall be indicated by an alarm and recorded.

6.2.5 Safety systems shall be designed for preference using conventional technology (hard wired).

6.2.6 The power supply shall be monitored and loss of power shall be indicated by an alarm and recorded.

The power supply to the safety system is to be maintained for at least 15 minutes following a possible failure of the vessel's general supply network. Separate provision shall be made for this.

6.2.7 Safety systems are to perform the following functions when hazard limits are reached:

a) temporary adaptation of operation to the remaining possibilities (slow down or signal to reduce power)

b) protection of machinery and boilers from critical operating conditions (shutdown or signal to shut down).

Within certain limits, safety systems provide redundancy for the alarm system.

6.3 Testing

6.3.1 The safety systems are to be tested in accordance with the requirements in Ch 3, Sec 6.

SECTION 3 COMPUTER BASED SYSTEMS

1 General

1.1 Scope

1.1.1 These Rules apply additionally, if computers are used for tasks essential to the safety of the vessel, cargo, crew or passengers and are subject to classification.

1.2 References to other Rules and Regulations

1.2.1 IEC 61508 or EN 61508 “Functional safety of electrical/ electronic/ programmable electronic safety related systems”.

1.3 Requirements applicable to computer systems

1.3.1 Computer systems shall fulfill the requirements of the process under normal and abnormal operating conditions. The following shall be considered:

- danger to persons
- environmental impact
- endangering of technical equipment
- usability of computer systems
- operability of all equipment and systems in the process.

1.3.2 If process times for important functions of the system to be supervised are shorter than the reaction times of a supervisor and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

1.3.3 Computer systems shall be designed in such a way that they can be used without special previous knowledge. Otherwise, appropriate assistance shall be provided for the user.

2 Requirement classes

2.1 General requirements

2.1.1 Computer systems are assigned, on the basis of a risk analysis, to requirement classes as shown in Tab 1. This assignment shall be accepted by the Society. Tab 2 gives examples for such an assignment.

2.1.2 The assignment is divided into five classes considering the extent of the damage caused by an event.

2.1.3 Considered is only the extent of the damage directly caused by the event, but not any consequential damage.

2.1.4 The assignment of a computer system to a corresponding requirement class is made under the maximum possible extent of direct damage to be expected.

2.1.5 In addition to the technical measures stated in this section also organizational measures may be required if the risk increases. These measures shall be agreed with the Society.

2.2 Risk parameters

2.2.1 The following aspects may lead to assignment to a different requirement class, see Tab 1.

a) Dependence on the type and size of vessel:
   - number of persons endangered
   - transportation of dangerous goods
   - vessel’s speed.

b) Presence of persons in the endangered area with regard to duration respectively frequency:
   - rarely
   - often
   - very often
   - at all times.

c) Averting of danger

   To evaluate the possibility of danger averting, the following criteria shall be considered:
   - operation of the technical equipment with or without supervision by a person
   - temporal investigation into the processing of a condition able to cause a damage, the alarming of the danger and the possibilities to avert the danger.

d) Probability of occurrence of the dangerous condition

   This assessment is made without considering the available protection devices.

   Probability of occurrence:
   - very low
   - low
   - relatively high.

e) Complexity of the system:
   - integration of various systems
   - linking of functional features.

2.2.2 The assignment of a system into the appropriate requirement class shall be agreed on principle with the Society.

Table 1 : Definition of requirement classes

Requirement class	Extent of damage		
	Effects on persons	Effects on the environment	Technical damage
1	none	none	insignificant
2	slight injury	insignificant	minor
3	serious, irreversible injury	significant	fairly serious
4	loss of human life	critical	considerable
5	much loss of human life	catastrophic	loss

Table 2 : Examples of assignment into requirement classes

Requirement class	Examples
1	Supporting systems for maintenance Systems for general administrative tasks Information and diagnostic systems
2	"Off line" cargo computers Navigational instruments Machinery alarm and monitoring systems Tank capacity measuring equipment
3	Controls for auxiliary machinery Speed governors "On line" cargo computers, networked (bunkers, draughts, etc.) Remote control for main propulsion Fire detection systems Fire extinguishing systems Integrated monitoring and control systems Control systems for tank and fuel Rudder control systems Course control systems Machinery protection systems/ equipment
4	Burner control systems for boilers and thermal oil heater Electronic injection systems
5	Systems where manual intervention to avert danger in the event of failure or malfunction is no longer possible and the extent of damage under requirement class 5 can be reached

2.3 Measures required to comply with the requirement class

2.3.1 The measures to comply with the requirements of classes 4 and 5 may require for computer equipment and conventional equipment a separation or for the computer equipment a redundant, diversified design.

2.3.2 Protection against modification of programs and data

The measures required depend on the requirement class and the system configuration (see Tab 3).

Table 3 : Program and data protection measures in relation to the requirement class (examples)

Requirement class	Program/Data memory
1	Protection measures are recommended e.g. diskette, magnetic disk etc.
2	Protection against unintentional/unauthorised modification e.g. buffered RAM etc.
3	Protection against unintentional/unauthorised modification and loss of data e.g. EEPROM etc.
4	No modifications by the user possible e.g. EPROM etc.
5	No modifications possible e.g. ROM etc.

Computer systems shall be protected against unintentional or unauthorized modification of programs and data.

For large operating systems and programs, other storage media such as hard disks may be used by agreement.

Significant modifications of program contents and system specific data, as well as a change of version, shall be documented and must be retraceable.

For systems of requirement class 4 and 5 all modifications, the modifications of parameters too, shall be submitted for review / approval.

The examples of program and data protection shown in Tab 3 may be supplemented and supported by additional measures in the software and hardware, for example:

- user name, identification number
- code word for validity checking, key switch
- assignment of authorizations in the case of common use of data/withdrawal of authorizations for the change or erasing of data
- coding of data and restriction of access to data, virus protection measures
- recording of workflow and access operations.

Note 1: A significant modification is a modification which influences the functionality and/or safety of the system.

3 System configuration

3.1 General requirements

3.1.1 The technical design of a computer system is given by its assignment to a requirement class. The measures listed below for example, graded according to the requirements of the respective requirement class, shall be ensured.

3.1.2 For functional units, evidence shall be proved that the design is self-contained and produces no feedback.

3.1.3 The computer systems must be fast enough to perform autonomous control operations and to inform the user correctly and carry out his instructions in correct time under all operating conditions.

3.1.4 Computer systems shall monitor the program execution and the data flow automatically and cyclically e.g. by means of plausibility tests, monitoring of the program and data flow over time.

3.1.5 In the event of failure and restarting of computer systems, the process shall be protected against undefined and critical states.

3.2 Power supply

3.2.1 The power supply shall be monitored and failures shall be indicated by an alarm.

3.2.2 Redundant systems shall be separately protected against short circuits and overloads and shall be selectively fed.

3.3 Hardware

3.3.1 The design of the hardware shall be clear for easy access to interchangeable parts for repairs and maintenance.

3.3.2 Plug-in cards and plug-in connections shall be appropriately marked to protect against unintentional transposition or, if inserted in an incorrect position, shall not be destroyed and not cause any malfunctions which might cause a danger.

3.3.3 For integrated systems, it is recommended that subsystems be electrically isolated from each other.

3.3.4 Computers shall preferably be designed without forced ventilation. If forced ventilation of the computers is necessary, it shall be ensured that an alarm is given in the case of an unacceptable rise of temperature.

3.4 Software

3.4.1 Examples of software are:

- operating systems
- application software
- executable code
- database contents and structures
- bitmaps for graphic displays
- logic programs in PAL's
- microcode for communication controllers.

3.4.2 The manufacturer shall prove that a systematic procedure is followed during all the phases of software development.

3.4.3 After drafting the specification, the test scheduling shall be made (listing the test cases and establishment of the software to be tested and the scope of testing). The test schedule lays down when, how and in what depth testing shall be made.

3.4.4 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests must be retraceable.

3.4.5 The version of the Software with the relevant date and release have to be documented and shall be recognizable of the assignment to the particular requirement class.

3.5 Data communication links

3.5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and specified accordingly.

3.5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

3.5.3 The data communication link shall be continuously self-checking, for detection of failures on the link itself and for data communication failure on the nodes.

3.5.4 When the same data communication link is used for two or more essential functions, this link shall be redundant.

3.5.5 Switching between redundant links shall not disturb data communication or continuous operation of functions.

3.5.6 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

3.5.7 If approved systems are extended, proof of trouble free operation of the complete system shall be provided.

3.6 Integration of systems

3.6.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

3.6.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

3.6.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

3.7 User interface

3.7.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

3.7.2 The status of the computer system shall be recognizable.

3.7.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

3.7.4 For using computer systems, a general comprehensible user guide shall be provided.

3.8 Input devices

3.8.1 The feedback of control commands shall be indicated.

3.8.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

3.8.3 Operator panels located on the bridge shall be individually illuminated. The lighting must be adapted non-glare to the prevailing ambient conditions.

3.8.4 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices.

3.8.5 If the operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

- use of a special key lock
- use of two or more keys.

3.8.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

3.8.7 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

3.9 Output devices

3.9.1 The size, colour and density of text, graphic information and alarm signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

3.9.2 Information shall be displayed in a logical priority.

3.9.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

3.10 Graphical user interface

3.10.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

3.10.2 When general purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

3.10.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

4 Testing

4.1 General

4.1.1 Computer systems are to be tested in accordance with the requirements in Ch 3, Sec 6.

SECTION 4 CONSTRUCTIONAL REQUIREMENTS

1 General

1.1 General

1.1.1 Automation systems are to be so constructed as:

- to withstand the environmental conditions, as defined in Ch 2, Sec 2, [1], in which they operate
- to have necessary facilities for maintenance work.

1.2 Materials

1.2.1 Materials are generally to be of the flame-retardant type.

1.2.2 Connectors are to be able to withstand standard vibrations, mechanical constraints and corrosion conditions as given in Ch 3, Sec 6.

1.3 Component design

1.3.1 Automation components are to be designed to simplify maintenance operations. They are to be so constructed as to have:

- easy identification of failures
- easy access to replaceable parts
- easy installation and safe handling in the event of replacement of parts (plug and play principle) without impairing the operational capability of the system, as far as practicable
- facility for adjustment of set points or calibration
- test point facilities, to verify the proper operation of components.

2 Power electronic systems

2.1 General

2.1.1 For power electronics in electrical propulsion plants, see Ch 2, Sec 13.

2.2 Construction

2.2.1 Each power-electronics system shall be provided with separate means for disconnection from the mains.

In the case of consumers up to a nominal current of 315 A the combination fuse-contactor may be used. In all other cases a circuit breaker shall be provided on the mains side.

2.2.2 Equipment shall be readily accessible for purposes of measurement and repair. Devices such as simulator circuits, test sockets, indicating lights, etc. are to be provided for functional supervision and fault location.

2.2.3 Control and alarm electronics must be galvanically separated from power circuits.

2.2.4 External pulse cables are to be laid twisted in pairs and screened, and kept as short as possible.

2.3 Rating and design

2.3.1 Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation.

2.3.2 Rectifier systems must guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see Ch 2, Sec 5, [1]. In the event of unacceptably large frequency and/or voltage variations in the supply voltage, the system must shut-off or remain in a safe operating condition.

2.3.3 The semiconductor rectifiers and the associated fuses shall be so selected that their load current is at least 10% less than the limit current determined in accordance with the coolant temperature, the load and the mode of operation.

2.3.4 Electrical charges in power electronic modules must drop to a voltage of less than 50 V in a period of less than 5 s after disconnection from the mains supply. Should longer periods be required for discharge, a warning label is to be affixed to the appliance.

2.3.5 If the replacement of plug-in printed circuit boards while the unit is in operation can cause the destruction of components or the uncontrolled behaviour of drives, a caution label must be notifying to this effect.

2.3.6 The absence of external control signals, e.g. due to a circuit break, shall not cause a dangerous situation.

2.3.7 Control-circuit supplies are to be safeguarded against unintended disconnection, if this could endanger or damage the plant.

2.3.8 It is necessary to ensure that, as far as possible, faults do not cause damage in the rest of the system, or in other static converters.

2.3.9 Special attention shall be paid to the following points:

- mutual interference of static converters connected to the same busbar system
- voltage distortion and reacting to other consumers
- selection of the ratio between the subtransient reactance of the system and the commutating reactance of the static converter

- consideration of reactions from rectifier installations on the commutation of DC machines
- influence by harmonics and high-frequency interference.

Where filter circuits and capacitors are used for reactive current compensation, attention is to be paid to the:

- reaction on the mean and peak value of the system voltage in case of frequency fluctuations
- inadmissible effects on the voltage regulation of generators.

2.4 Cooling

2.4.1 Natural cooling is preferred.

2.4.2 The safety in operation shall be proved for liquid cooling and forced cooling.

2.4.3 An impairment of cooling shall not result in unacceptable overtemperatures, an overtemperature alarm shall be provided.

2.5 Control and monitoring

2.5.1 Control, adjustment and monitoring must ensure that the permissible operating values of the facilities are not exceeded.

2.6 Protection equipment

2.6.1 Power electronic equipment shall be protected against exceeding of their current and voltage limits.

For protective devices, it must be ensured that upon actuating:

- the output will be reduced or defective part-systems will be selectively disconnected
- drives will be stopped under control
- the energy stored in components and in the load circuit cannot have a damaging effect, when switching off.

2.6.2 Special semiconductor fuses shall be monitored. After tripping the equipment has to be switched off, if this is necessary for the prevention of damage. Activating of a safety device shall trigger an alarm.

2.6.3 Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semiconductor components.

3 Pneumatic systems

3.1 General

3.1.1 Pneumatic automation systems are to comply with Ch 1, Sec 10, [17].

3.1.2 Pneumatic circuits of automation systems are to be independent of any other pneumatic circuit on board.

4 Hydraulic systems

4.1 General

4.1.1 Hydraulic automation systems are to comply with Ch 1, Sec 10, [14].

4.1.2 Suitable filtering devices are to be incorporated into the hydraulic circuits.

4.1.3 Hydraulic circuits of automation systems are to be independent of any other hydraulic circuit on board.

5 Automation consoles

5.1 General

5.1.1 Automation consoles are to be designed on ergonomic principles. Handrails are to be fitted for safe operation of the console.

5.2 Indicating instruments

5.2.1 The operator is to receive feed back information on the effects of his orders.

5.2.2 Indicating instruments and controls are to be arranged according to the logic of the system in control. In addition, the operating movement and the resulting movement of the indicating instrument are to be consistent with each other.

5.2.3 The instruments are to be clearly labelled. When installed in the wheelhouse, all lighted instruments of consoles are to be dimmable, where necessary.

5.3 VDU's and keyboards

5.3.1 Visual display units in consoles are to be located so as to be easily readable from the normal position of the operator. The environmental lighting is not to create any reflection which makes reading difficult.

5.3.2 The keyboard is to be located to give easy access from the normal position of the operator. Special precautions are to be taken to avoid inadvertent operation of the keyboard.

SECTION 5 INSTALLATIONS REQUIREMENTS

1 General

1.1

1.1.1 Automation systems are to be installed taking into account:

- the maintenance requirements (test and replacement of systems or components)
- the influence of EMI. The IEC 60533 standard is to be taken as guidance
- the environmental conditions corresponding to the location in accordance with Ch 2, Sec 2, [1] and Ch 2, Sec 2, [6.2].

1.1.2 Control stations are to be arranged for the convenience of the operator.

1.1.3 Automation components are to be properly fitted. Screws and nuts are to be locked, where necessary.

2 Sensors and components

2.1 General

2.1.1 Sensors are to be selected and located such that their output is a realistic measure of the parameter. Sensors are to be installed in places where there is a minimum risk for damage during normal overhaul and maintenance.

2.1.2 The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located.

2.1.3 Means are to be provided for testing, calibration and replacement of automation components. Such means are to be designed, as far as practicable, so as to avoid perturbation of the normal operation of the system.

2.1.4 A tag number is to identify automation components and is to be clearly marked and attached to the component. These tag numbers are to be collected on the instrument list mentioned in Ch 3, Sec 1, Tab 1.

2.1.5 Electrical connections are to be arranged for easy replacement and testing of sensors and components. They are to be clearly marked.

2.1.6 Low level signal sensors are to be avoided. When installed they are to be located as close as possible to amplifiers, so as to avoid external influences. Failing this, the wiring is to be provided with suitable EMI protection and temperature correction.

2.2 Temperature elements

2.2.1 Temperature sensors, thermostats or thermometers are to be installed in a thermowell of suitable material, to permit easy replacement and functional testing. The thermowell is not to significantly modify the response time of the whole element.

2.3 Pressure elements

2.3.1 Three-way valves or other suitable arrangements are to be installed to permit functional testing of pressure elements, such as pressure sensors, pressure switches, without stopping the installation.

2.3.2 In specific applications, where high pulsations of pressure are likely to occur, a damping element, such as a capillary tube or equivalent, is to be installed.

2.4 Level switches

2.4.1 Level switches fitted to flammable oil tanks, or similar installations, are to be installed so as to reduce the risk of fire.

3 Cables

3.1 Installation

3.1.1 Cables are to be installed according to the requirements in Ch 2, Sec 12, [7].

3.1.2 Suitable installation features such as screening and/or twisted pairs and/or separation between signal and other cables are to be provided in order to avoid possible interference on control and instrumentation cables.

3.1.3 Specific transmission cables (coaxial cables, twisted pairs, etc.) are to be routed in specific cable-ways and mechanically protected to avoid loss of any important transmitted data. Where there is a high risk of mechanical damage, the cables are to be protected with pipes or equivalent.

3.1.4 The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the manufacturer.

For mineral insulated cables, coaxial cables or fibre optic cables, whose characteristics may be modified, special precautions are to be taken according to the manufacturer's instructions.

3.2 Cable terminations

3.2.1 Cable terminations are to be arranged according to the requirements in Part C, Chapter 2. Particular attention is to be paid to the connections of cable shields. Shields are to be connected only at the sensor end when the sensor is earthed, and only at the processor end when the sensor is floating.

3.2.2 Cable terminations are to be able to withstand the identified environmental conditions (shocks, vibrations, salt mist, humidity, etc.).

3.2.3 Terminations of all special cables such as mineral insulated cables, coaxial cables or fibre optic cables are to be arranged according to the manufacturer's instructions.

4 Pipes

4.1

4.1.1 For installation of piping circuits used for automation purposes, see the requirements in Ch 1, Sec 10.

4.1.2 As far as practicable, piping containing liquids is not to be installed in or adjacent to electrical enclosures.

4.1.3 Hydraulic and pneumatic piping for automation systems is to be marked to indicate its function.

5 Automation consoles

5.1 General

5.1.1 Consoles or control panels are to be located so as to enable a good view of the process under control, as far as practicable. Instruments are to be clearly readable in the ambient lighting.

5.1.2 The location is to be such as to allow easy access for maintenance operations.

SECTION 6 TESTING

1 General

1.1 General

1.1.1 Automation systems are to be tested for type approval, at works and on board, when required. Tests are to be carried out under the supervision of a Surveyor of the Society.

1.1.2 The type testing conditions for electrical, control and instrumentation equipment, computers and peripherals are described in [2].

1.1.3 Automation systems are to be inspected at works, according to the requirements of Article [3], in order to check that the construction complies with the Rules.

1.1.4 Automation systems are to be tested when installed on board and prior to sea trials, to verify their performance and adaptation on site, according to [4].

2 Type approval

2.1 General

2.1.1 Type approval of the automation systems is to be performed according to NR467, Pt C, Ch 3, Sec 6, [2].

3 Acceptance testing

3.1 General

3.1.1 Acceptance tests are generally to be carried out at the manufacturer's facilities before the shipment of the equipment, when requested.

Acceptance tests refer to hardware and software tests as applicable.

3.2 Hardware testing

3.2.1 Final acceptance will be granted subject to:

- the results of the tests listed in [3.2.2]
- the type test report or type approval certificate.

3.2.2 Hardware acceptance tests include, where applicable:

- visual inspection
- operational tests and, in particular:
  - tests of all alarm and safety functions
  - verification of the required performance (range, calibration, repeatability, etc.) for analogue sensors
  - verification of the required performance (range, set points, etc.) for on/off sensors
  - verification of the required performance (range, response time, etc.) for actuators
  - verification of the required performance (full scale, etc.) for indicating instruments
- endurance test (burn-in test or equivalent)
- high voltage test
- hydrostatic tests.

Additional tests may be required by the Society.

3.3 Software testing

3.3.1 Software acceptance tests of computer based systems are to be carried out according to Ch 3, Sec 3, [3.4].

4 On board tests

4.1 General

4.1.1 Testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program. After test completion, installed versions of computer based systems software are to be recorded inside the Software Registry.

4.1.2 On board tests are to be carried out on automation systems associated with essential services to verify their compliance with the Rules, by means of visual inspection and the performance and functionality according to Tab 1.

On board testing is to verify that correct functionality has been achieved with all systems integrated.

Table 1 : On board tests

Equipment	Nature of tests
Electronic equipment	Main hardware and software functionalities with all systems integrated
Analogue sensors	Signal calibration, trip set point adjustment
On/off sensors	Simulation of parameter to verify and record the set points
Actuators	Checking of operation in whole range and performance (response time, pumping)
Reading instruments	Checking of calibration, full scale and standard reference value

When completed, automation systems are to be such that a single failure, for example loss of power supply, is not to result in a major degradation of the propulsion or steering of the ship. In addition, a blackout test is to be carried out to show that automation systems are continuously supplied.

Upon completion of on board tests, test reports are to be made available to the Surveyor.

4.1.3 For wireless data communication equipment, tests during harbour and navigation trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not itself fail as a result of electromagnetic interference during expected operating conditions.

Part C

Machinery, Electricity and Fire

Chapter 4

FIRE PROTECTION, DETECTION AND EXTINCTION

SECTION 1 GENERAL

SECTION 2 PREVENTION OF FIRE

SECTION 3 DETECTION AND ALARM

SECTION 4 FIRE FIGHTING

SECTION 5 ESCAPE

SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 This Chapter applies to fire protection, fire detection and fire extinguishing equipment.

1.1.2 Fire extinguishing systems not dealt with in these Rules are to be in compliance with other applicable Rules of the Society.

1.2 Statutory Regulations

1.2.1 Where available, statutory Regulations in the operating area of the vessel (e.g. European directive) are to take precedence over the requirements of this Chapter.

1.3 Applicable requirements depending on vessel type

1.3.1 Unless expressly provided otherwise:

a) requirements not referring to a specific vessel type apply to all vessels

b) additional requirements on fire protection, fire detection and fire extinction on passenger vessels are given in Pt D, Ch 1, Sec 6, [3]

c) additional requirements on fire protection, fire detection and fire extinction on tankers intended for the carriage of dangerous goods are given in the relevant Sections of Part D, Chapter 3

d) additional requirements on fire protection, fire detection and fire extinction on dry cargo vessels intended for the carriage of dangerous goods are given in Pt D, Ch 3, Sec 7

e) vessels equipped with helicopter facilities are to comply with other applicable Rules of the Society.

1.3.2 Vessels assigned additional class notation **Fire** are also to comply with the requirements of Pt D, Ch 2, Sec 7.

1.4 Documentation to be submitted

1.4.1 The interested party is to submit to the Society the documents listed in Tab 1.

Table 1 : Documentation to be submitted

No	I/A **(1)**	Document
1	A	Means of escape and, where required, the relevant dimensioning.
2	A	Automatic fire detection systems
3	A	Fire pumps and fire main including pumps head and capacity, hydrant and hose locations
4	A	Arrangement of fixed gas fire-extinguishing systems **(2)**
5	A	Arrangement of sprinkler systems including the capacity and head of the pumps **(2)**
6	A	Electrical diagram of the fixed gas fire-extinguishing systems
7	A	Electrical diagram of the sprinkler systems
8	A	Electrical diagram of power control and position indication circuits for fire doors
9	I	General arrangement plan

(1) A : to be submitted for review
I : to be submitted for information.

(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification, such as:
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems
- capacity, in volume and/or in mass, of vessels or bottles containing the extinguishing media or propelling gases, for gas, automatic sprinkler, foam and powder fire-extinguishing systems
- type, number and location of nozzles of extinguishing media for gas, automatic sprinkler, pressure water-spraying, foam and powder fire-extinguishing systems.

All or part of the information may be provided, instead of on the above plans, in suitable operation manuals or in specifications of the systems.

Table 2 : Equivalent steel A class divisions without testing or approval

Classification	Product description
Class A-0 bulkhead	A steel bulkhead with a scantling not less than the minimum given below: • thickness of plating: 4 mm • stiffeners 60 x 60 x 5 mm spaced 600 mm apart or structural equivalence
Class A-0 deck	A steel deck with a scantling not less than the minimum given below: • thickness of plating: 4 mm • stiffeners 95 x 65 x 7 mm spaced 600 mm apart or structural equivalence

1.5 Type approved products

1.5.1 The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which the acceptance may be given for individual vessels on the basis of suitable documentation or ad hoc tests.

a) fire-resisting and fire-retarding divisions (bulkheads or decks) and associated doors

b) fire dampers

c) hoses

d) water spray nozzles

e) discharge nozzles

f) fixed gas fire extinguishing systems (performance of the extinguishing agent with specific nozzle type)

g) portable fire extinguishers

h) detection and alarm system.

Exceptions to these Rules compatible with the statutory Regulations of the vessel’s country of registration may be agreed with the Society.

The Society may request type approval for other materials, equipment, systems or products required by the applicable provisions for vessels or installations of special types.

2 Definitions

2.1 Accommodation spaces

2.1.1 Accommodation is a space intended for the use of persons normally living on board, including galleys, storage space for provisions, toilets and washing facilities, laundry facilities, ante-rooms and passageways, but not the wheelhouse.

2.2 A class divisions

2.2.1 "A" class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

b) they are suitably stiffened

c) they are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:

- class "A-60" .... 60 minutes
- class "A-30" .... 30 minutes
- class "A-15" .... 15 minutes
- class "A-0" .... 0 minutes

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test; and

e) the Society required a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code (see [2.6]) to ensure that it meets the above requirements for integrity and temperature rise.

2.2.2 The products indicated in Tab 2 may be installed without testing or approval.

2.3 B class divisions

2.3.1 "B" class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials used in the construction and erection of "B" class divisions are non-combustible, with the exception that surface materials may have low flame spread characteristics

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

- class "B-15" .... 15 minutes
- class "B-0" .... 0 minutes

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test; and

d) the Society required a test of a prototype division in accordance with the Fire Test Procedures Code (see [2.6]) to ensure that it meets the above requirements for integrity and temperature rise.

2.3.2 In order to be defined as B class, a metal division is to have plating thickness not less than 2 mm when constructed of steel.

2.4 Fire divisions other than steel

2.4.1 Attention is drawn to the use of composite and/or plywood materials from the point of view of structural fire protection. Regulations of the country where the vessel is registered may entail in some cases a limitation in the use of composite and/or plywood materials.

2.4.2 Insulation is to be such that the temperature of the structural core does not rise above the point at which the structure would begin to lose its strength at any time during the exposure to the standard fire test (60 minutes for A-class equivalence, 30 minutes for B-class equivalence).

a) Aluminium alloy structures

   The insulation is to be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable fire exposure.

b) Composite structures

   The insulation is to be such that the temperature of the laminate does not rise more than the minimum temperature of deflection under load (HDT) of the resin at any time during the applicable fire exposure. The temperature of deflection under load is to be determined in accordance with a recognized international standard (as for example ISO 75-2004).

Note 1: Alternatively, the temperature of deflection under load of the complete composite structure, if available, may be taken as a criterion in lieu of the temperature of deflection under load of the resin.

c) Wood structures

   Wood structures are to be given special consideration from the Society. As a principle, the insulation is to be such that the temperature of the structural core does not rise more than the minimum temperature of deflection under load of the wood at any time during the applicable fire exposure.

2.4.3 Equivalent fire divisions without testing or approval

A fire-resisting bulkhead may be considered to be equivalent to A class without testing, if its composition is one of the following:

- an aluminium alloy plate minimum 5,5 mm thick insulated with 80 mm of non-combustible rock wool (minimal density: 96 kg/m³; welded bi-metallic pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class
- a composite structure insulated with 120 mm of non-combustible rock wool (minimal density: 96 kg/m³; pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class.

A fire-resisting bulkhead may be considered to be equivalent to B class without testing, if its composition is one of the following:

- an aluminium alloy plate with 50 mm of non-combustible rock wool (minimal density: 96 kg/m³): equivalent to B-15 and B-0 class
- a composite structure insulated with 75 mm of non-combustible rock wool (minimal density: 96 kg/m³; pins spacing: maximum 300 mm): equivalent to B-15 and B-0 class.

2.5 Control centre

2.5.1 Control centre is a wheelhouse or an area with a centre permanently occupied by on-board personnel or crew members containing items such as vessel's radio equipment, centralised fire alarm equipment, centralised emergency public address system stations, remote controls of doors or fire dampers, etc.

2.6 Fire Test Procedures Code

2.6.1 Fire Test Procedures Code means the "International Code for Application of Fire Test Procedures", as adopted by the Maritime Safety Committee of the IMO by Resolution MSC.307 (88), as may be amended by the IMO.

2.7 Galleys

2.7.1 Galley is a room with stove or a similar cooking appliance.

2.8 Lounge

2.8.1 Lounge is a room of an accommodation or a passenger area. On board passenger vessels, galleys are not regarded as lounges.

2.9 Low flame-spread

2.9.1 A low flame-spread means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code.

2.9.2 Non-combustible materials are considered as low flame spread. However, due consideration will be given by the Society to the method of application and fixing.

2.10 Machinery spaces of category A

2.10.1 Machinery spaces of category A are defined in Ch 1, Sec 1, [1.4].

2.11 Machinery spaces

2.11.1 Machinery spaces are defined in Ch 1, Sec 1, [1.5].

2.12 Main fire zones

2.12.1 Main fire zones are those sections into which the hull, superstructures and deckhouses are divided by divisions of adequate fire integrity:

- the mean length and width of which on any deck does not, in general, exceed 40 m, or
- the area of which on any deck does not exceed 800 m^2.

2.13 Muster areas

2.13.1 Muster areas are areas of the vessel which are specially protected and in which persons muster in the event of danger.

2.14 Non-combustible material

2.14.1 Non-combustible material is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code. Any other material is a combustible material.

2.14.2 In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

2.15 Not readily ignitable material

2.15.1 Not readily ignitable material is a material having approved characteristics of ignitability. These characteristics are to be determined in accordance with a test procedure deemed acceptable by the society.

2.16 Passenger areas

2.16.1 Passenger areas are areas on board intended for passengers and enclosed areas such as lounges, offices, shops, hairdressing salons, drying rooms, laundries, saunas, toilets, wash rooms, passageways, connecting passages and stairs not encapsulated by walls.

2.17 Steel or other equivalent material

2.17.1 Steel or other equivalent material means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g., aluminium alloy with appropriate insulation).

2.18 Service spaces

2.18.1 Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

2.19 Stairwell

2.19.1 Stairwell is the well of an internal staircase or of a lift.

2.20 Standard fire test

2.20.1 A standard fire test is a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve in accordance with the test method specified in the Fire Test Procedures Code (see [2.6]).

2.21 Store room

2.21.1 Store room is a room for the storage of flammable liquids or a room with an area of over 4 m^2 for storing supplies.

SECTION 2 PREVENTION OF FIRE

1 Probability of ignition

1.1 Arrangements for fuel oil, lubrication oil and other flammable oils

1.1.1 Limitation in the use of oils as fuel

See Ch 1, Sec 1, [2.9].

1.1.2 Arrangements for fuel oil

For arrangement of fuel oil, see:

- Ch 1, Sec 10, [5].
- Ch 1, Sec 10, [11].

1.1.3 Arrangements for lubricating oil

For arrangement of lubricating oil, see:

- Ch 1, Sec 10, [5].
- Ch 1, Sec 10, [12].

1.1.4 Arrangements for other flammable oils

See Ch 1, Sec 10.

1.2 Arrangements for gaseous fuel for domestic purposes

1.2.1 Where gaseous fuel is used for domestic purposes the arrangements for the storage, distribution and utilisation of the fuel shall be such that, having regard to the hazards of fire and explosion which the use of such fuel may entail, the safety of the vessel and the persons on board is preserved.

See also Ch 1, Sec 13.

1.2.2 Gaseous fuel systems may only be considered for cargo vessels.

1.2.3 Storage of the gas bottles is to be located on the open deck or in a well ventilated space which opens only to the open deck.

1.3 Installation of boilers

1.3.1 Auxiliary and domestic boilers are to be arranged in such a way that other equipment is not endangered, even in the event of overheating. They must, in particular, be placed as far away as possible from fuel tanks, lubricating oil tanks and hold bulkheads. Oiltight trays are to be located below oil-fired boilers.

1.4 Insulation of hot surfaces

1.4.1 See Ch 1, Sec 1, [3.7].

1.5 Protective measures against explosion

1.5.1 For protective measures against explosion, see Ch 2, Sec 2, [5.2]

1.6 Miscellaneous items of ignition sources and ignitability

1.6.1 Electric heating appliances

No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

Where heaters are fitted in the bulkhead lining, a trough made of non-combustible material shall be mounted behind each heater in such a way as to prevent the accumulation of heat behind the lining.

1.6.2 Waste receptacles

In principle, all waste receptacles shall be constructed of non-combustible materials with no openings in the sides or bottom.

1.6.3 Insulation of surfaces against oil penetration

In spaces where penetration of oil products is possible, the surface of insulation shall be impervious to oil or oil vapours.

2 Fire growth potential

2.1 Control of flammable liquid supply

2.1.1 Fuel pumps, thermal oil pumps, fan motors and boiler fans are to be equipped with emergency stops. The outlet valves of fuel service tanks must be fitted with remotely operated shutoff devices. Emergency stops and remotely operated shutoff devices must be capable of being operated from permanently accessible open deck and protected from unauthorized use.

2.2 Control of air supply

2.2.1 Means must be provided for the airtight sealing of boiler, engine and pump rooms. The air ducts to these spaces are to be fitted with closing appliances or equivalent devices made of non-combustible material which can be closed from the deck. Engine room skylights must also be able to be closed from outside.

2.3 Fire protection materials

2.3.1 Use of non-combustible materials

Insulating materials shall be non-combustible, except in cargo spaces and refrigerated compartments of service spaces. Vapour barriers and adhesives used in conjunction with insulation, as well as insulation of pipe fittings for cold service systems, need not be of non-combustible materials, but they shall be kept to the minimum quantity practicable and their exposed surfaces shall have low flame-spread characteristics.

Cold service means refrigeration systems and chilled water piping for air conditioning systems.

3 Smoke generation potential and toxicity

3.1 Paints, varnishes and other finishes

3.1.1 Paints, varnishes and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

3.1.2 Requirement [3.1.1] only applies to accommodation spaces, service spaces and control stations as well as stairway enclosures.

SECTION 3 DETECTION AND ALARM

1 General

1.1 Minimum number of detectors

1.1.1 Where a fixed fire detection and fire alarm system is required for the protection of spaces, at least one detector complying with the requirements given in [1.3] shall be installed in each such space.

1.2 Initial and periodical tests

1.2.1 The function of fixed fire detection and fire alarm systems required by the relevant Sections of this Chapter shall be tested under varying conditions of ventilation after installation.

1.2.2 The function of fixed fire detection and fire alarm systems shall be periodically tested to the satisfaction of the Society by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond.

1.3 Detector requirements

1.3.1 Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

1.3.2 Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12,5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

1.3.3 Heat detectors shall be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

1.3.4 At the discretion of the Society, the permissible temperature of operation of heat detectors may be increased to 30°C above the maximum temperature in the upper part of engine and boiler rooms.

1.3.5 All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

1.4 System control requirements

1.4.1 The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in the wheelhouse, the accommodation and the space to be protected.

2 Protection of machinery spaces

2.1 Installation

2.1.1 A fixed fire detection and fire alarm system shall be installed in any machinery space:

a) which is periodically unattended,

b) where the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space, or

c) where the main propulsion and associated machinery including sources of main melectrical supply is provided with various degrees of automatic or remote control and is under continuous manned supervision from a control room.

For fire detecting system for unattended machinery spaces, see also Pt D, Ch 2, Sec 8, [3.2].

2.2 Design

2.2.1 The fire detection system required in [2.1] shall be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors are not permitted.

3 Protection of accommodation and service spaces

3.1 Smoke detectors in stairways, corridors and escape route

3.1.1 Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

3.1.2 Accommodation and service spaces of cargo vessels and tank vessels shall be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler, fire detection and fire alarm system, depending on a protection method adopted.

SECTION 4 FIRE FIGHTING

Symbols

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3].

1 Water supply systems

1.1 General

1.1.1 Vessels shall be provided with fire pumps, fire mains, hydrants and hoses complying with the applicable requirements of this Article.

1.1.2 Additional requirements for passenger vessels are given in Pt D, Ch 1, Sec 6, [3.7].

1.1.3 The Society may waive the requirements of this Article for non-propelled vessels not intended to carry passengers wether:

- the vessel is part of a specified pushed convoy or side-by-side formation and the fire-fighting system of the propulsion vessel is determined in compliance with the requirements of this Article considering the pushed convoy or side-by-side formation as a single vessel, or
- the vessel is fitted with suitable piping systems connectable to the fire-fighting system of the propulsion vessel.

1.2 Fire mains and hydrants

1.2.1 General

Materials readily rendered ineffective by heat shall not be used for fire mains and hydrants unless adequately protected. The pipes and hydrants shall be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants shall be such as to avoid the possibility of freezing. Suitable drainage provisions shall be provided for fire main piping. Isolation valves shall be installed for all open deck fire main branches used for purposes other than fire-fighting.

Fire mains are to be so arranged that a water jet can at all times be projected to any part of the vessel through a single length of hose not exceeding 20 m.

Deck-washing lines may be incorporated in the fire extinguishing system.

1.2.2 Number of hydrants

At least three hydrants are to be provided.

For vessels less than 40 m in length, at least two hydrants are to be provided.

1.3 Fire pumps

1.3.1 Pumps accepted as fire pumps

Combined ballast pumps, bilge pumps or other pumps exclusively pumping water may be accepted as fire pumps and shall be connected to the fire main by means of a non return valve.

1.3.2 Capacity of fire pumps

Self-propelled vessels are to be equipped with a power-driven pump suitable for use as a fire pump.

The capacity of the fire pump, acting through fire mains and hoses, must be sufficient to project at least one jet of water to any part of the vessel. This is to be based on a length of throw of 12 m from a 12 mm diameter nozzle.

The minimum pump capacity must be 10 m^3/h.

The pump must have a drive independent of the main propulsion unit. On vessels with a gross volume (L·B·D) of up to 800 m^3 or with a propulsive power of up to 350 kW, a bilge pump or cooling water pump coupled to the main engine may also be used provided that the propeller shafting can be disengaged.

Fire pumps are to be located aft of the forward collision bulkhead.

Outboard connections for fire pumps are to be located as deep as possible. Pump suction must be safeguarded even in lightship condition.

1.4 Fire hoses and nozzles

1.4.1 Hoses must be able to be connected to the fire mains via fire hydrants and quick couplings.

At least two hoses with dual purpose nozzles are to be provided. These are to be stowed in hose boxes placed close to the hydrants.

Hose boxes are to be properly marked. Hose wrenches are to be provided in every hose box.

1.5 Non propelled vessels

1.5.1 Where a water fire extinguishing system is provided on a non propelled vessel, the requirements set out in [1.2] and [1.3] are to be applied as appropriate.

2 Portable fire extinguishers

2.1 Extinguishing media and weights of charge

2.1.1 Fire extinguishers must have been type approved, or approved by Authorities.

2.1.2 The weight of the charge in dry powder extinguishers should be at least 6 kg.

2.1.3 In the case of water, foam and carbon dioxide extinguishers, the charge shall provide a fire extinguishing capability at least equivalent to that of a 6 kg dry powder extinguisher as required in [2.1.2].

2.1.4 The maximum weight of a portable fire extinguisher ready for use shall not exceed 20 kg.

2.1.5 The extinguishing agent must be suitable at least for the class of fire most likely to occur in the space (or spaces) for which the fire extinguisher is intended. See Tab 1.

Table 1 : Classification of extinguishing media

Fire class	Fire hazard	Extinguishing media
A	Solid combustible materials of organic nature (e.g. wood, coal, fibre materials)	Water, dry powder, foam
B	Flammable liquids (e.g. oils, tars, petrol)	Dry powder, foam, carbon dioxide
C	Gases (e.g. acetylene, propane)	Dry powder, carbon dioxide
D	Metals (e.g. aluminium, magnesium, sodium)	Special dry powder

2.1.6 On vessels with electrical installations having an operating voltage greater than 50 V, the extinguishing agent must also be suitable for fighting fire in electrical equipment.

2.1.7 On motor vessels and vessels with oil-fired equipment, engine rooms and accommodation spaces are to be provided with dry powder extinguishers covering class A, class B and class C fires.

2.1.8 As extinguishing agent, fire extinguishers may contain neither CO_2 nor agents capable of emitting toxic gases in use.

2.1.9 Nevertheless, CO_2 extinguishers may be used for galleys and electrical installations.

2.1.10 Fire extinguishers with charges which are sensitive to frost or heat are to be mounted or protected in such a way that their effectiveness is guaranteed at all times.

2.1.11 Where fire extinguishers are mounted under cover, the covering must be properly marked.

2.2 Arrangement of fire extinguishers

2.2.1 Portable fire extinguishers of appropriate types are to be provided as follows.

One portable fire extinguisher is to be provided:

- in the wheelhouse
- close to each entrance from the deck to accommodation areas
- close to each entrance to spaces which are not accessible from the accommodation area and which contain heating, cooking or cooling equipment operated with solid or liquid fuels or with liquefied gas
- at each entrance to engine rooms
- at each entrance to spaces in which oil-fired auxiliary boilers or heating boilers are installed
- at each entrance to spaces in which materials presenting a fire hazard are stored
- at suitable points below deck in engine rooms and boiler rooms such that no position in the space is more than 10 metres walking distance away from an extinguisher.

3 Automatic pressure water spraying system (sprinkler system)

3.1 General

3.1.1 Where fitted, automatic pressure water spraying system shall comply with the provisions of this Article.

Alternative systems complying with recognized standards may, subject to review or type approval, be accepted.

3.2 Pressure water tanks

3.2.1 Pressure water tanks are to be fitted with a safety valve, connected directly without valves to the water compartment, with a water level indicator that can be shut off and is protected against damage, and with a pressure gauge. Furthermore, Ch 1, Sec 3 is to be applied.

3.2.2 The volume of the pressure water tank shall be equivalent to at least twice the specified pump delivery per minute.

3.2.3 The tank shall contain a standing charge of fresh water equivalent to at least the specified volume delivered by the pump in one minute.

3.2.4 The tank is to be fitted with a connection to enable the entire system to be refilled with fresh water.

3.2.5 The pressure water tank is to be installed in a frost-proof space.

3.2.6 Means are to be provided for replenishing the air cushion in the pressure water tank.

3.2.7 Other means can be used to meet the functional requirements stipulated in [3.2.2] and [3.2.6].

3.3 Pressure water spraying pumps

3.3.1 The pressure pumps may only be used for supplying water to the pressure water-spraying systems.

3.3.2 In the event of a pressure drop in the system, the pump shall start up automatically before the fresh water charge in the pressure water tank has been exhausted. Suitable means of testing are to be provided.

3.3.3 The system shall be able to spray water at a rate of at least 5 l/m² per minute over an area of at least 75 m².

For large rooms to be protected, one of the following provisions shall be complied with, depending on the fire risk encountered, at the Society's discretion:

- the rooms to be protected will be considered without sprinkler installation for determining the appropriate fire integrity standards to be applied to boundaries
- the sprinkler pump capacity will be determined on the basis of a minimum water rate of 5 l/m² per minute, considering the area of the largest room, limited to 280 m².

3.3.4 The pump is to be provided with a direct suction connection at the vessel's side. The shutoff device is to be secured in the open position. A suitable raw water filter is to be fitted, the mesh size of which is able to prevent coarse impurities from clogging the nozzles. The pump delivery is to be fitted with a test valve with connecting pipes, the cross-section of which is compatible with the pump capacity at the prescribed head.

3.4 Location

3.4.1 Pressure water tanks and pressure water pumps are to be located outside, and at a sufficient distance from, the rooms to be protected.

3.5 Water supply

3.5.1 The system shall be completely charged with fresh water when not in operation.

3.5.2 In addition to the water supply to the spraying equipment located outside the spaces to be protected, the system is also to be connected to the fire main via a screw-down non-return valve.

3.5.3 The equipment must be kept permanently under pressure and must be ready at all times for immediate, automatic operation. With the test valve at the alarm valve in the fully open position, the pressure at the level of the highest spray nozzles shall still be at least 1,75 bar.

3.6 Power supply

3.6.1 At least two mutually independent power sources shall be provided for supplying the pump and the automatic indicating and alarm systems. Each source shall be sufficient to power the equipment.

3.7 Piping, valves and fittings

3.7.1 Lines between suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in Ch 1, Sec 10, Tab 6. Lines shall be effectively protected against corrosion.

3.7.2 Check valves are to be fitted to ensure that raw water cannot penetrate into the pressure water tank nor water for fire extinguishing be discharged overboard through pump suction lines.

3.7.3 Hose connections are to be provided at suitable points on the port and starboard sides for supplying the equipment with water from the shore. The connecting valves are to be secured against being opened unintentionally.

3.7.4 Each line leading to a section of the system is to be equipped with an alarm valve (see also [3.9]).

3.7.5 Shutoff devices located between the pump delivery and the alarm valves are to be secured in the open position.

3.8 Spray nozzles

3.8.1 The system shall be divided into sections, each with no more than 50 spray nozzles.

A sprinkler section may extend only over one main fire zone or one watertight compartment and may not include more than two vertically adjacent decks.

3.8.2 The spray nozzles are to be so arranged in the upper deck area that a water volume of not less than 5 l/m² per minute is sprayed over the area to be protected.

3.8.3 Inside accommodation and service spaces the spray nozzles shall be activated within a temperature range from 68°C to 79°C. This does not apply to spaces such as drying rooms with higher temperatures. Here the triggering temperature may be up to 30°C above the maximum temperature in the deck head area.

3.8.4 The nozzles are to be made of corrosion-resistant material. Nozzles of galvanized steel are not allowed.

3.9 Indicating and alarm systems

3.9.1 Every spray nozzle section is to be equipped with an alarm valve which, when a nozzle is opened, actuates a visual and audible alarm at one or more suitable positions, at least one of which must be permanently manned. In addition, each alarm valve is to be fitted with a pressure gauge and a test valve with an inner diameter corresponding to a spray nozzle.

3.9.2 At the positions mentioned here above, an automatic indicating device is to be mounted which identifies the actuated sprinkler section.

3.9.3 The electrical installation must be self-monitoring and must be capable of being tested separately for each section.

4 Fixed fire extinguishing systems

4.1 Extinguishing agents

4.1.1 For protection of machinery spaces, the following extinguishing agents may be used in permanently installed fire-fighting systems:

a) CO_2 (carbon dioxide)

b) HFC 227 ea (heptafluoropropane)

c) IG-541 (52% nitrogen, 40% argon, 8% carbon dioxide)

d) FK-5-1-12 (dodecafluoro-2-methylpentan-3-one).

e) water (in the form of water mist)

f) K_2CO_3 (Potassium carbonate)

4.1.2 Other extinguishing agents are permitted only if agreed by the Society.

If other extinguishing agents will be permitted, these fixed fire-extinguishing systems are to be type approved by the Society as well.

4.1.3 The fixed fire-extinguishing systems according to [4.1.1] items b) to d) shall be type approved by the Society.

4.2 Ventilation, air intake

4.2.1 Combustion air for the propulsion engines shall not be extracted from rooms that are to be protected by permanently installed fire-fighting systems. This shall not apply where there are two mutually independent and hermetically separated main engine rooms or if next to the main engine room there is a separate engine room with a bow thruster, ensuring that the vessel is able to make way under its own power in the event of fire in the main engine room.

4.2.2 Any forced ventilation present in the room to be protected shall switch off automatically if the fire-fighting system is triggered.

4.2.3 There shall be devices available with which all apertures which can allow air to enter or gas to escape from the room to be protected can be quickly closed. It shall be clearly recognisable whether they are open or closed.

4.2.4 The air escaping from relief valves in the compressed-air tanks installed in engine rooms shall be conveyed to the open air.

4.2.5 Over- or underpressure resulting from the inflow of extinguishing agent shall not destroy the components of the surrounding partitions of the room to be protected. It shall be possible for the pressure to equalise without danger.

4.2.6 Protected rooms shall have a facility for extracting the extinguishing agent and the combustion gases. Such facilities shall be capable of being operated from positions outside the protected rooms and which would not be made inaccessible by a fire within such spaces. If there are permanently installed extractors, it shall not be possible for these to be switched on while the fire is being extinguished.

4.3 Fire alarm system

4.3.1 The room to be protected shall be monitored by means of an appropriate fire alarm system. The alarm shall be noticeable in the wheelhouse, the accommodation spaces and the room to be protected.

4.4 Piping system

4.4.1 The extinguishing agent shall be routed to and distributed in the space to be protected by means of a permanent piping system. Piping installed in the space to be protected and the reinforcements it incorporates shall be made of steel. This shall not apply to the connecting nozzles of tanks and compensators provided that the materials used are fire resistant. Piping shall be protected against corrosion both internally and externally.

4.4.2 The discharge nozzles shall be so arranged as to ensure the regular diffusion of the extinguishing agent. In particular, the extinguishing agent must also be effective beneath the floor.

4.4.3 The necessary pipes for conveying fire-extinguishing medium into protected spaces shall be provided with control valves so marked as to indicate clearly the space to which the pipes are led. Suitable provision shall be made to prevent inadvertent release of the medium into the space. Where a cargo space fitted with a gas fire-extinguishing system is used as a passenger space the gas connection shall be blanked during such use.

The pipelines may pass through accommodation spaces providing they are of substantial thickness and their tightness is verified with a pressure test, after installation, at a pressure head not less than 5 MPa. In addition, pipelines passing through accommodation spaces are to be joined only by welding and are not to be fitted with drains or other openings within such spaces. The pipelines are not to pass through refrigerated spaces.

4.5 Triggering device

4.5.1 Automatically activated fire-extinguishing systems are not permitted.

4.5.2 It shall be possible to activate the fire-extinguishing system from outside the space to be protected.

4.5.3 Triggering devices shall be so installed that they can be activated in the event of a fire and so that the risk of their breakdown in the event of a fire or an explosion in the space to be protected is reduced as far as possible.

Systems which are not mechanically activated shall be supplied from two energy sources independent of each other. These energy sources shall be located outside the space to be protected. The control lines located in the space to be protected shall be so designed as to remain capable of operating in the event of a fire for a minimum of 30 minutes. The electrical installations are deemed to meet this requirement if they conform to the IEC 60331-21:1999 standard.

When the triggering devices are so placed as not to be visible, the component concealing them shall carry the "Fire-fighting system" symbol, each side being not less than 10 cm in length, with the following text in red letters on a white ground:

FIRE-FIGHTING INSTALLATION

4.5.4 If the fire-extinguishing system is intended to protect several spaces, it shall comprise a separate and clearly marked triggering device for each space.

4.5.5 The instructions shall be posted alongside all triggering devices and shall be clearly visible and indelible. The instructions are to be at least in a language the master can read and understand and if this language is not English, French or German, they are to be at least in English, French or German in addition.

They shall include information concerning:

a) the activation of the fire-extinguishing system

b) the need to ensure that all persons have left the space to be protected

c) the correct behaviour of the crew in the event of activation or diffusion, in particular in respect of the possible presence of dangerous substances

d) the correct behaviour of the crew in the event of the failure of the fire-extinguishing system to function properly.

4.5.6 The instructions shall mention that prior to the activation of the fire-extinguishing system, combustion engines installed in the space and aspirating air from the space to be protected shall be shut down.

4.6 Alarm device

4.6.1 Permanently fixed fire-extinguishing systems shall be fitted with an audible and visual alarm device.

4.6.2 The alarm device shall be set off automatically as soon as the fire-extinguishing system is first activated. The alarm device shall function for an appropriate period of time before the extinguishing agent is released; it shall not be possible to turn it off.

4.6.3 Alarm signals shall be clearly visible in the spaces to be protected and their access points and be clearly audible under operating conditions corresponding to the highest possible sound level. It shall be possible to distinguish them clearly from all other sound and visual signals in the space to be protected.

4.6.4 Sound alarms shall also be clearly audible in adjoining spaces, with the communicating doors shut, and under operating conditions corresponding to the highest possible sound level.

4.6.5 If the alarm device is not intrinsically protected against short circuits, broken wires and drops in voltage, it shall be possible to monitor its operation.

4.6.6 A sign with the following text in red letters on a white ground shall be clearly posted at the entrance to any space the extinguishing agent may reach:

WARNING, FIRE-FIGHTING INSTALLATION !

LEAVE THE ROOM AS SOON AS THE
WARNING SIGNAL SOUNDS (description of the signal)

4.7 Pressurized tanks, fittings and piping

4.7.1 Pressurized tanks, fittings and piping shall conform to the requirements of the competent authority.

4.7.2 Pressurized tanks shall be installed in accordance with the manufacturer's instructions and in compliance with other applicable rules of the Society.

4.7.3 Pressurized tanks, fittings and piping shall not be installed in the accommodation.

4.7.4 The temperature of cabinets and storage spaces for pressurized tanks shall not exceed 50°C.

4.7.5 Cabinets or storage spaces on deck shall be securely stowed and shall have vents so placed that in the event of a pressurized tank not being gastight, the escaping gas cannot penetrate into the vessel. Direct connections with other spaces are not permitted.

4.8 Quantity of extinguishing agent

4.8.1 If the quantity of extinguishing agent is intended for more than one space, the quantity of extinguishing agent available does not need to be greater than the quantity required for the largest of the spaces thus protected.

4.9 Fire extinguishing system operating with CO_2

4.9.1 In addition to the requirements contained in [4.1] to [4.8], fire-extinguishing systems using CO_2 as an extinguishing agent shall conform to the provisions of [4.9.2] to [4.9.7].

4.9.2 Tanks of CO_2 shall be placed in a gastight space or cabinet separated from other spaces. The doors of such storage spaces and cabinets shall open outwards; they shall be capable of being locked and shall carry on the outside the symbol "Warning: general danger", not less than 5 cm high and "CO_2" in the same colour and the same size.

4.9.3 Storage cabinets or spaces for CO_2 tanks located below deck shall only be accessible from the outside. These spaces shall have a mechanical ventilation system with extractor hoods and shall be completely independent of the other ventilation systems on board.

4.9.4 The level of filling of CO_2 tanks shall not exceed 0,75 kg/l. The volume of depressurised CO_2 shall be taken to be 0,56 m^3/kg.

4.9.5 The concentration of CO_2 in the space to be protected shall be not less than 40% of the gross volume of the space. This quantity shall be released within 120 seconds. It shall be possible to monitor whether diffusion is proceeding correctly.

Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire-extinguishing system, the Society shall require the provision of an additional quantity of fire-extinguishing medium.

The volume of starting air receivers, converted to free air volume, shall be added to the gross volume of the machinery space when calculating the necessary quantity of extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

4.9.6 The opening of the tank valves and the opening of the directional valve shall correspond to two different operations.

4.9.7 The appropriate period of time mentioned in [4.6] shall be not less than 20 seconds. A reliable installation shall ensure the timing of the diffusion of CO_2.

4.10 Fire extinguishing system operating with HFC-227 ea (heptafluoropropane)

4.10.1 In addition to the requirements of [4.1] to [4.8], fire extinguishing systems using HFC-227 ea as an extinguishing agent shall conform to the provisions of [4.10.2] to [4.10.9].

4.10.2 Where there are several spaces with different gross volumes, each space shall be equipped with its own fire extinguishing system.

4.10.3 Every tank containing HFC-227 ea placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.

4.10.4 Every tank shall be fitted with a device permitting control of the gas pressure.

4.10.5 The level of filling of tanks shall not exceed 1,15 kg/l. The specific volume of unpressurized HFC-227 ea shall be taken to be 0,1374 m^3/kg.

4.10.6 The volume of HFC-227 ea in the space to be protected shall be not less than 8% of the gross volume of the space. This quantity shall be released within 10 seconds.

4.10.7 Tanks of HFC-227 ea shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected.

4.10.8 After discharge, the concentration in the space to be protected shall not exceed 10,5% (volume).

4.10.9 The fire-extinguishing system shall not comprise aluminium parts.

4.11 Fire extinguishing system operating with IG-541

4.11.1 In addition to the requirements of [4.1] to [4.8], fire extinguishing systems using IG-541 as an extinguishing agent shall conform to the provisions of [4.11.2] to [4.11.6].

4.11.2 Where there are several spaces with different gross volumes, every space shall be equipped with its own fire-extinguishing system.

4.11.3 Every tank containing IG-541 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.

4.11.4 Each tank shall be fitted with a device for checking the contents.

4.11.5 The filling pressure of the tanks shall not exceed 200 bar at a temperature of +15°C.

4.11.6 The concentration of IG-541 in the space to be protected shall be not less than 44% and not more than 50% of the gross volume of the space. This quantity shall be released within 120 seconds.

4.12 Fire extinguishing system operating with FK-5-1-12

4.12.1 In addition to the requirements of [4.1] to [4.8], fire extinguishing systems using FK-5-1-12 as an extinguishing agent shall conform to the provisions [4.12.2] to [4.12.8].

4.12.2 Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system.

4.12.3 Every tank containing FK-5-1-12 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall insure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.

4.12.4 Every tank shall be fitted with a device permitting control of the gas pressure.

4.12.5 The level of filling of tanks shall not exceed 1,00 kg/l. The specific volume of depressurized FK-5-1-12 shall be taken to be 0,0719 m^3/kg.

4.12.6 The volume of FK-5-1-12 in the space to be protected shall be not less than 5,5% of the gross volume of the space. This quantity shall be released within 10 seconds.

4.12.7 Tanks of FK-5-1-12 shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected.

4.12.8 After discharge, the concentration in the space to be protected shall not exceed 10,0% (volume).

4.13 Fire extinguishing system operating with water

4.13.1 In addition to the requirements of [4.1] to [4.8], fire extinguishing systems using water as an extinguishing agent shall conform to the provisions [4.13.2] to [4.13.11].

4.13.2 Fire-fighting systems using water as the extinguishing agent may only release this agent into the space to be protected in the form of a water mist. The droplet size must be between 5 and 300 microns.

4.13.3 The fire-fighting system shall be of type-approved pursuant to Resolution MSC/Circ. 1165 of the Maritime Safety Committee of the IMO or another Standard recognised by the Society.

4.13.4 The fire-fighting system must be sized according to the largest of the spaces to be protected and must be able to spray water continuously into the space for a minimum of 30 minutes.

4.13.5 The pumps, their switching mechanisms and the valves that are required in order for the system to operate should be installed in a space outside the spaces to be protected. The space in which they are installed should be separated from adjacent by at least type A30 partition walls.

4.13.6 The fire-fighting system must be completely full of water at all times at least as far as the trip valves and be under the required initial operating pressure. The water supply pumps must be automatically initiated when the system is triggered. The system must feature a continuously operating water supply. Measures must be taken to ensure impurities do not affect system operation.

4.13.7 The capacity and design of the system's pipe network must be based on an hydraulic calculation.

4.13.8 The number and arrangement of nozzles must ensure sufficient distribution of water in the spaces to be protected. The spray nozzles must be located so as to ensure that the water mist is distributed throughout the space to be protected, especially in those areas where there is a higher risk of fire, including behind the fittings and beneath the floor.

4.13.9 The fire-fighting system's electrical components in the space to be protected must at a minimum comply with protection class IP54. The system shall feature two independent energy sources with automatic switching. One of the power sources must be located outside the space to be protected. Each power source should on its own be capable of ensuring the operation of the system.

4.13.10 The fire-fighting system must be fitted with redundant pumps.

4.13.11 The fire-fighting system must be equipped with a monitoring device which triggers an alarm signal in the wheelhouse in the following cases:

- drop in water tank level (if fitted),
- power supply failure,
- loss of pressure in the low pressure system pipework,
- loss of pressure in the high pressure circuit,
- when the system is activated.

4.14 Fire extinguishing system operating with K_2CO_3

4.14.1 In addition to the requirements of [4.1] to [4.8], fire extinguishing systems using K_2CO_3 as an extinguishing agent shall conform to the provisions [4.14.2] to [4.14.6].

4.14.2 The fire-fighting system shall be of type-approved pursuant to Resolution MSC/Circ. 1270 of the Maritime Safety Committee of the IMO or another Standard recognised by the Society.

4.14.3 Each space shall be provided with its own fire-fighting system.

4.14.4 The extinguishing agent must be stored in specially provided unpressurised tanks in the space to be protected. These tanks must be fitted in such a way that the extinguishing agent is dispensed evenly in the space. In particular the extinguishing agent must also work underneath the deck plates.

4.14.5 Each tank must be separately connected with the trigger device.

4.14.6 The quantity of extinguishing agent relative to the space to be protected is to be at least 120 g per m^3 of the net volume of this space. This net volume is calculated according to Resolution MSC/Circ. 1270 of the Maritime Safety Committee of the IMO. It shall be possible to supply the extinguishing agent within 120 seconds.

SECTION 5 ESCAPE

1 General

1.1

1.1.1 Unless expressly provided otherwise in this Section, at least two widely separated and ready means of escape shall be provided from all spaces or groups of spaces.

1.1.2 Lifts shall not be considered as forming one of the means of escape as required by this Section.

1.1.3 The escape trunk shall have clear dimensions of at least 0,6 x 0,6 m.

2 Means of escape from control centres, accommodation spaces and service spaces

2.1 General requirements

2.1.1 Stairways and ladders shall be so arranged as to provide ready means of escape from accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

2.1.2 All stairways in accommodation and service spaces and control stations shall be of steel frame construction except where the Society sanctions the use of other equivalent material.

2.1.3 Doors in escape routes shall, in general, open in way of the direction of escape, except that:

a) individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened, and

b) doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

2.2 Escape arrangements

2.2.1 Below the lowest open deck the main means of escape shall be a stairway and the second escape may be a trunk or a stairway.

2.2.2 Above the lowest open deck the means of escape shall be stairways or doors to an open deck or a combination thereof.

2.2.3 Exceptionally the Society may dispense with one of the means of escape, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

3 Means of escape from machinery spaces

3.1 Escape arrangements

3.1.1 Means of escape from each machinery space shall comply with the provisions of [3.1.2] and [3.1.3].

3.1.2 Every engine room and boiler room (machinery space of category A) shall be provided with two means of escape as widely separated as possible. One of the means of escape shall be an emergency exit. If a skylight is permitted as an escape, it must be possible to open it from the inside.

3.1.3 In case of engine rooms and boiler rooms (machinery space of category A) of less than 35 m^2 one means of escape may be accepted.

BUREAU VERITAS

Shaping a World of Trust

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Rules for the Classification of Inland Navigation Vessels

PART D – Additional Requirements for Notations

Chapters 1 – 2 – 3

NR 217.D1 DT R06 E **June 2021**

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BUREAU VERITAS MARINE & OFFSHORE

GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 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.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of the above listed being relieved from any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 Only the Society is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards ("Applicable Referential"), in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification (or Certification as defined in clause 2.2) is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules and/or to Applicable Referential for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules (available online on veristar.com), guidance notes and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the Rules and/or the Applicable Referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, and/or to the Applicable Referential, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate nor on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisement made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involves, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interest equal to twelve (12) months LIBOR plus two (2) per-cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to resolve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 The Services shall be automatically and immediately terminated in the event the Client can no longer establish any form of interest in the Unit (e.g. sale, scrapping).

9.3 The Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, or immediately in the event of termination under clause 9.2, subject to compliance with clause 4.1 and 6 above.

9.4 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, will be treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, other than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed in accordance with and governed by the laws of England and Wales.

15.2 Any dispute shall be finally settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

15.3 Notwithstanding clause 15.2, disputes relating to the payment of the Society's invoices may be submitted by the Society to the *Tribunal de Commerce de Nanterre*, France, or to any other competent local Court, at the Society's entire discretion.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics and, when applicable, Business Partner Code of Conduct both available at https://group.bureauveritas.com/group/corporate-social-responsibility/operational-excellence.

RULES FOR INLAND NAVIGATION VESSELS

Part D

Additional Requirements for Notations

Chapters **1 2 3**

Chapter 1	**SERVICE NOTATIONS**
Chapter 2	**ADDITIONAL CLASS NOTATIONS**
Chapter 3	**TRANSPORT OF DANGEROUS GOODS**

June 2021

These Rules apply to inland navigation vessels for which contracts for construction are signed on or after June 1st, 2021.

The English version of these Rules takes precedence over editions in other languages.

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Part D

Additional Requirements for Notations

Chapter 1

SERVICE NOTATIONS

SECTION 1 GENERAL CARGO VESSELS

SECTION 2 BULK CARGO VESSELS

SECTION 3 TANKERS

SECTION 4 CONTAINER VESSELS

SECTION 5 RORO CARGO VESSELS

SECTION 6 PASSENGER VESSELS

SECTION 7 TUGS AND PUSHERS

SECTION 8 PONTOONS

SECTION 9 VESSELS FOR DREDGING ACTIVITIES

SECTION 10 LAUNCHES

SECTION 11 PLEASURE VESSELS

SECTION 1 GENERAL CARGO VESSELS

Symbols

A_{SH} : Net web sectional area, in cm^2

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

g : Gravitational acceleration:

$$g = 9,81\ m/s^2$$

k : Material factor defined in:

- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- $R_y = 235/k\ N/mm^2$ for steel
- $R_y = 100/k\ N/mm^2$ for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Pt B, Ch 3, Sec 1, [2.4.3]

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

β_b, β_S : Span correction coefficients defined in Pt B, Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Pt B, Ch 5, Sec 1, [1.3]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Pt B, Ch 5, Sec 1, [1.3]

λ_b, λ_s : Coefficients for pressure distribution correction defined in Pt B, Ch 2, Sec 4, [6.3]

ℓ : Stiffener span, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **General cargo vessel**, as defined in Pt A, Ch 1, Sec 3, [2.1.3].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stipulated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to general cargo vessels.

1.2 Direct calculation

1.2.1 The following requirements apply for the analysis of primary supporting members.

Direct calculation is to be carried out in compliance with Pt B, Ch 2, Sec 8, [2].

1.2.2 Loading conditions and load cases in service conditions

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in the primary supporting members.

The following loading conditions are generally to be considered:

a) Harbour
   - full cargo load in hold/vessel at the relevant draught T_1
   - empty hold/vessel at the relevant draught T_1

b) Navigation
   - full cargo load/vessel at the scantling draught T
   - lightship/vessel at the relevant draught T_1.

1.2.3 Structure checks

The following checks are to be carried out:

- level of normal stresses and shear stresses, in particular in way of holes and passage of longitudinals
- buckling strength of unstiffened webs
- for double hull vessels, continuity of double bottom in side tanks.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

2.2 Intact stability

2.2.1 The stability of general cargo vessels for all intended loading conditions is to comply with Pt B, Ch 2, Sec 2, [4].

3 Single side general cargo vessels

3.1 General

3.1.1 Application

The requirements of this Article apply to open deck vessels of single side construction, with or without double bottom, intended primarily to carry general cargoes.

The loading/unloading may be performed in one or two runs.

3.2 Protection of cargo holds

3.2.1 Coating

All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

Suitable coatings for the intended cargoes (in particular for the compatibility with the cargo) are to be chosen and applied in accordance with the manufacturer's requirements.

3.2.2 Cargo hold ceiling

The cargo hold bottom is to be sheathed up to the upper part of bilges by wooden or metallic ceiling of thickness depending on the cargo nature.

Where a side ceiling is provided, it is to be secured every 4-frame spacing to the side frames by an appropriate system.

3.3 Bottom structure

3.3.1 Single bottom vessels are to be fitted with girders in compliance with Pt B, Ch 5, Sec 2, [4.2] or Pt B, Ch 5, Sec 2, [5.3].

3.3.2 Transversely framed single bottom

A single bottom transversely framed is to be fitted with floors at every frame.

3.3.3 Longitudinally framed single bottom

Longitudinal stiffeners are generally to be continuous when crossing primary members.

The section modulus of longitudinals located in way of the web frames of transverse bulkheads is to be increased by 10%.

Longitudinals are to be supported by transverses whose spacing is to be neither greater than 8-frame spacing, nor than 4 m, whichever is less.

3.4 Transversely framed side

3.4.1 Connection of frames with floors

The frames are to be connected to the floors in compliance with Pt B, Ch 5, Sec 3, [4.1].

3.4.2 Connection with deck structure

At the upper end of the frames, connecting brackets are to be provided, in compliance with Pt B, Ch 5, Sec 3, [8]. Such brackets are to extend to the hatch coaming.

3.4.3 Web frames

Web frames are to be fitted with a spacing not exceeding 5 m.

Their scantling is to be performed according to [3.7.2].

3.4.4 Connection of frames to bottom longitudinals

In the case of a longitudinally framed single bottom, the side frames are to be connected to the bottom longitudinal the most at side, either directly, or by means of a bracket.

Similarly, at the frame upper part, connecting brackets are to be provided, extending up to the deck longitudinal the most at side and, even, to the hatch coaming, in general.

3.5 Longitudinally framed side

3.5.1 Side transverses

Side transverses are to be fitted, in general, with a spacing not greater than 8-frame spacing, nor than 4 m.

Their scantling is to be performed according to [3.7.2].

The side transverses are generally directly welded to the shell plating.

In the case of a double bottom, the side transverses are to be bracketed to the bottom transverses.

3.5.2 Side longitudinals

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

In the case the longitudinals are interrupted by a primary supporting member, brackets on both sides of the primary supporting member are to be fitted in perfect alignment.

3.6 Topside structure

3.6.1 Strength continuity

At the ends of the cargo hold space, the members taking part in the overall strength are to be correctly staggered.

Arrangements are to be made to ensure strength continuity of the topside structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming which is located above deck and to connect it to the side bulkheads of the accommodation spaces.

3.7 Hull scantlings

3.7.1 General

The hull scantlings are to be as specified in Part B, Chapter 5, unless otherwise specified.

3.7.2 Transverse rings

Where necessary, transverse rings are to be fitted to provide additional supports of the stringer plate.

The ring component scantlings are not to be less than the values given in Tab 1.

Table 1 : Net scantling of transverse rings

Primary supporting member		w (cm³)	A_{Sh} (cm²)
Reinforced floors Bottom transverses		$w = \dfrac{\gamma_R \gamma_m \beta_b p}{m R_y} S B^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \dfrac{p}{R_y} S B$
Side webs and side transverses **(1)**	• if $\ell_0 \le \ell$	$w = 26 \dfrac{\gamma_R \gamma_m \beta_b \ell}{m R_y} S \ell_0^{\,2} 10^3$	$A_{sh} = 68 \gamma_R \gamma_m \beta_s \dfrac{\ell}{R_y} S \ell_0$
	• if $\ell_0 > \ell$	$w = 4,4 \dfrac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \dfrac{p}{R_y} S \ell$
Strong box beams		see Pt B, Ch 5, Sec 4, [2.4.4]	

Note 1:

p : Design load, in kN/m², defined in Pt B, Ch 5, Sec 1, [2.1]

ℓ_0 : Span parameter, in m: $\ell_0 = p_d / g$

p_d : Total pressure, in kN/m², at the lower end of the stiffener

m : Boundary coefficient, to be taken equal to 8.

(1) Scantlings of web frames and side transverses at the lower end are to be the same as those of floors or bottom transverses connected to them.

3.7.3 Transverse hold bulkhead structure

The number and location of transverse bulkheads are defined in Pt B, Ch 5, Sec 5.

Where necessary, additional bulkheads are to be fitted to provide for sufficient transverse strength of the vessel.

The scantlings of transverse hold bulkheads are not to be less than the values required in Pt B, Ch 5, Sec 5.

a) Vertically framed plate bulkhead

The upper end of the vertical stiffeners is to be connected either to a strong deck box beam or to a stringer located at the stringer plate level or above.

As far as practicable, the bottom of the box beam or the bulkhead end stringer is to be located in the same plane as the stringer plate.

Where this is not the case, the bulkhead plating or the box beam sides are to be fitted with an efficient horizontal framing at that level.

b) Horizontally framed bulkhead

The upper part of horizontally framed bulkheads are to be specially considered by the Society.

c) Plate bulkhead end stringer

The net scantlings of the plate bulkhead end stringer is to be determined, using the following formula:

$$w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_A)} S \ell^2 10^3$$

where:

p : Bulkhead end stringer design load, in kN/m², to be determined according to Pt B, Ch 2, Sec 5, [3.1]

S : Bulkhead stringer spacing, in m

σ_A : Bulkhead end stringer axial stress, in N/mm²:

$$\sigma_A = \frac{10 q D_1}{A}$$

A : Bulkhead end stringer sectional area, in cm²

q : Distributed transverse load acting on the stringer plate, in kN/m, to be determined as stated in Pt B, Ch 5, Sec 4, [2.4.1]

D_1 : Unsupported stringer plate length, in m, defined in Pt B, Ch 5, Sec 4, [2.4.2].

In way of hold end bulkheads, D_1 is to be substituted by 0,5 D_1

m : Boundary coefficient, to be taken equal to 8.

4 Double hull general cargo vessels

4.1 General

4.1.1 Application

The requirements of this Article apply to open deck vessels of double hull construction, intended primarily to carry general cargoes.

The loading/unloading may be performed in one or two runs.

4.1.2 Protection of cargo holds

All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

Suitable coatings for the intended cargoes (in particular for the compatibility with the cargo) are to be chosen and applied in accordance with the manufacturer's requirements.

4.2 Welding

4.2.1 General

Welding is to comply with the requirements of Pt B, Ch 8, Sec 2.

4.2.2 Arrangements applying to the shell plating and the double hull

Transverse butts are to be butt welded. Double bottom butts may be welded in way of floor face plate which then acts as a support.

The longitudinal joints are to be obtained either by butt welding or by overlap welding. In the second case, the outer line welding is to be continuous with a throat thickness of 0,5 t, whereas the inner line of welding may be discontinuous with a ratio p/d < 4 and a throat thickness of 0,5 t; however, for spaces which are not accessible after construction, the inner weld is to be carried out with a continuous line welding.

4.2.3 Arrangements applying to the topside plating

Butt weldings are to be carried out on the transverse butts of the sheerstrake, stringer plate and coaming.

4.2.4 Connection of inner bottom with floors

Where the floors cannot be welded to the inner bottom by means of fillet welds, the connection may be obtained by slot welds, in compliance with Pt B, Ch 8, Sec 2, [2.7]. In that case, the floors are to be fitted with flange of adequate width.

4.3 Transversely framed double side

4.3.1 Structural arrangement

Where the inner side does not extend down to the outer bottom, it is to be held in position by means of brackets or vertical stiffeners fitted to the floors.

Adequate continuity strength is to be ensured in way of changes in width of the double side. In particular, scarfing of the inner side is to be ensured beyond the cargo hold region.

4.3.2 Side and inner side frames

At their upper end, side and inner side frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames.

Where the outer and inner side frames are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected frames.

At their lower end, the frames are to be adequately connected to the floors or top tank.

4.3.3 Side and inner side web frames

It is recommended to provide side web frames, fitted every 3 m and, in general, not more than 6-frame spacings apart.

At their upper end, side and inner side web frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames. An attached plating strip, where applicable, may be taken into account.

The web frames are to be connected at their mid-span by means of struts, the cross sectional area of which is not to be less than those of the connected web frames.

At their lower end, the web frames are to be adequately connected to the floors or top tank.

4.3.4 Plate webs

Plate webs may be fitted in addition or instead of web frames.

Plate webs are to be fitted with horizontal stiffeners, the spacing of which is not to be greater than 1 m.

The scantling of plate webs with large openings is to be examined by the Society on a case by case basis.

4.4 Longitudinally framed double side

4.4.1 Inner side plating

The requirements of [4.3.1] also apply to longitudinally framed double side, with the transverses instead of web frames.

4.4.2 Side and inner side longitudinals

Where the outer and inner side longitudinals are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected longitudinals.

4.4.3 Side transverses

The requirements of [4.3.3] also apply to longitudinally framed double side, with the transverses instead of web frames.

4.4.4 Plate webs

The requirements of [4.3.4] also apply to longitudinally framed double side.

4.5 End structure

4.5.1 Arrangements for self-propelled vessels

At the ends of the cargo hold space, the strength continuity of members taking part in the overall strength is to be adequately ensured.

In particular, arrangements are to be made to ensure strength continuity of the top structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming located above deck and to connect it to the side bulkheads of the accommodation spaces.

The longitudinal boundaries of the engine room side bunkers are to be located, as far as practicable, in the extension of the double hull sides.

4.5.2 Arrangements for pushed vessels

Where the compartments outside the cargo hold space are of small size, the strength continuity is to be ensured by scarfing of strength members.

The double hull sides are to be extended, in the shape of brackets, outside the cargo hold space over a distance equal to twice the stringer plate width.

Strength continuity of the inner bottom is to be ensured by means of brackets, one of which is to be along the vessel centreline. Where the vessel ends are built on the longitudinal system, the brackets are to be connected to the bottom longitudinals; otherwise, they are to be connected to keelsons.

Pushing transoms, if any, are to be designed in compliance with Pt B, Ch 7, Sec 6, [2.2].

4.6 Hull scantlings

4.6.1 General

The hull scantlings and arrangements are to be determined according to Part B, Chapter 5, unless otherwise specified.

4.6.2 General arrangements of double bottom structure

Where the inner side plating does not extend down to the bottom plating, the floors of vessels built in the transverse system are to be stiffened, at each frame, in way of the inner side plating, by means of a section, the net sectional area of which, in cm^2, is not to be less than:

$$A = 0,01\ b\ t_F$$

where:

t_F : Net thickness of floor web, in mm

b : Section height, in mm:

$b = 100\ H_D$

H_D : Double bottom height, in m.

As a rule, manholes are not to be provided into the centreline girder.

4.6.3 Transverse hold bulkhead structure

Arrangements and scantlings of transverse hold bulkheads are to be in compliance with Pt B, Ch 5, Sec 5.

SECTION 2 BULK CARGO VESSELS

Symbols

A_{SH} : Net web sectional area, in cm^2

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

g : Gravitational acceleration:

$$g = 9,81\ m/s^2$$

k : Material factor defined in:

- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Pt B, Ch 3, Sec 1, [2.4.3]

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

β_b, β_S : Span correction coefficients defined in Pt B, Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Pt B, Ch 5, Sec 1, [1.3]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Pt B, Ch 5, Sec 1, [1.3]

λ_b, λ_s : Coefficients for pressure distribution correction defined in Pt B, Ch 2, Sec 4, [6.3]

ℓ : Stiffener span, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Bulk cargo vessel**, as defined in Pt A, Ch 1, Sec 3, [2.1.1].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stipulated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to bulk cargo vessels.

1.2 Estimated still water design bending moments

1.2.1 Estimated still water design bending moments are to be determined in compliance with Pt B, Ch 3, Sec 2. If parameters X_{AV} and X_{AR} are not known, they are not to be taken less than:

$$X_3 = \frac{p_S}{19,6\rho_B \tan\varphi_B}$$

where:

p_S : Bottom or inner bottom still water design pressure, in kN/m^2, defined in Pt B, Ch 3, Sec 4, [3.2.3]

ρ_B, φ_B : Dry bulk cargo density, in t/m^3, and angle of repose, in degree.

1.3 Direct calculation

1.3.1 The following requirements apply to the analysis of primary supporting members.

Direct calculation is to be carried out in compliance with Pt B, Ch 2, Sec 8, [2].

1.3.2 Loading conditions and load cases in service conditions

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in the primary supporting members.

The following loading conditions are generally to be considered:

a) Harbour
- full cargo load in hold/vessel at the relevant draught T_1
- empty hold/vessel at the relevant draught T_1

b) Navigation
- full cargo load/vessel at the scantling draught T
- lightship/vessel at the relevant draught T_1.

1.3.3 Structure checks

The following checks are to be carried out:

- level of normal stresses and shear stresses, in particular in way of holes and passage of longitudinals
- buckling strength of unstiffened webs
- for double hull vessels, continuity of double bottom in side tanks.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

2.2 Semi-liquid cargo

2.2.1 For a bulk dry cargo likely to redistribute itself if the vessel lists to an inclination greater than its angle of repose, such as grain or cement (semi-liquid cargo), requirements of [2.2.2], [2.2.3] and [2.2.4] are to be additionally complied with.

2.2.2 Stowage of cargo

a) Trimming

All necessary and reasonable trimming is to be performed to level all free cargo surfaces and minimise the effect of cargo shifting.

b) Cargo securing

Unless account is taken of the adverse heeling effect due to cargo shift according to these Rules, the surface of the bulk cargo in any partially filled compartment is to be secured so as to prevent a cargo shift by overstowing.

c) Longitudinal subdivisions

The proper precaution is to fit one or more temporary longitudinal subdivisions in the holds or compartments to minimise the possibility of shift of cargo.

2.2.3 Calculation of the heeling moment due to cargo shifting

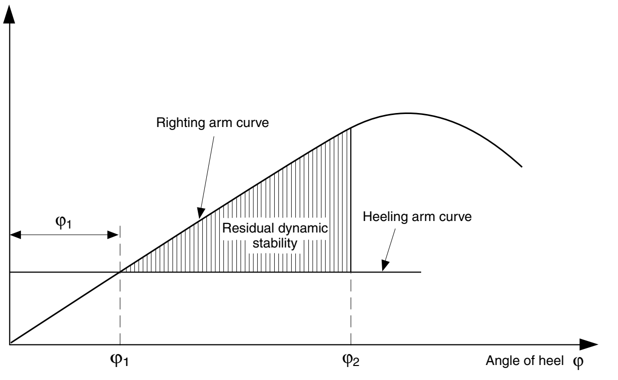
The heeling moment due to cargo shifting is to be determined in relation with the hold or compartment geometry, assuming an angle to the horizontal of the resulting cargo surface after shifting of 12°.

2.2.4 Additional intact stability criteria

The intact stability characteristics of any vessel carrying bulk dry cargo likely to redistribute itself if the vessel lists to an inclination greater than its angle of repose, such as grain or cement, are to be shown to meet, throughout the voyage, at least the following criteria after taking into account the heeling moment due to cargo shifting (see Fig 1):

- the angle of heel φ_1 due to the shift of cargo is not to be greater than 12° or the angle at which the deck edge is immersed, whichever is the lesser
- in statical stability diagram, the net or residual area between the heeling arm curve and the righting arm curve up to the angle of heel φ_2 of maximum difference between the ordinates of the two curves, or 27° or the angle of flooding, whichever is the lesser, is in all conditions of loading to be not less than 0,024 m·rad
- the initial metacentric height, after correction for the free surface effects of liquids in tanks, as specified in Pt B, Ch 2, Sec 2, [2.3], is to be not less than 0,15 m.

Figure 1 : Stability curve



3 Single side bulk cargo vessels

3.1 General

3.1.1 Application

The requirements of this Article apply to open deck vessels of single side construction, with or without double bottom, intended primarily to carry bulk dry cargoes.

The loading/unloading may be performed in one or two runs.

3.2 Protection of cargo holds

3.2.1 Coating

All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

Suitable coatings for the intended cargoes (in particular for the compatibility with the cargo) are to be chosen and applied in accordance with the manufacturer's requirements.

3.2.2 Cargo hold ceiling

The cargo hold bottom is to be sheathed up to the upper part of bilges by wooden or metallic ceiling of thickness depending on the cargo nature.

Where a side ceiling is provided, it is to be secured every 4-frame spacing to the side frames by an appropriate system.

3.3 Bottom structure

3.3.1 Single bottom vessels are to be fitted with girders in compliance with Pt B, Ch 5, Sec 2, [4.2] or Pt B, Ch 5, Sec 2, [5.3].

3.3.2 Transversely framed single bottom

A single bottom transversely framed is to be fitted with floors at every frame.

3.3.3 Longitudinally framed single bottom

Longitudinal stiffeners are generally to be continuous when crossing primary members.

The section modulus of longitudinals located in way of the web frames of transverse bulkheads is to be increased by 10%.

Longitudinals are to be supported by transverses whose spacing is to be not greater than 8-frame spacing, nor than 4 m, whichever is less.

3.4 Transversely framed side

3.4.1 Connection of frames with floors

The frames are to be connected to the floors in compliance with Pt B, Ch 5, Sec 3, [4.1].

3.4.2 Connection with deck structure

At the upper end of frames, connecting brackets are to be provided, in compliance with Pt B, Ch 5, Sec 3, [8]. Such brackets are to extend to the hatch coaming.

3.4.3 Web frames

Web frames are to be fitted with a spacing not exceeding 5 m.

Their scantling is to be performed according to [3.7.2].

3.4.4 Connection of frames to bottom longitudinals

In the case of a longitudinally framed single bottom, the side frames are to be connected to the bottom longitudinal the most at side, either directly or by means of a bracket.

Similarly, at the frame upper part, connecting brackets are to be provided, extending up to the deck longitudinal the most at side and, even, to the hatch coaming, in general.

3.5 Longitudinally framed side

3.5.1 Side transverses

Side transverses are to be fitted, in general, with a spacing not greater than 8-frame spacing, nor than 4 m.

Their scantling is to be performed according to [3.7.2].

The side transverses are generally directly welded to the shell plating.

In the case of a double bottom, the side transverses are to be bracketed to the bottom transverses.

3.5.2 Side longitudinals

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

In the case the longitudinals are interrupted by a primary supporting member, brackets on both sides of the primary supporting member are to be fitted in perfect alignment.

3.6 Topside structure

3.6.1 Strength continuity

At the ends of the cargo hold space, the members taking part in the overall strength are to be correctly staggered.

Arrangements are to be made to ensure strength continuity of the topside structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming which is located above deck and to connect it to the side bulkheads of the accommodation spaces.

3.7 Hull scantlings

3.7.1 General

The hull scantlings are to be as specified in Part B, Chapter 5, unless otherwise specified.

3.7.2 Transverse rings

Where necessary, transverse rings are to be fitted to provide additional supports of the stringer plate.

The ring component scantlings are not to be less than the values given in Tab 1.

3.7.3 Transverse hold bulkhead structure

The number and location of transverse bulkheads are defined in Pt B, Ch 5, Sec 5.

Where necessary, additional bulkheads are to be fitted to provide for sufficient transverse strength of the vessel.

The scantlings of transverse hold bulkheads are not to be less than the values required in Pt B, Ch 5, Sec 5.

a) Vertically framed plate bulkhead

   The upper end of the vertical stiffeners is to be connected either to a strong deck box beam or to a stringer located at the stringer plate level or above.

   As far as practicable, the bottom of the box beam or the bulkhead end stringer is to be located in the same plane as the stringer plate.

   Where this is not the case, the bulkhead plating or the box beam sides are to be fitted with an efficient horizontal framing at that level.

b) Horizontally framed bulkhead

   The upper part of horizontally framed bulkheads are to be specially considered by the Society.

c) Plate bulkhead end stringer

   The net scantlings of the plate bulkhead end stringer is to be determined using the following formula:

$$w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_A)} S \ell^2 10^3$$

where:

- p : Bulkhead end stringer design load, in kN/m², to be determined using applicable formulae given in Pt B, Ch 3, Sec 4, [3]
- S : Bulkhead stringer spacing, in m
- σ_A : Bulkhead end stringer axial stress, in N/mm²:

$$\sigma_A = \frac{10 q D_1}{A}$$

- A : Bulkhead end stringer sectional area, in cm²
- q : Distributed transverse load acting on the stringer plate, in kN/m, to be determined as stated in Pt B, Ch 5, Sec 4, [2.4.1]
- D_1 : Unsupported stringer plate length, in m, defined in Pt B, Ch 5, Sec 4, [2.4.2].

  In way of hold end bulkheads, D_1 is to be substituted by 0,5 D_1
- m : Boundary coefficient, to be taken equal to 8.

Table 1 : Net scantling of transverse rings

Primary supporting member		w (cm^3)	A_{sh} (cm^2)
Reinforced floors Bottom transverses		$w = \frac{\gamma_R \gamma_m \beta_b p}{m R_y} S B^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S B$
Side webs and side transverses **(1)**	• if $\ell_0 \leq \ell$	$w = 26 \frac{\gamma_R \gamma_m \beta_b \ell}{m R_y} S {\ell_0}^2 10^3$	$A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} S \ell_0$
	• if $\ell_0 > \ell$	$w = 4,4 \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$	$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \frac{p}{R_y} S \ell$
Strong box beams		see Pt B, Ch 5, Sec 4, [2.4.4]	

(1) Scantlings of web frames and side transverses at the lower end are to be the same as those of floors or bottom transverses connected to them.

Note 1:

- p : Design load, in kN/m^2, defined in Pt B, Ch 5, Sec 1, [2.1]
- ℓ_0 : Span parameter, in m:
  $\ell_0 = p_d / g$
- p_d : Total pressure, in kN/m^2, at the lower end of the stiffener
- m : Boundary coefficient, to be taken equal to 8.

3.7.4 Strengthening of cargo hold structures

In case of grab loading/unloading, the scantlings of structural elements within the cargo hold are to be increased according to Ch 2, Sec 10, [2].

4 Double hull bulk cargo vessels

4.1 General

4.1.1 Application

The requirements of this Article apply to open deck vessels of double hull construction, intended primarily to carry bulk dry cargoes.

The loading/unloading may be performed in one or two runs.

4.1.2 Protection of cargo holds

All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

Suitable coatings for the intended cargoes (in particular for the compatibility with the cargo) are to be chosen and applied in accordance with the manufacturer's requirements.

4.2 Welding

4.2.1 General

Welding is to comply with the requirements of Pt B, Ch 8, Sec 2.

4.2.2 Arrangements applying to the shell plating and the double hull

Transverse butts are to be butt welded. Double bottom butts may be welded in way of floor faceplate which then acts as a support.

The longitudinal joints are to be obtained either by butt welding or by overlap welding. In the second case, the outer line welding is to be continuous with a throat thickness of 0,5 t, whereas the inner line of welding may be discontinuous with a ratio p/d < 4 and a throat thickness of 0,5 t; however, for spaces which are not accessible after construction, the inner weld is to be carried out with a continuous line welding.

4.2.3 Arrangements applying to the topside plating

Butt weldings are to be carried out on the transverse butts of the sheerstrake, stringer plate and coaming.

4.2.4 Connection of inner bottom with floors

Where the floors cannot be welded to the inner bottom by means of fillet welds, the connection may be obtained by slot welds, in compliance with Pt B, Ch 8, Sec 2, [2.7]. In that case, the floors are to be fitted with flange of adequate width.

4.3 Transversely framed double side

4.3.1 Structural arrangement

Where the inner side does not extend down to the outer bottom, it is to be held in position by means of brackets or vertical stiffeners fitted to the floors.

Adequate continuity strength is to be ensured in way of changes in width of the double side. In particular, scarfing of the inner side is to be ensured beyond the cargo hold region.

4.3.2 Side and inner side frames

At their upper end, side and inner side frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames.

Where the outer and inner side frames are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected frames.

At their lower end, the frames are to be adequately connected to the floors or top tank.

4.3.3 Side and inner side web frames

It is recommended to provide side web frames, fitted every 3 m and, in general, not more than 6-frame spacings apart.

At their upper end, side and inner side web frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames. An attached plating strip, where applicable, may be taken into account.

The web frames are to be connected at their mid-span by means of struts, the cross sectional area of which is not to be less than those of the connected web frames.

At their lower end, the web frames are to be adequately connected to the floors or top tank.

4.3.4 Plate webs

Plate webs may be fitted in addition or instead of web frames.

Plate webs are to be fitted with horizontal stiffeners, the spacing of which is not to be greater than 1 m.

The scantling of plate webs with large openings is to be examined by the Society on a case by case basis.

4.4 Longitudinally framed double side

4.4.1 Inner side plating

The requirements of [4.3.1] also apply to longitudinally framed double side, with the transverses instead of web frames.

4.4.2 Side and inner side longitudinals

Where the outer and inner side longitudinals are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected longitudinals.

4.4.3 Side transverses

The requirements of [4.3.3] also apply to longitudinally framed double side, with the transverses instead of web frames.

4.4.4 Plate webs

The requirements of [4.3.4] also apply to longitudinally framed double side.

4.5 End structure

4.5.1 Arrangements for self-propelled vessels

At the ends of the cargo hold space, the strength continuity of members taking part in the overall strength is to be adequately ensured.

In particular, arrangements are to be made to ensure strength continuity of the top structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming located above deck and to connect it to the side bulkheads of the accommodation spaces.

The longitudinal boundaries of the engine room side bunkers are to be located, as far as practicable, in the extension of the double hull sides.

4.5.2 Arrangements for pushed vessels

Where the compartments outside the cargo hold space are of small size, the strength continuity is to be ensured by scarfing of strength members.

The double hull sides are to be extended, in the shape of brackets, outside the cargo hold space over a distance equal to twice the stringer plate width.

Strength continuity of the inner bottom is to be ensured by means of brackets, one of which is to be along the vessel centreline. Where the vessel ends are built on the longitudinal system, the brackets are to be connected to the bottom longitudinals; otherwise, they are to be connected to keelsons.

Pushing transoms, if any, are to be designed in compliance with Pt B, Ch 7, Sec 6, [2.2].

4.6 Hull scantlings

4.6.1 General

The hull scantlings and arrangements are to be determined according to Part B, Chapter 5, unless otherwise specified.

4.6.2 General arrangements of double bottom structure

Where the inner side plating does not extend down to the bottom plating, the floors of vessels built in the transverse system are to be stiffened, at each frame, in way of the inner side plating, by means of a section, the net sectional area of which, in cm², is not to be less than:

$A = 0,01\ b\ t_F$

where:

t_F : Net thickness of floor web, in mm

b : Section height, in mm:

$b = 100\ H_D$

H_D : Double bottom height, in m.

As a rule, manholes are not to be provided into the centreline girder.

4.6.3 Transverse hold bulkhead structure

Arrangements and scantlings of transverse hold bulkheads are to be in compliance with Pt B, Ch 5, Sec 5.

4.6.4 Strengthening of cargo hold structure

In case of grab loading/unloading, the scantlings of structural elements within the cargo hold are to be increased according to Ch 2, Sec 10, [2].

SECTION 3 TANKERS

Symbols

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

s : Spacing of ordinary stiffeners, in m

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Pt B, Ch 3, Sec 1, [2.4.3]

t : Net thickness, in mm, of plating.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Tanker**, as defined in Pt A, Ch 1, Sec 3, [3.1.1].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to tankers.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

2.2 Intact stability

2.2.1 The stability of tankers for all intended loading conditions is to comply with Pt B, Ch 2, Sec 2, [4].

3 Vessel arrangement

3.1 Basic structural configuration

3.1.1 Single hull tankers

In a single hull tanker (see Fig 1), the cargo tanks are bounded by the vessel outer shell, which means the bottom, the sides of the shell plating and the decks simultaneously act as tank walls.

3.1.2 Double hull tankers

As it is the case for a single hull tanker, the cargo tanks form part of the vessel structure. However, the bottom and side plating does not function simultaneously as tank walls (see Fig 2). For certain products, minimum distances between tank boundaries and bottom or side plating are to be observed. Accessibility is, however, to be guaranteed in every case.

3.1.3 Tankers with inserted cargo tanks

In this type of vessel, the cargo tanks are independent of the vessel structure but are permanently installed (see Fig 3).

3.1.4 Tankers with membrane cargo tank

Membrane cargo tanks are non-self supporting cargo tanks that consists of a thin liquid and gastight layer (membrane) supported through insulation by the adjacent hull structure.

Membrane cargo tanks are installed in hold spaces bounded by double hull spaces and double bottom (see Fig 4).

3.2 Minimum side tank width

3.2.1 The side tank width is to be not less than 600 mm.

4 Stability

4.1 Tankers carrying dangerous goods

4.1.1 For vessels carrying dangerous goods, see Part D, Chapter 3.

4.2 Other tankers

4.2.1 Where the tank breadth exceeds 0,7 B, cargo tanks are normally to be provided with centre longitudinal bulkheads. Where the tank breadth is greater than the figure mentioned and centre longitudinal bulkheads are not fitted, proof of sufficient intact stability according to Pt B, Ch 2, Sec 2, [4] is to be furnished.

Figure 1 : Single hull tankers

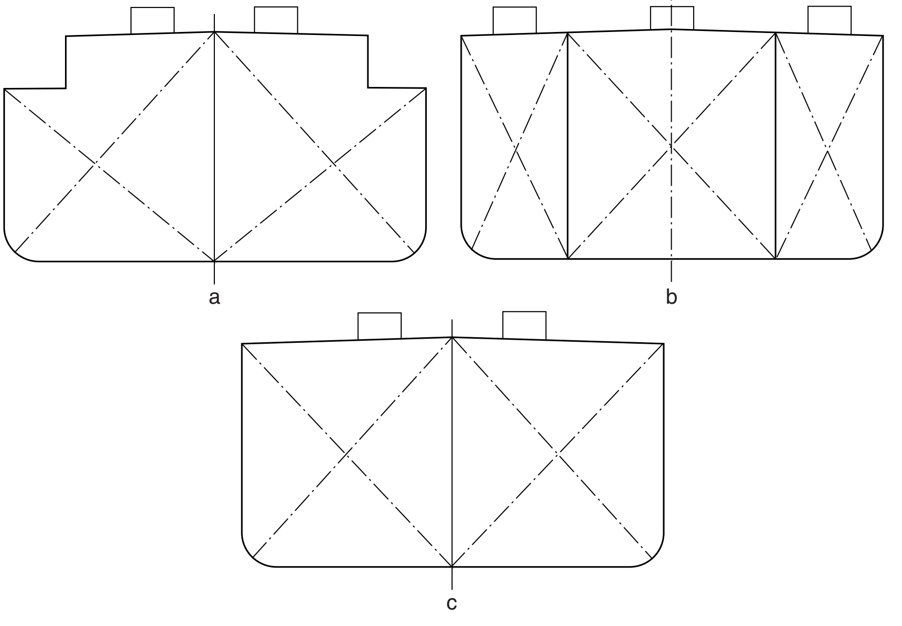


Figure 2 : Double hull tankers

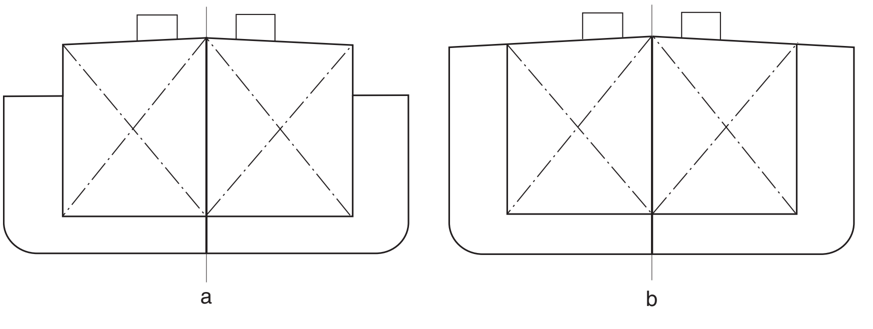


Figure 3 : Inserted cargo tank

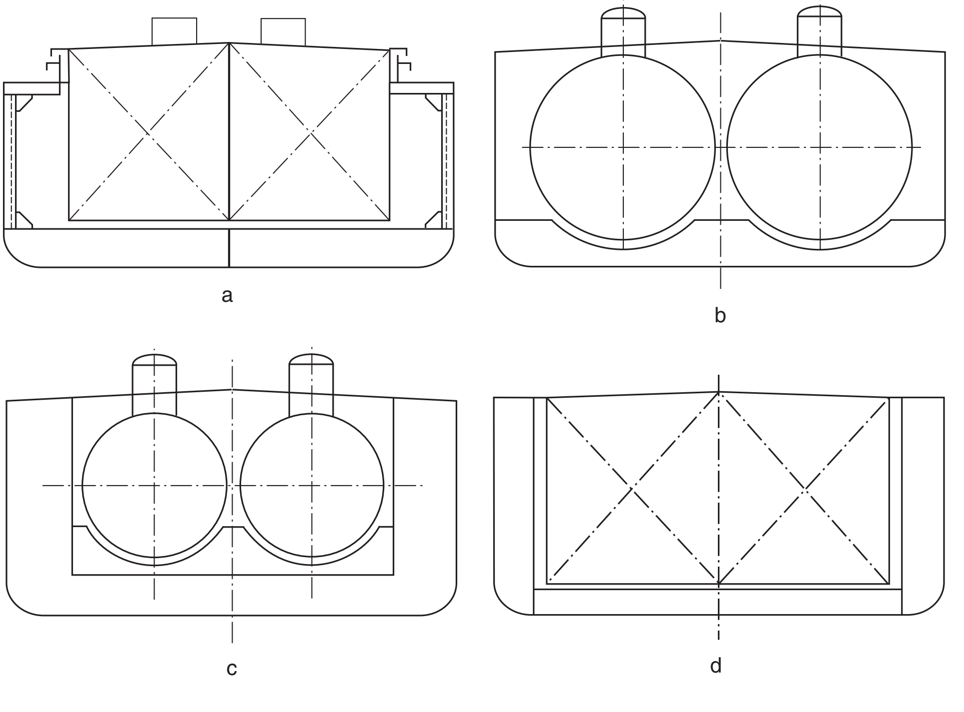
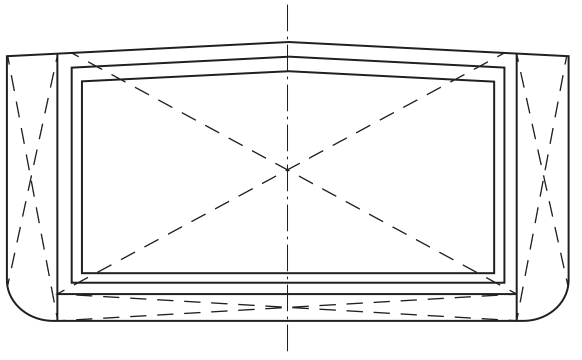


Figure 4 : Membrane cargo tank



5 Machinery and systems

5.1 Bilge system

5.1.1 Size of bilge pipes

The inside diameter of the bilge lines shall not be taken less than 50 mm nor than the values derived from the following formulae:

- main pipe:

  $$d_1 = 3,0\sqrt{(B+D)\ell_1} + 35$$

- branch pipe:

  $$d_2 = 2,0\sqrt{(B+D)\ell} + 25$$

where:

ℓ_1 : Total length, in m, of spaces between cofferdam or cargo bulkhead and stern tube bulkhead

d_1 : Inside diameter of main bilge pipe, in mm

d_2 : Inside diameter of branch bilge pipe, in mm

ℓ : Length of the watertight compartment, in m.

6 Hull scantlings

6.1 General

6.1.1 The hull scantlings are to be determined as specified in Part B, Chapter 5, using the adequate design loads, unless otherwise specified in this Article.

In the cargo tank area, including cofferdams, the net thickness of plates and structural members in spaces intended to contain liquids are not to be less than 4,4 mm.

6.1.2 Independent tanks

Scantlings of independent tanks are to be determined in compliance with Part B, Chapter 5, where the hull girder stresses may be taken equal to zero.

6.1.3 Thermal stresses

Where heated liquids are intended to be carried in tanks, a calculation of thermal stresses is required, if the carriage temperature of the liquid exceeds 90°C.

The calculations are to be carried out for both temperatures, the actual carriage temperature and the limit temperature specified hereabove.

The calculations are to give the resultant stresses in the hull structure based on a water temperature of 0°C and an air temperature of −5°C.

Constructional measures and/or strengthenings will be required on the basis of the results of the calculation for both temperatures.

6.2 Other requirements

6.2.1 Minimum net thickness of web plating

The net thickness, in mm, of the web plating of ordinary stiffeners is to be not less than:

- for L < 120 m:

  $t = 1,63 + 0,004\ L\ (k_0k)^{0,5} + 4,5\ s$

- for L ≥ 120 m:

  $t = 3,9\ (k_0k)^{0,5} + s$

The net thickness, in mm, of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$t = 1,14\ L^{1/3}\ (k_0k)^{0,5}$

7 Transverse rings

7.1 General

7.1.1 The strength check of the transverse rings is to be performed by direct calculation according to Pt B, Ch 2, Sec 8, [2].

In particular, the requirements of [7.2] to [7.4] are to be complied with.

7.1.2 Loading conditions and load cases

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in the primary supporting members.

The following loading conditions are generally to be considered:

a) Harbour
   - full cargo load in tank/vessel at the relevant draught T_1
   - empty cargo tank/vessel at the relevant draught T_1

b) Navigation
   - full cargo load/vessel at the scantling draught T
   - lightship/vessel at the relevant draught T_1

c) Testing conditions
   - fully loaded cargo tank subjected to test pressure (see Pt B, Ch 3, Sec 4, [5]).

7.2 Floors and bottom transverses in way of rings

7.2.1 The following checks are to be carried out:

- level of shear stresses, in particular in way of holes and passage of longitudinals
- buckling strength of unstiffened webs
- continuity of double bottom in the side tanks.

7.3 Web frames and side transverses in way of rings

7.3.1 For side primary supporting members, the level of normal stresses and shear stresses in way of holes and passage of longitudinals is to be checked.

7.4 Strong beams and deck transverses in way of rings

7.4.1 The following checks are to be carried out:

- level of normal stresses and shear stresses, in particular, in way of holes and passage of longitudinals
- buckling strength of unstiffened web
- continuity of structure and lateral support of deck transverses, notably, when the flange of the deck transverse is a round bar.

7.5 Pillars

7.5.1 Strong beams and deck transverses in way of rings are to be supported by pillars. The pillar scantlings are to be determined according to Pt B, Ch 5, Sec 4, [8], where the deck pressure is not to be taken less than 5 kN/m^2. The pillars and their attachments are also to be examined for traction resulting from the relevant test pressure related to the respective vessel type.

7.5.2 Tubular pillars are to be avoided in the cargo tanks as far as possible. For tank vessels intended to carry flammable liquids or chemicals, tubular pillars are not permitted.

7.5.3 The pillars are to be attached to the girders as well as to the floor plates located below by means of welding.

7.6 Break in the deck

7.6.1 A reinforced deck transverse, pillars or a transverse bulkhead is to be fitted in way of the deck break.

8 Vessel structural arrangements

8.1 Vessels with integrated tanks, transverse framing system

8.1.1 Beams

Beams are to be fitted at every frame. They are to be discontinuous in way of longitudinal bulkheads, to which they are connected with brackets. Deck beams are not to be discontinuous in way of expansion tanks, unless efficient compensations are provided.

8.1.2 Strong beams

As a rule, strong beams are to have the same scantlings as side web frames to which they are connected by brackets or any other equivalent arrangement, so as to ensure strength continuity.

8.1.3 Floors

Floors are to be fitted at every frame. They are to be discontinuous in way of bulkheads to which they are connected by means of brackets or other equivalent arrangement ensuring strength continuity.

An adequate number of limbers is to be cut out in floors, longitudinals and transverses to ensure the draining of cargo to the pump suctions.

8.2 Vessels with integrated tanks, longitudinal framing system

8.2.1 Side transverses

The side transverses are to be spaced not more than 3 m apart.

The span of side shell strength transverses is to be taken equal to the vertical distance between bottom and deck.

8.2.2 Deck longitudinals

The deck longitudinals are to be continuous through expansion tanks, unless efficient compensations are fitted.

8.3 Vessels with integrated tanks, combination system

8.3.1 Web frames

It is recommended to provide side shell and longitudinal bulkhead web frames in way of bottom and deck transverses.

8.4 Vessels with independent tanks

8.4.1 General

Vessels with independent tanks are to be built on the transverse framing system. When a longitudinal framing system is applied, it is to be specially considered by the Society.

8.4.2 Stiffening

The side stiffeners may be inside or outside the tank.

When tank longitudinal sides are framed vertically, stiffeners are to form continuous frames with the top and bottom stiffeners, whether the frames are connected or not by brackets.

The vertical or horizontal stiffeners of transverse sides are to be welded on to the perpendicular tank sides, either directly or by means of brackets extending up to the first stiffener of previous sides.

To ensure proper contact between tank plates and vessel bottom, the bottom structure is to be adequately stiffened.

8.4.3 Floors

In way of floors not in contact with tanks, for instance floors located between tanks and floors at hold ends, at least two keelsons with intercostal plating are to be provided. The keelsons are to be fitted approximately at one-third of the width and extending at least over three frame spaces beyond tank end bulkheads.

8.5 Double hull arrangements

8.5.1 General

All parts of the cargo zone are to be well ventilated and accessible to ensure surveys and maintenance.

8.5.2 Floor reinforcement

Where the inner side plating does not extend down to the bottom plating, the floors of vessels built in the transverse system are to be stiffened, at each frame, in way of the double hull shell plating, by means of a section, the net sectional area of which, in cm², is not to be less than:

$A = 0{,}01\ b\ t_F$

where:

b	:	Section height, in mm, equal to: $b = 100\ H_D$ where H_D is the double bottom height, in m
t_F	:	Net thickness of floor web, in mm.

8.6 Ends of cargo zone

8.6.1 The inner longitudinal side is to be extended inside the cofferdam. Moreover, when possible, it is to be extended in the fore and aft ends of the vessel by means of brackets.

9 Supports of independent cargo tanks

9.1 Structural arrangement

9.1.1 General

The reaction forces in way of tank supports are to be transmitted as directly as possible to the hull primary supporting members, minimising stress concentrations.

Where the reaction forces are not in the plane of primary members, web plates and brackets are to be provided in order to transmit these loads through shear stresses.

Stress concentrations in the tank walls are to be avoided, and care is to be taken to ensure that the tank seatings do not impede the contraction of the tank when cooled down to the transport temperature.

9.1.2 Chocking of tanks

The tank seatings are to be constructed in such a way as to make it impossible for the tanks to move in relation to the vessel structure.

The tanks are to be supported by floors or bottom longitudinals.

When the stringer plate is chocked against tanks in way of some web frames or side shell transverses, chocking may consist in a bolted assembly. In case of applying wedges in hard wood or synthetic material capable of transmitting the chocking stress, arrangements are to be provided to avoid an accidental shifting during navigation.

9.1.3 Anti-flotation arrangements

Anti-flotation arrangements are to be provided for independent tanks. The anti-flotation arrangements are to be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the damage draught of the vessel, without plastic deformation likely to endanger the hull structure.

9.1.4 Openings

In primary supporting members and hull structures in way of tank supports, openings are to be avoided and local strengthening may be necessary.

9.2 Loads and load cases

9.2.1 The design of the tank supports is to be based on the following assumed forces.

Relaxation of the following may be granted by the Society on a case by case basis.

a) In the vertical direction:
   - the weight of the filled tanks acting downwards
   - the buoyancy of the empty tanks assuming the vessel is in the damaged condition, acting upwards
   - the weight of the filled tanks assuming the vessel is capsized

b) Athwartships and in the capsized conditions:
   - the tank seatings in the athwartship direction are to be designed for the total heeling range up to the completely capsized condition

c) In the fore-and-aft direction:
   - the design of the tank seatings in the fore-and-aft direction is to be based on a force equal to 0,30 P

     where:

     P : Weight of tank including contents.

9.3 Calculation of reaction forces in way of tank supports

9.3.1 The reaction forces in way of tank supports are to be obtained from the structural analysis of the tank, considering the loads specified in [9.2].

If the tank supports are not able to react in tension, the final distribution of the reaction forces at the supports may not show any tensile forces.

9.4 Scantlings of independent tank supports and hull structures in way

9.4.1 Scantlings

The net scantlings of plating, ordinary stiffeners and primary supporting members of tank supports and hull structures in way are to be not less than those obtained by applying the criteria in Part B, Chapter 5, taking into account the hull girder loads and the lateral pressure calculated according to Part B, Chapter 3 as well as the reaction forces determined according to [9.3].

10 Expansion tanks

10.1 General

10.1.1 Each tank is to be provided at about mid-length with an expansion tank whose height above tank top is not to be less than 0,5 m.

10.1.2 Scantlings of expansion tank covers are to be specially examined by the Society.

11 Subdivision

11.1 General

11.1.1 Bulkheads adjacent to tanks, cofferdams and hold are to be welded or assembled by means of an equivalent approved process. They are to have no openings.

11.1.2 The bulkhead scantlings are to be determined in compliance with Pt B, Ch 5, Sec 5, [2] and Pt B, Ch 5, Sec 5, [3], taking into account additional requirements stated under [11.2] and [11.3].

11.2 Minimum thickness of bulkhead plating

11.2.1 Minimum plating thickness

The net thickness, in mm, of liquid cargo tank bulkheads is to be not less than the value obtained from the following formula:

$t_1 = 1,36 + 0,011\ L\ (k_0k)^{0,5} + 3,6\ s$

11.3 Minimum net thickness of structural member web

11.3.1 Ordinary stiffeners

The minimum net thickness, in mm, of the web plate of ordinary stiffeners fitted on liquid cargo tank bulkhead is to be obtained from the following formula:

$t = 0,61\ L^{1/3}\ (k_0k)^{0,5} + 3,6\ s$

11.3.2 Primary supporting members

The minimum net thickness, in mm, of the web plate of primary supporting members is to be obtained using the following formula:

$t = 1,14\ L^{1/3}\ (k_0k)^{0,5}$

11.4 Corrugated bulkheads

11.4.1 General

In place of plane bulkheads provided with stiffeners, corrugated bulkheads, designed according to Pt B, Ch 5, Sec 5, [6], may be built in.

11.4.2 Direct calculation

The relevant service and test pressure related to the vessel type are to be considered.

The following checks are to be carried out:

- section modulus of beam
- section modulus of welds
- buckling of face plate
- section modulus of welds when there is no continuity of web in double bottom.

For the allowable stresses, see Pt B, Ch 2, Sec 8, [2].

SECTION 4 CONTAINER VESSELS

Symbols

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

g : Gravitational acceleration:

$g = 9,81 \text{ m/s}^2$

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 0 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

n : Navigation coefficient defined in Pt B, Ch 3, Sec 1, [5.2]

R_y : Minimum yield stress, in N/mm², of the material to be taken equal to:
- R_y= 235/k N/mm² for steel
- R_y= 100/k N/mm² for aluminium alloys

unless otherwise specified

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Pt B, Ch 3, Sec 1, [2.4.3]

t : Net thickness, in mm, of plating

β_b , β_S : Span correction coefficients defined in Pt B, Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Pt B, Ch 5, Sec 1, [1.3]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Pt B, Ch 5, Sec 1, [1.3]

λ_b , λ_s : Coefficients for pressure distribution correction defined in Pt B, Ch 2, Sec 4, [6.3].

1 General

1.1 Application

1.1.1 The service notation **Container vessel** is assigned, in accordance with Pt A, Ch 1, Sec 3, [2.1.2], to vessels intended to carry dry unit cargoes.

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to container vessels.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, the following information is to be submitted to the Society:
- container arrangement in holds, on decks and on hatch covers, indicating size and gross mass of containers
- container lashing arrangement indicating securing and load bearings arrangements
- drawings of load bearing structures and cell guides, indicating the design loads and including the connections to the hull structures and the associated structural reinforcements.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article, depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

2.1.3 In addition, the requirements of [2.2], [2.3] and [2.4] are to be complied with, as applicable, in the following cases:

a) $B < 9,5$ and $n_T > 1$

b) $9,5 \le B < 11$ and $n_T > 2$

c) $B \ge 11$ and:
- ($n_S > 3$ and $n_T > 2$), or
- $n_T > 3$

where:

n_T : Number of container tiers

n_S : Number of container stacks over the breadth B.

2.2 Stowage of containers

2.2.1 Secured containers

A cargo of containers shall be considered to be secured if each individual container is firmly secured to the hull of the vessel by means of rails or turnbuckles and its position cannot alter during the voyage.

2.2.2 In the case of vessels likely to carry either secured or non-secured containers, separate documents concerning stability are required for the carriage of each type of container.

2.3 Intact stability in case of non-secured containers

2.3.1 All methods of calculating a vessel's stability in the case of non-secured containers shall meet the following limit conditions:

a) metacentric height GM shall not be less than 1,00 m

b) under the joint action of the wind thrust, centrifugal force resulting from the vessel's turning and the effect of free surfaces induced by the hold or double bottom fillings, the angle of heel shall not exceed 5° and the edge of the deck shall not be immersed.

2.3.2 The heeling lever, in m, resulting from the centrifugal force caused by the vessel turning shall be determined in accordance with the following formula:

$$h_{KZ} = 0,00308\frac{v^2}{L_{WL}}\left(KG - \frac{T}{2}\right)$$

2.3.3 The heeling lever, in m, resulting from the wind thrust is to be determined in accordance with the following formula:

$$h_{KW} = 0,1p_{WD}\frac{A_W}{\Delta}\left(\ell_W + \frac{T}{2}\right)$$

where:

p_{WD} : Wind pressure, in kN/m², defined in Pt B, Ch 3, Sec 4, [2.1.3].

A_W : Side surface above the waterline of the loaded vessel, in m²

ℓ_W : Height, in m, of the centre of gravity of the side surface A_W above the waterline.

2.3.4 The heeling lever, in m, resulting from the free surfaces of rainwater and residual water within the hold or the double bottom shall be determined in accordance with the following formula:

$$h_{KFO} = \frac{0,015}{\Delta}\sum[b\ell(b - 0,55\sqrt{b})]$$

where:

b : Width of hold or section of the hold in question, in m

ℓ : Length of hold or section of the hold in question, in m.

2.3.5 Half of the fuel and fresh water supply shall be taken into account for each load condition.

2.3.6 The stability of a vessel carrying non-secured containers shall be considered to be sufficient if the effective KG does not exceed the KG_Z determined according to [2.3.7].

2.3.7 KG_Z is the maximum permissible height, in m, of the loaded vessel's centre of gravity above its base.

KG_Z shall be calculated for various displacements covering all of the possible draught variations, according to the following formulae:

$$KG_Z = \frac{KM + \frac{B_{WL}}{2F}\left(Z_Z\frac{T_m}{2} - h_{KW} - h_{KFO}\right)}{\frac{B_{WL}}{2F}Z_Z + 1}$$

$KG_Z = KM - 1$

whichever is the lesser,

where:

$B_{WL} / 2F > 11,5$

KM : Height of the metacentre above the base, in m.

If no curve diagram is available the value of KM may be determined, for example, via the following approximation formulae:

- vessels in the form of a pontoon:

$$KM = \frac{B_{WL}^2}{\left(12,5 - \frac{T_m}{D}\right)T_m} + \frac{T_m}{2}$$

- other vessels:

$$KM = \frac{B_{WL}^2}{\left(12,7 - 1,2\frac{T_m}{D}\right)T_m} + \frac{T_m}{2}$$

F : Effective freeboard at 0,5 L_{OA}

B_{WL} : Vessel waterline breadth, in m

T_m : Average draught, in m

Z_Z : Parameter for the centrifugal force resulting from turning:

$$Z_Z = 0,00308\frac{v^2}{L_{WL}}$$

2.4 Intact stability in case of secured containers

2.4.1 In the case of secured containers, all means of calculation used in order to determine vessel stability shall meet the following limit conditions:

- metacentric height GM shall not be less than 0,50 m
- no hull opening shall be immersed by the combined action of the centrifugal force resulting from the turning of the vessel, wind thrust and free surfaces of liquids.

2.4.2 The heeling moments resulting from the wind thrust, centrifugal force due to vessel's turning and free surfaces of liquids, are to be determined in accordance with [2.3].

Half of the supply of fuel and fresh water for each load condition shall be taken into account.

2.4.3 The stability of a vessel carrying secured containers shall be considered to be adequate if the effective KG does not exceed the KG_Z determined according to [2.4.4].

2.4.4 KG_Z is the maximum permissible height, in m, of the loaded vessel's centre of gravity above its base.

KG_Z shall be calculated for various displacements covering all of the possible draught variations, according to the following formulae:

$$KG_Z = \frac{KM - KM_1 + KM_2}{0,75\frac{B_{WL}}{F^*}Z_Z + 1}$$

$KG_Z = KM - 0,5$

whichever is the lesser,

where:

$B_{WL} / F^* \geq 6{,}6$

KM_1 : Parameter equal to:

$$KM_1 = \frac{I - i}{2\nabla}\left(1 - 1{,}5\frac{F}{F^*}\right) \geq 0$$

KM_2 : Parameter equal to:

$$KM_2 = 0{,}75\frac{B_{WL}}{F^*}\left(Z_Z\frac{T_m}{2} - h_{KW} - h_{KFO}\right)$$

with $B_{WL} / F^* \geq 6{,}6$

F^* : Ideal freeboard, in m:

$F^* = \min(F_1^* ; F_2^*)$

$F_1^* = D^* - T_m$

$$F_2^* = \frac{aB_{WL}}{2b}$$

a : Vertical distance between the lower edge of the opening that is first immersed in the event of heeling and the water line in the vessel's normal position, in m

b : Distance of the same opening as above from the centre of the vessel, in m

D^* : Ideal depth, in m:

$$D^* = D + \frac{q}{0{,}9L_{OA}B_{WL}}$$

q : Sum of the volumes, in m^3, of the deckhouses, hatchways, trunk decks and other superstructures up to a height of 1,0 m above D or up to the lowest opening in the space under consideration, the lowest value shall be taken.

Parts of spaces located within the area of 0,05 L_{OA} from the extremities of the vessel shall not be taken into account

∇ : Displacement of the vessel at T_m, in m^3

i : Transverse moment of inertia, in m^4, of waterline area parallel to the base, at height, in m:

$h = T_m + 2 F^* / 3$

I : Transverse moment of inertia, in m^4, of waterline area T_m

If there are no hydrostatic curves, the value needed for calculating transverse moment of inertia I of the waterline area may be obtained from the following approximation formulae:

- vessels in the form of a pontoon:

$$I = \frac{\nabla B_{WL}^2}{\left(12{,}5 - \frac{T_m}{D}\right)T_m}$$

- other vessels:

$$I = \frac{\nabla B_{WL}^2}{\left(12{,}7 - 1{,}2\frac{T_m}{D}\right)T_m}$$

T_m : Average draught, in m.

3 Structure arrangements

3.1 Strength principles

3.1.1 Local reinforcements

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

The forces applying on the fixed cargo securing devices are to be indicated by the designer.

3.2 Bottom structure

3.2.1 Floor and girder spacing

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

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

3.2.2 Strength continuity

Adequate strength continuity of floors and bottom transverses is to be ensured in way of the side tank by means of brackets.

3.2.3 Reinforcements in way of cell guides

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

3.3 Fixed cell guides

3.3.1 General

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

3.3.2 Arrangement of fixed cell guides

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

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

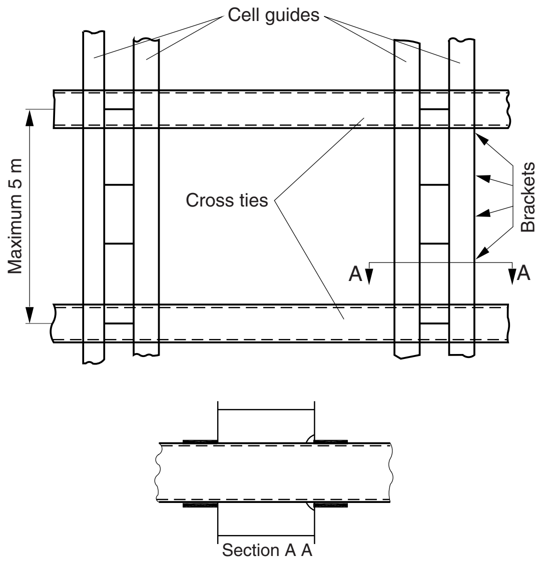
In general, the spacing between cross-ties connecting the guides may not exceed 5 metres, and their position is to coincide as nearly as possible with the one of the container corners (see Fig 1).

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

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

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

Figure 1 : Typical structure of cell guides



3.4 Fixed cargo securing devices

3.4.1 Where containers are carried, in particular on the hatch covers and on deck, container supporting members of adequate scantlings are to be fitted.

3.5 Hatch covers carrying containers

3.5.1 Efficient retaining arrangements are to be provided to prevent translation of the hatch cover under the action of the longitudinal and transverse forces exerted by the stacks of containers on the cover. These retaining arrangements are to be located in way of the hatch coaming side brackets.

Solid fittings are to be welded on the hatch cover where the corners of the containers are resting. These parts are intended to transmit the loads of the container stacks onto the hatch cover on which they are resting and also to prevent horizontal translation of the stacks by means of special intermediate parts arranged between the supports of the corners and the container corners.

4 Single side vessels

4.1 Protection of cargo holds

4.1.1 Coating

All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

4.2 Bottom structure

4.2.1 Single bottom vessels are to be fitted with girders in compliance with Pt B, Ch 5, Sec 2, [4.2] or Pt B, Ch 5, Sec 2, [5.3].

4.2.2 Transversely framed single bottom

A single bottom transversely framed is to be fitted with floors at every frame.

4.2.3 Longitudinally framed single bottom

Longitudinal stiffeners are generally to be continuous when crossing primary members.

The section modulus of longitudinals located in way of the web frames of transverse bulkheads is to be increased by 10%.

Longitudinals are to be supported by transverses whose spacing is to be not greater than 8-frame spacing, nor than 4 m, whichever is less.

4.3 Transversely framed side

4.3.1 Connection of frames with floors

The frames are to be connected to the floors in compliance with Pt B, Ch 5, Sec 3, [4.1].

4.3.2 Connection with deck structure

At the upper end of frames, connecting brackets are to be provided, in compliance with Pt B, Ch 5, Sec 3, [8]. Such brackets are to extend to the hatch coaming.

4.3.3 Web frames

Web frames are to be fitted with a spacing not exceeding 5 m.

Their scantling is to be performed according to [7.3.1].

4.3.4 Connection of frames to bottom longitudinals

In the case of a longitudinally framed single bottom, the side frames are to be connected to the bottom longitudinal the most at side, either directly or by means of a bracket.

Similarly, at the frame upper part, connecting brackets are to be provided, extending up to the deck longitudinal the most at side and, even, to:

- the hatch coaming, in general
- the side trunk bulkhead, in case of a trunk vessel.

4.4 Longitudinally framed side

4.4.1 Side transverses

Side transverses are to be fitted, in general, with a spacing not greater than 8-frame spacing, nor than 4 m.

Their scantling is to be performed according to [7.3.1].

The side transverses are generally directly welded to the shell plating.

In the case of a double bottom, the side transverses are to be bracketed to the bottom transverses.

4.4.2 Side longitudinals

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

In the case the longitudinals are interrupted by a primary supporting member, brackets on both sides of the primary supporting member are to be fitted in perfect alignment.

4.5 Topside structure

4.5.1 Strength continuity

At the ends of the cargo hold space, the members taking part in the hull girder strength are to be correctly staggered.

Arrangements are to be made to ensure strength continuity of the topside structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming which is located above deck and to connect it to the side bulkheads of the accommodation spaces.

5 Double hull vessels

5.1 Protection of cargo holds

5.1.1 All metallic structures are to be protected against corrosion according to Pt B, Ch 8, Sec 1.

5.2 Welding

5.2.1 General

Welding is to comply with the requirements of Pt B, Ch 8, Sec 2.

5.2.2 Arrangements applying to the shell plating and the double hull

Transverse butts are to be butt welded. Double bottom butts may be welded in way of floor faceplate which then acts as a support.

The longitudinal joints are to be obtained either by butt welding or by overlap welding. In the second case, the outer line welding is to be continuous with a throat thickness of 0,5 t, whereas the inner line of welding may be discontinuous with a ratio p/d < 4 and a throat thickness of 0,5 t; however, for spaces which are not accessible after construction, the inner weld is to be carried out with a continuous line welding.

5.2.3 Arrangements applying to the topside plating

Butt weldings are to be carried out on the transverse butts of the sheerstrake, stringer plate and coaming.

5.2.4 Connection of inner bottom with floors

Where the floors cannot be welded to the inner bottom by means of fillet welds, the connection may be obtained by slot welds, in compliance with Pt B, Ch 8, Sec 2, [2.7]. In that case, the floors are to be fitted with flange of adequate width.

5.3 Transversely framed double side

5.3.1 Structural arrangement

Where the inner side does not extend down to the outer bottom, it is to be held in position by means of brackets or vertical stiffeners fitted to the floors.

Adequate continuity strength is to be ensured in way of changes in width of the double side. In particular, scarfing of the inner side is to be ensured beyond the cargo hold region.

5.3.2 Side and inner side frames

At their upper end, side and inner side frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames.

Where the outer and inner side frames are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected frames.

At their lower end, the frames are to be adequately connected to the floors or top tank.

5.3.3 Side and inner side web frames

It is recommended to provide side web frames, fitted every 3 m and, in general, not more than 6-frame spacings apart.

At their upper end, side and inner side web frames are to be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to the one of the side web frames. An attached plating strip, where applicable, may be taken into account.

The web frames are to be connected at their mid-span by means of struts, the cross sectional area of which is not to be less than those of the connected web frames.

At their lower end, the web frames are to be adequately connected to the floors or top tank.

5.3.4 Plate webs

Plate webs may be fitted in addition or instead of web frames.

Plate webs are to be fitted with horizontal stiffeners, the spacing of which is not to be greater than 1 m.

The scantling of plate webs with large openings is to be examined by the Society on a case by case basis.

5.4 Longitudinally framed double side

5.4.1 Inner side plating

The requirements of [5.3.1] also apply to longitudinally framed double side, with the transverses instead of web frames.

5.4.2 Side and inner side longitudinals

Where the outer and inner side longitudinals are connected by means of struts located at mid-span, their section modulus may be reduced by 30%.

The strut sectional area is to be not less than those of the connected longitudinals.

5.4.3 Side transverses

The requirements of [5.3.3] also apply to longitudinally framed double side, with the transverses instead of web frames.

5.4.4 Plate webs

The requirements of [5.3.4] also apply to longitudinally framed double side.

5.5 End structure

5.5.1 Arrangements for self-propelled vessels

At the ends of the cargo hold space, the strength continuity of members taking part in the hull girder strength is to be adequately ensured.

In particular, arrangements are to be made to ensure strength continuity of the top structure at the end of the hatchways. As far as practicable, it is recommended to extend the part of the hatch coaming located above deck and to connect it to the side bulkheads of the accommodation spaces.

The longitudinal boundaries of the engine room side bunkers are to be located, as far as practicable, in the extension of the double hull sides.

5.5.2 Arrangements for pushed vessels

Where the compartments outside the cargo hold space are of small size, the strength continuity is to be ensured by scarfing of strength members.

The double hull sides are to be extended, in the shape of brackets, outside the cargo hold space over a distance equal to twice the stringer plate width.

Strength continuity of the inner bottom is to be ensured by means of brackets, one of which is to be along the vessel's centreline. Where the vessel ends are built on the longitudinal system, the brackets are to be connected to the bottom longitudinals; otherwise, they are to be connected to keelsons.

Pushing transoms, if any, are to be designed in compliance with Pt B, Ch 7, Sec 6, [2.2].

6 Design loads

6.1 Design torsional torque

6.1.1 Where no specific data are provided by the Designer, the design still water torsional torque induced by the non-uniform distribution of cargo, consumable liquids and ballast is to be obtained at the midship section, in kN.m, from the following formula:

$M_T = 31{,}4\ F_T\ n_S\ n_T\ B$

where:

F_T : Distribution factor defined in Tab 1 as a function of the x co-ordinate of the hull transverse section with respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2, [3]

n_S : Number of container stacks over the breadth B

n_T : Number of container tiers in cargo hold amidships (including containers on hatch covers).

Table 1 : Distribution factor F_T

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

6.2 Forces on containers

6.2.1 Still water and inertial forces

The force F_i applied to one container located at the level "i", as defined in Fig 2, is to be determined in compliance with Pt B, Ch 3, Sec 4, [3.4].

The mass of the containers is to be defined by the Designer.

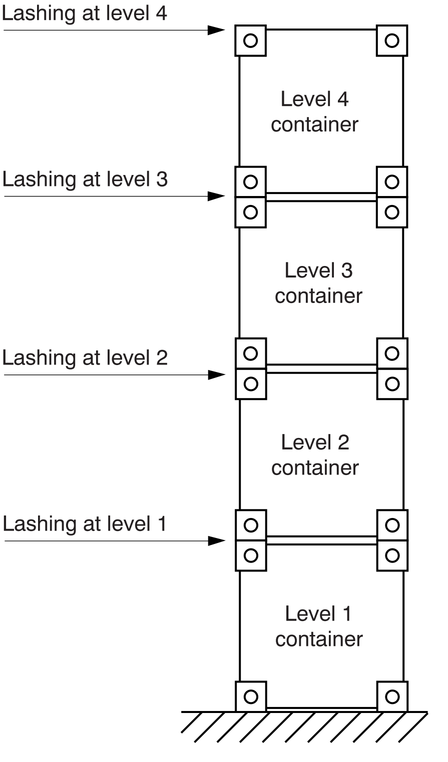
Where the mass of loaded containers is not known, the following values may be used:

- for 40-feet containers: $m_i = 27$ t
- for 20-feet containers: $m_i = 17$ t

Where empty containers are stowed at the top of a stack, the following values may be used:

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

Figure 2 : Containers level in a stack



6.2.2 Wind forces applied to one container

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

- in x direction:

  $F_{X,\ WD,\ i} = p_{WD}\ h_C\ b_C$

- in y direction:

  $F_{Y,\ WD,\ i} = p_{WD}\ h_C\ \ell_C$

where:

h_C : Height, in m, of a container

ℓ_C , b_C : Dimensions, in m, of the container stack in the vessel longitudinal and transverse directions, respectively

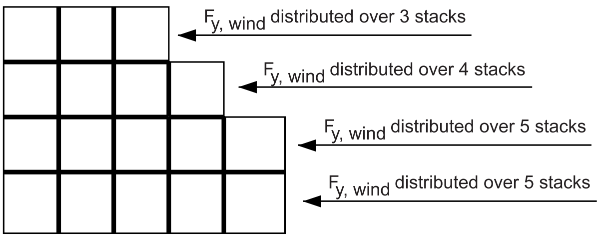
p_{WD} : Wind pressure, in kN/m^2, defined in Pt B, Ch 3, Sec 4, [2.1.3].

These forces are only acting on the stack exposed to wind.

In the case of M juxtaposed and connected stacks of the same height, the wind forces are to be distributed over the M stacks.

In the case of juxtaposed and connected stacks of different heights, the wind forces are to be distributed taking into account the number of stacks at the level considered (see example in Fig 3).

Figure 3 : Distribution of wind forces in the case of stacks of different heights



6.2.3 Stacks of containers

The still water, inertial and wind forces to be considered as being applied at the centre of gravity of the stack, and those transmitted at the corners of such stack is to be obtained, in kN, as specified in Tab 2.

6.2.4 Securing load

The scantling load of securing devices is to be determined assuming an angle of list of 12°.

7 Hull scantlings

7.1 General

7.1.1 In general, the hull scantlings and arrangements are to be in compliance with Part B, Chapter 5.

7.1.2 Scantlings of structural members subjected to concentrated loads are to be determined by direct calculation according to Pt B, Ch 2, Sec 8, [2]. In particular, the requirements of [8] are to be complied with.

7.1.3 Where the operating conditions (loading/unloading sequence as well as consumable and ballast distribution) are likely to induce excessive torsional torque, the torsional strength is to be checked, using the design torsional torque derived from [6.1.1].

7.2 Container seating

7.2.1 The hull girder normal stress σ_{X1} to be considered for the strength check of container seating plating is to be determined according to Pt B, Ch 5, Sec 1, [2.3].

For vessels assigned the range of navigation **IN(1,2 < x ≤ 2)**, see Ch 2, Sec 12, [4.2].

7.2.2 The net thickness, in mm, of container seating, if fitted, is to be not less than the thickness of the adjacent inner bottom plating nor than the thickness obtained from the following formula:

$$t_{CS} = 0,8C_{CS}\sqrt{\frac{kn_CR}{\lambda}}$$

where:

R : Force, in kN, transmitted at the corner of each stack of containers, to be determined according to Tab 2

λ : Coefficient taken equal to:

- in general:
  - for longitudinally framed plating:

$$\lambda_L = \sqrt{1-0,95\left(\gamma_m\frac{\sigma_{x1}}{R_y}\right)^2}-0,225\gamma_m\frac{\sigma_{x1}}{R_y}$$

  - for transversely framed plating:

$$\lambda_T = 1-0,89\gamma_m\frac{\sigma_{x1}}{R_y}$$

- where alternative method developed in Pt B, Ch 5, Sec 6 is followed for L < 40 m:
  - for longitudinally framed plating:

$$\lambda_L = \sqrt{1-0,95\left(\gamma_m\frac{\sigma_{for}}{R_y}\right)^2}-0,225\gamma_m\frac{\sigma_{for}}{R_y}$$

  - for transversely framed plating:

$$\lambda_T = 1-0,89\gamma_m\frac{\sigma_{for}}{R_y}$$

  where:

  σ_{for} : Parameter, in N/mm², taken equal to
  - σ_{for} = 100 N/mm² for steel
  - σ_{for} = 45 N/mm² for aluminium alloys

n_C : Number of stacks of container corners on the seating

C_{CS} : Coefficient to be taken equal to:

$$C_{CS} = 2,15-\frac{0,05\ell}{s}+0,02\left(4-\frac{\ell}{s}\right)\alpha^{0,5}-1,75\alpha^{0,25}$$

where ℓ/s is to be taken not greater than 3

$$\alpha = \frac{n_CA_C}{\ell s}$$

A_C : Area of a stack of container corner, in m²

In the case of several container corners on the same plate panel, A_C is the area corresponding to the group of corners

ℓ = max (a ; b)

s = min (a ; b)

a, b : Spacings, in m, of the container supporting members.

7.3 Additional requirements for single side vessels

7.3.1 Transverse rings

Where necessary, transverse rings are to be fitted to provide additional supports of the stringer plate.

The ring component scantlings are not to be less than required in Tab 3.

Table 2 : Containers - Still water, inertial and wind forces

Vessel condition	Still water force F_S, in kN, and inertial and wind force F_W, in kN, acting on each container stack	Vertical still water force R_S, in kN, and inertial and wind force R_W, in kN, transmitted at the corners of each container stack
Still water condition	$F_S = \sum_{i=1}^{N} F_{S,i}$	$R_S = \frac{F_S}{4}$
Upright condition (see Fig 4)	• in x direction: $F_{W,X} = \sum_{i=1}^{N} (F_{W,X,i} + F_{X,WD,i})$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,X}}{4\ell_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,X}}{4\ell_C}$
	• in z direction: $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	
Inclined condition (negative roll angle) (see Fig 5)	• in y direction: $F_{W,Y} = \sum_{i=1}^{N} (F_{W,Y,i} + F_{Y,WD,i})$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,Y}}{4 b_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,Y}}{4 b_C}$
	• in z direction: $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	

Note 1:
N_C : Number of containers per stack
h_C : Height, in m, of a container
ℓ_C, b_C : Dimensions, in m, of the container stack in the vessel longitudinal and transverse directions, respectively.

Figure 4 : Inertial and wind forces Upright vessel condition

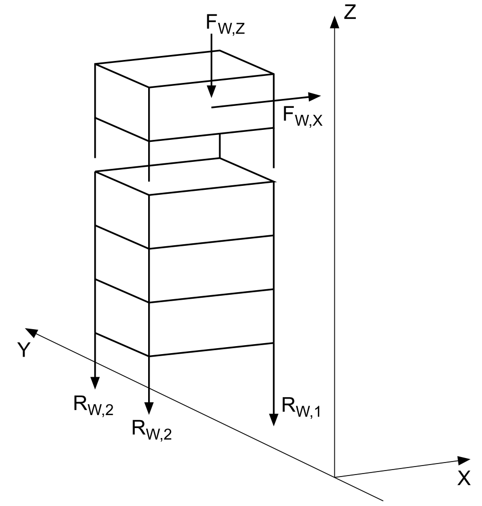
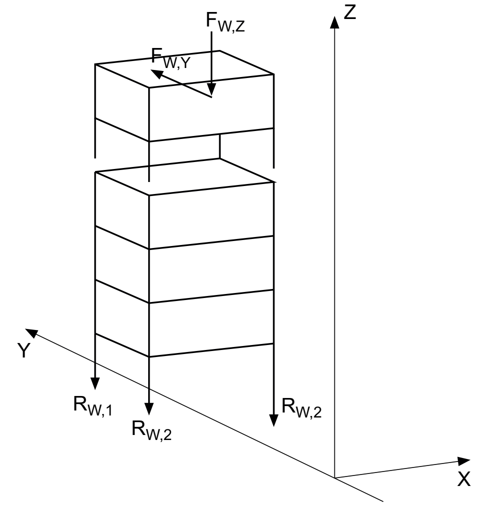


Figure 5 : Inertial and wind forces Inclined vessel condition



7.3.2 Transverse hold bulkhead structure

The number and location of transverse bulkheads are defined in Pt B, Ch 5, Sec 5.

Where necessary, additional bulkheads are to be fitted to provide for sufficient transverse strength of the vessel.

The scantlings of transverse hold bulkheads are to be not less than the values required in Pt B, Ch 5, Sec 5.

a) Vertically framed plate bulkhead

The upper end of the vertical stiffeners is to be connected either to a strong deck box beam or to a stringer located at the stringer plate level or above.

As far as practicable, the bottom of the box beam or the bulkhead end stringer is to be located in the same plane as the stringer plate.

Where this is not the case, the bulkhead plating or the box beam sides are to be fitted with an efficient horizontal framing at that level.

b) Horizontally framed bulkhead

The upper part of horizontally framed bulkheads are to be specially considered by the Society.

c) Plate bulkhead end stringer

The net scantlings of the plate bulkhead end stringer is to be determined, using the formula:

$$w = \beta_b \frac{p}{m(226/k - \sigma_A)} S \ell^2 10^3$$

Table 3 : Net scantling of transverse rings

<table>
<tr><th colspan="2">Primary supporting member</th><th>w (cm³)</th><th>A_{Sh} (cm²)</th></tr>
<tr><td colspan="2">Reinforced floors
Bottom transverses</td><td>$w = \frac{\gamma_R \gamma_m \beta_b p}{m R_y} S B^2 10^3$</td><td>$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S B$</td></tr>
<tr><td rowspan="2">Side webs and
side transverses **(1)**</td><td>• if $\ell_0 \leq \ell$</td><td>$w = 26 \frac{\gamma_R \gamma_m \beta_b \ell}{m R_y} S \ell_0^{\,2} 10^3$</td><td>$A_{sh} = 68 \gamma_R \gamma_m \beta_s \frac{\ell}{R_y} S \ell_0$</td></tr>
<tr><td>• if $\ell_0 > \ell$</td><td>$w = 4,4 \frac{\gamma_R \gamma_m \lambda_b \beta_b p}{m R_y} S \ell^2 10^3$</td><td>$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \frac{p}{R_y} S \ell$</td></tr>
<tr><td colspan="2">Strong box beams</td><td colspan="2">see Pt B, Ch 5, Sec 4, [2.4.4]</td></tr>
<tr><td colspan="4">**(1)** Scantlings of web frames and side transverses at the lower end are to be the same as those of floors or bottom transverses connected to them.
Note 1:
p : Design load, in kN/m², defined in Pt B, Ch 3, Sec 4
ℓ_0 : Span parameter, in m: $\ell_0 = p_d / g$
p_d : Total pressure, in kN/m², at the lower end of the stiffener
m : Boundary coefficient, to be taken equal to 8.</td></tr>
</table>

where:

p : Bulkhead end stringer design load, in kN/m², to be determined according to Pt B, Ch 2, Sec 5, [3.1]

S : Bulkhead stringer spacing, in m

m : Boundary coefficient to be taken equal to 8

σ_A : Bulkhead end stringer axial stress, in N/mm²:

$$\sigma_A = \frac{10 q D_1}{A}$$

q : Distributed transverse load acting on the stringer plate, in kN/m, to be determined as stated in Pt B, Ch 5, Sec 4, [2.4.1]

D_1 : Unsupported stringer plate length, in m, defined in Pt B, Ch 5, Sec 4, [2.4.2]

In way of hold end bulkheads, D_1 is to be substituted by 0,5 D_1

A : Bulkhead end stringer sectional area, in cm².

7.4 Additional requirements for double hull vessels

7.4.1 Double bottom arrangement

Where the inner side plating does not extend down to the bottom plating, the floors of vessels built in the transverse system are to be stiffened, at each frame, in way of the inner side plating, by means of a section, the net sectional area of which, in cm², is not to be less than:

$A = 0,01\ b\ t_F$

where:

t_F : Net thickness of floor web, in mm

b : Section height, in mm: $b = 100\ H_D$

H_D : Double bottom height, in m.

As a rule, manholes are not to be provided into the centreline girder.

8 Direct calculation

8.1 General

8.1.1 The following requirements apply for the grillage analysis of primary supporting members subjected to concentrated loads.

Direct calculation is to be carried out in compliance with Pt B, Ch 2, Sec 8, [2].

8.2 Loading conditions and load cases in service conditions

8.2.1 Bottom and side structures

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in the primary supporting members.

The following loading conditions are generally to be considered:

a) Harbour
   - full cargo load in hold/vessel at the relevant draught T_1
   - empty hold/vessel at the relevant draught T_1

b) Navigation
   - full cargo load/vessel at the scantling draught T
   - lightship/vessel at the relevant draught T_1.

8.2.2 Deck structure

Where containers are intended to be loaded on the deck, the analysis of the deck structure is to be carried out taking into account a full container load, considering the navigation case.

8.3 Structure checks

8.3.1 The following checks are to be carried out:

- level of bending stresses and shear stresses, in particular in way of holes and passage of longitudinals
- buckling strength of unstiffened webs
- continuity of double bottom in the side tanks, for bottom structure.

SECTION 5 RoRo Cargo Vessels

Symbols

A_{sh} : Net web shear sectional area, in cm^2

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

F : Wheeled force, in kN, defined in Pt B, Ch 3, Sec 4, [3.5]

g : Gravitational acceleration:

$$g = 9,81 \; m/s^2$$

I_Y : Net moment of inertia, in cm^4, of the hull transverse section around its horizontal neutral axis, to be calculated according to Pt B, Ch 4, Sec 1

K_S, K_T : Coefficients taking into account the number of axles considered as acting on the stiffener, defined in Tab 2

k : Material factor defined in:

- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

R_y : Minimum yield stress, in N/mm^2, of the material to be taken equal to:

- R_y= 235/k N/mm^2 for steel
- R_y= 100/k N/mm^2 for aluminium alloys

unless otherwise specified

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

T_1 : Draught associated with each cargo and ballast distribution, in m, defined in Pt B, Ch 3, Sec 1, [2.4.3]

t : Net thickness, in mm, of plating

w : Net section modulus, in cm^3, of ordinary stiffeners or primary supporting members

α_W : Coefficient taking into account the number of wheels and wheels per axle considered as acting on the stiffener, defined in Tab 1

β_b, β_S : Span correction coefficients defined in Pt B, Ch 2, Sec 4, [5.2]

γ_R : Partial safety factor covering uncertainties regarding resistance, defined in Pt B, Ch 5, Sec 1, [1.3]

γ_m : Partial safety factor covering uncertainties regarding material, defined in Pt B, Ch 5, Sec 1, [1.3]

λ_b, λ_s : Coefficients for pressure distribution correction defined in Pt B, Ch 2, Sec 4, [6.3]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members.

1 General

1.1 Application

1.1.1 The service notation **RoRo cargo vessel** is assigned, in accordance with Pt A, Ch 1, Sec 3, [2.1.4], to vessels intended to carry wheeled vehicles.

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to RoRo cargo vessels.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, the following information is to be submitted:

a) Plans of ramps, elevators for cargo handling and movable decks, if any, including:
   - structural arrangements of ramps, elevators and movable decks with their masses
   - arrangements of securing and locking devices
   - connection of ramps, lifting and/or hoisting appliances to the hull structures, with indication of design loads (amplitude and direction)
   - wire ropes and hoisting devices in working and stowed position
   - hydraulic jacks
   - loose gear (blocks, shackles, etc.) indicating the safe working loads and the testing loads
   - test conditions

b) Plan of arrangement of motor vehicles, railway cars and/or other types of vehicles which are intended to be carried and indicating securing and load bearing arrangements

c) Characteristics of motor vehicles, railways cars and/or other types of vehicles which are intended to be carried: (as applicable) axle load, axle spacing, number of wheels per axle, wheel spacing, size of tyre print

d) Plan of dangerous areas, in the case of vessels intended for the carriage of motor vehicles with petrol in their tanks.

Table 1 : Wheeled loads - Coefficient α_W

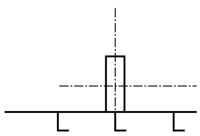
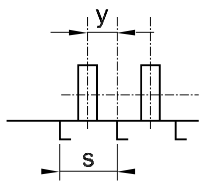
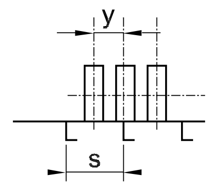
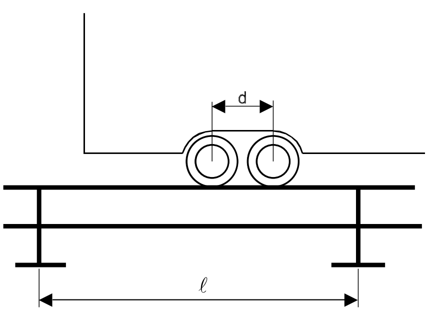
	Single wheel	Double wheels	Triple wheels
Configuration			
α_W	1,00	$2\left(1-\frac{y}{s}\right)$	$3-2\frac{y}{s}$
Note 1: y is defined as the distance, in m, from the external wheel of a group of wheels to the stiffener under consideration, to be taken equal to the distance from the external wheel to the centre of the group of wheels.			

Table 2 : Wheeled loads - Coefficients K_S and K_T

Coefficients	Single axle	Double axle
K_S	1,00	• if $d \leq \ell/\sqrt{3}$ $\frac{172}{81}-\frac{4d}{3\ell}-\frac{d^2}{\ell^2}+\frac{d^4}{\ell^4}$ • if $d > \ell/\sqrt{3}$ $\frac{4}{3}-\frac{4d}{3\ell}+3\frac{d^2}{\ell^2}-\frac{8d^3}{3\ell^3}$
K_T	1,00	$2-\frac{d}{2\ell}-\frac{3d^2}{2\ell^2}+\frac{d^3}{\ell^3}$
Note 1: d : Distance, in m, between two axles (see Fig 1).		

Figure 1 : Wheeled load on stiffeners - Double axles



1.3 Direct calculation

1.3.1 The following requirements apply for the analysis of primary supporting members.

Direct calculation is to be carried out in compliance with Pt B, Ch 2, Sec 8, [2].

1.3.2 Loading conditions and load cases in service conditions

The loads are to be calculated for the most severe loading conditions, with a view to maximising the stresses in the primary supporting members.

The following loading conditions are generally to be considered:

a) Harbour
- full cargo load in hold/vessel at the relevant draught T_1
- empty hold/vessel at the relevant draught T_1

b) Navigation
- full cargo load/vessel at the scantling draught T
- lightship/vessel at the relevant draught T_1.

1.3.3 Structure checks

The following checks are to be carried out:

- level of normal stresses and shear stresses, in particular in way of holes and passage of longitudinals
- buckling strength of unstiffened webs
- for double hull vessels, continuity of double bottom in the side tanks.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

2.2 Intact stability

2.2.1 The stability of RoRo cargo vessels for all intended loading conditions is to comply with Pt B, Ch 2, Sec 2, [4].

3 Vessel arrangements

3.1 Sheathing

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

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

3.2 Drainage of cargo spaces, other than RoRo spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

3.2.1 Scupper draining

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

3.3 Hull structure

3.3.1 Framing

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

4 Hull scantlings

4.1 General

4.1.1 The hull scantlings and arrangements are to be in compliance with Part B, Chapter 5.

4.1.2 In addition, scantlings of plating and structural members subjected to wheeled loads are to be in compliance with [4.3] to [4.5].

4.2 Hull girder normal stresses

4.2.1 The hull girder normal stress σ_{X1} to be considered for the strength check of structural members subjected to wheeled loads is to be determined according to Pt B, Ch 5, Sec 1, [2.3].

For vessels assigned the range of navigation IN(1,2<x<= 2), see Ch 2, Sec 12, [4.2].

4.3 Plating

4.3.1 Single wheel or group of wheels

The net thickness of plate panels subjected to wheeled loads is to be not less than the value obtained, in mm, from the following formula:

$$t = 0,8 C_{WL} \sqrt{\frac{k_0 k n_p F}{\lambda}}$$

where:

C_{WL} : Coefficient to be taken equal to:

$$C_{WL} = 2,15 - 0,05\frac{\ell}{s} + 0,02\left(4 - \frac{\ell}{s}\right)\alpha^{0,5} - 1,75\alpha^{0,25}$$

where ℓ/s is to be taken not greater than 3

$$\alpha = \frac{A_T}{\ell s}$$

A_T : Tyre print area, in m². In the case of double or triple wheels, A^T is the print area of the group of wheels. A_T is not to be taken greater than the value given in [4.3.2]

ℓ , s : Lengths, in m, of, respectively, the longer and the shorter sides of the plate panel

n_p : Number of wheels on the plate panel, taken equal to:

- 1 in the case of a single wheel
- the number of wheels in a group of wheels in the case of double or triple wheels

λ : Coefficient taken equal to:

- in general:
  - for longitudinally framed plating:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{x1}}{R_y}\right)^2} - 0,225\gamma_m \frac{\sigma_{x1}}{R_y}$$

  - for transversely framed plating:

$$\lambda_T = 1 - 0,89\gamma_m \frac{\sigma_{x1}}{R_y}$$

- where alternative method developed in Pt B, Ch 5, Sec 6 is followed for L < 40 m:
  - for longitudinally framed plating:

$$\lambda_L = \sqrt{1 - 0,95\left(\gamma_m \frac{\sigma_{for}}{R_y}\right)^2} - 0,225\gamma_m \frac{\sigma_{for}}{R_y}$$

  - for transversely framed plating:

$$\lambda_T = 1 - 0,89\gamma_m \frac{\sigma_{for}}{R_y}$$

where:

σ_{for} : Parameter, in N/mm², taken equal to

- σ_{for} = 100 N/mm² for steel
- σ_{for} = 45 N/mm² for aluminium alloys

4.3.2 Tyre print area

When the tyre print area is not known, it may be taken equal to:

$$A_T = 9,81 \frac{n_p Q_A}{n_W p_T}$$

where:

n_p : Number of wheels on the plate panel, defined in [4.3.1]

Q_A : Axle load, in t

n_W : Number of wheels for the axle considered

p_T : Tyre pressure, in kN/m². When the tyre pressure is not indicated by the designer, it may be taken as defined in Tab 3.

Table 3 : Type pressures p_T for vehicles

Vehicle type	Tyre pressure p_T, in kN/m²	
	Pneumatic tyres	Solid rubber tyres
Private cars	250	Not applicable
Vans	600	Not applicable
Trucks and trailers	800	Not applicable
Handling machines	1100	1600

4.3.3 Wheels spread along the panel length

In the case where two to four wheels of the same properties (load and tyre print area) are spread along the plate panel length as shown in Fig 2, the net thickness of deck plating is to be not less than the value obtained, in mm, from the following formulae:

$$t = t_1 \sqrt{1 + \sum_{i=2}^{n_p} \beta_i}$$

where:

n_p : Number of wheels on the plate panel, to be taken not less than 2

t_1 : Net thickness obtained, in mm, from [4.3.1] for $n_P = 1$, considering one wheel located on the plate panel

β_i : Coefficients obtained from the following formula, replacing i respectively by 2, 3 and 4 (see Fig 2):

- for $\alpha_i < 2$:

  $\beta_i = 0{,}8\ (1{,}2 - 2{,}02\ \alpha_i + 1{,}17\ \alpha_i^2 - 0{,}23\ \alpha_i^3)$

- for $\alpha_i \geq 2$:

  $\beta_i = 0$

with:

$$\alpha_i = \frac{x_i}{s}$$

x_i : Distance, in m, from the wheel considered to the reference wheel (see Fig 2)

4.3.4 Wheels spread along the panel breadth

In the case where two wheels of the same properties (load and tyre print area) are spread along the plate panel breadth as shown in Fig 3, the net thickness of deck plating is to be not less than the value obtained, in mm, from the following formula:

$$t = t_2 \sqrt{\delta}$$

where:

t_2 : Net thickness obtained, in mm, from [4.3.1] for $n_P = 2$, considering one group of two wheels located on the plate panel

δ : Coefficient obtained from the following formula:

$$\delta = \frac{\delta_1 + \delta_2}{2}$$

$$\delta_1 = 1 - \frac{w_s}{s - v}$$

$$\delta_2 = 1 - \frac{3w_s^2 + 6w_s v}{3s^2 - 4v^2}$$

w_s : Distance between the two wheels, as shown in Fig 3

v : Individual wheel breadth, as shown in Fig 3.

When this two-wheel arrangement is repeated several times over the panel length (2, 3 or 4 times), the required net thickness calculated in [4.3.4] is to be multiplied by:

$$\sqrt{1 + \sum_{i=2}^{n_p} \beta_i}$$

as calculated in [4.3.3], where n_p is the number of two wheels groups.

4.3.5 Wheels larger than plate panel

In the particular case of wheels or group of wheel where u > s, the tyre print outside of the plate panel is to be disregarded. The load and the area to be considered are to be adjusted accordingly (see Fig 4).

Figure 2 : Wheels spread along the panel length

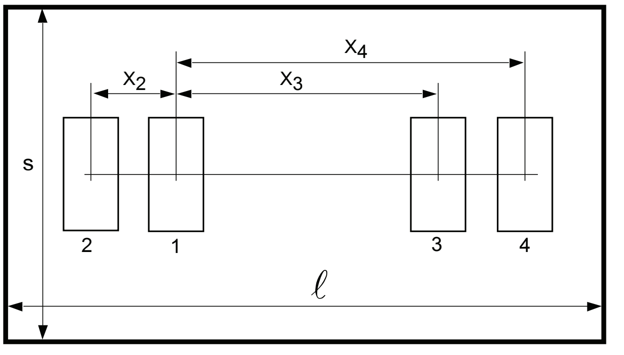


Figure 3 : Wheels spread along the panel breadth

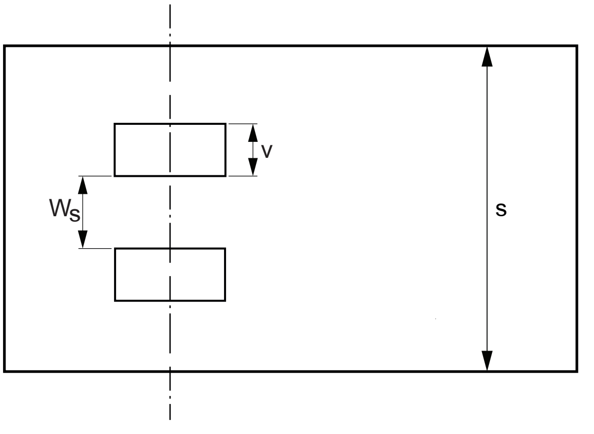
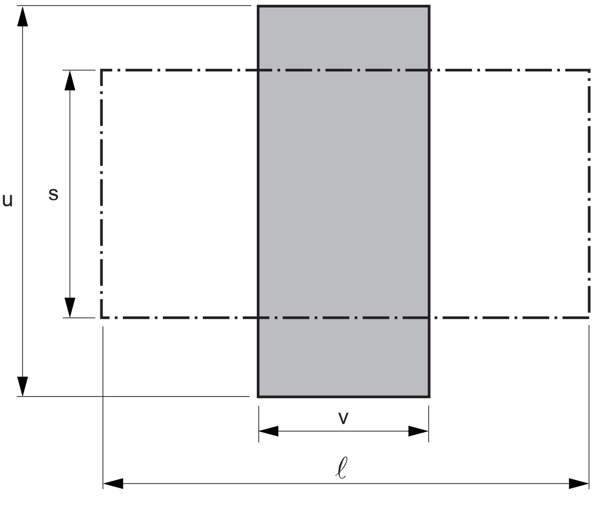


Figure 4 : Tyre print with u > s



4.4 Ordinary stiffeners subjected to wheeled loads

4.4.1 Net section modulus

The net section modulus w, cm³ of ordinary stiffeners subjected to wheeled loads are to be obtained from the following formulae:

- in general:

$$w = \alpha_W K_S \frac{\gamma_R \gamma_m F}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} \ell 10^3$$

- where alternative method developed in Pt B, Ch 5, Sec 6 is followed for L < 40 m:

$$w = \alpha_W K_S \frac{\gamma_R \gamma_m F}{m R_y (1 - 0,18 \gamma_R \gamma_m K_{MZ})} \ell 10^3$$

where:

m : Boundary coefficient to be taken equal to 6

K_{MZ} : Coefficient defined in Pt B, Ch 5, Sec 6.

4.4.2 Net shear sectional area

The net shear sectional area A_{Sh}, in cm², of ordinary stiffeners subjected to wheeled loads are to be obtained from following formula:

$$A_{sh} = 20 \gamma_R \gamma_m \frac{\alpha_W K_T F}{R_y}$$

4.5 Primary supporting members

4.5.1 Wheeled loads

The scantlings of primary supporting members subjected to wheeled loads are to be determined according to Tab 5 considering uniform pressures equivalent to the distribution of vertical concentrated forces, when such forces are closely located.

For the determination of the equivalent uniform pressures, the most unfavorable case, i.e. where the maximum number of axles is located on the same primary supporting member according to Fig 5 to Fig 7, is to be considered.

The equivalent still water pressure and inertial pressure are indicated in Tab 4.

4.5.2 For arrangements different from those shown in Fig 5 to Fig 7, the yielding check of primary supporting members is to be carried out by direct calculation, in compliance with Pt B, Ch 2, Sec 8, [2], taking into account the distribution of concentrated loads induced by the vehicles.

5 Other structures

5.1 Movable decks and inner ramps

5.1.1 The requirements applicable to movable decks and inner ramps are defined in Pt B, Ch 6, Sec 6, [1].

5.2 External ramps

5.2.1 The requirements applicable to external ramps are defined in Pt B, Ch 6, Sec 6, [2].

**Table 4 : Wheeled loads
Equivalent uniform still water and inertial pressures**

Ship condition	Load case	Still water pressure p_S and inertial pressure p_W, in kN/m²
Still water condition		$p_S = p_{eq}$
Upright condition	"a"	No inertial pressure
	"b"	$p_W = \alpha\, p_{eq}\, a_{Z1} / g$
Inclined condition	"c"	The inertial pressure may be disregarded
	"d"	$p_W = \alpha\, p_{eq}\, a_{Z2} / g$

Note 1:

$$p_{eq} = 10 \frac{n_V Q_A}{\ell s}\left(3 - \frac{X_1 + X_2}{s}\right)$$

n_V : Maximum number of vehicles possible located on the primary supporting member

Q_A : Maximum axle load, in t, defined in Pt B, Ch 3, Sec 4, [3.5]

X_1 : Minimum distance, in m, between two consecutive axles (see Fig 6 and Fig 7)

X_2 : Minimum distance, in m, between axles of two consecutive vehicles (see Fig 7)

α : Coefficient taken equal to:
- 0,5 in general
- 1,0 for landing gears of trailers

Figure 5 : Wheeled loads - Distribution of vehicles on a primary supporting member

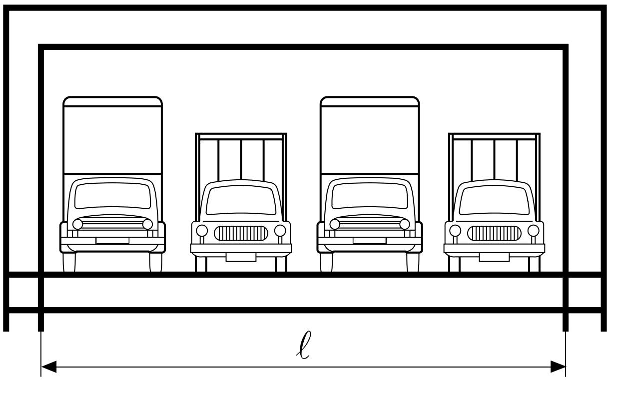


**Figure 6 : Wheeled loads
Distance between two consecutive axles**

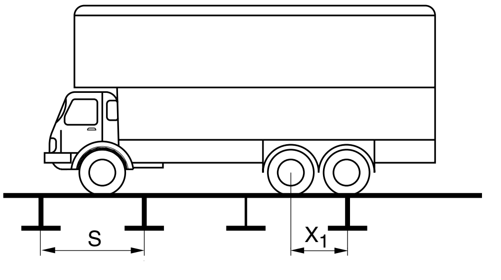


Figure 7 : Wheeled loads
Distance between axles of two consecutive vehicles

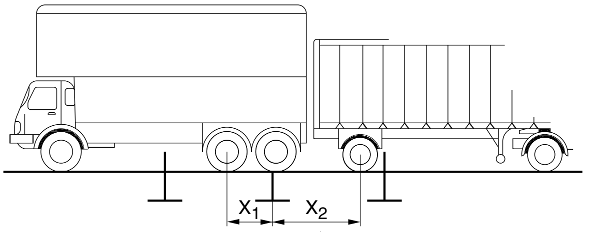


Table 5 : Net scantlings of primary supporting members

Item	w (cm^3)		A_{Sh} (cm^2)
Transverse primary supporting members	$w = \frac{\gamma_R \gamma_m \beta_b p}{m R_y} S \ell^2 10^3$		$A_{sh} = 10 \gamma_R \gamma_m \beta_s \frac{p}{R_y} S \ell$
Deck girders Double bottom girders	$w = \frac{\gamma_R \gamma_m \beta_b p}{m(R_y - \gamma_R \gamma_m \sigma_{X1})} S \ell^2 10^3$	**(1)**	$A_{Sh} = 10 \gamma_R \gamma_m \beta_S \frac{p}{R_y} S \ell$
	$w = \frac{\gamma_R \gamma_m \beta_b p}{m R_y (1 - 0,18 \gamma_R \gamma_m K_{MZ})} S \ell^2 10^3$	**(2)**	
Vertical primary supporting members	$w = \frac{\gamma_R \gamma_m \lambda_b \beta_b p_E}{m(R_y - \gamma_R \gamma_m \sigma_A)} S \ell^2 10^3$		$A_{sh} = 10 \gamma_R \gamma_m \lambda_S \beta_s \frac{p_E}{R_y} S \ell$

(1) In general
(2) Where alternative requirements developed in Pt B, Ch 5, Sec 6 are applied for vessels with L < 40 m

Note 1:

p : Design load, in kN/m^2:

$p = p_S + p_W$

p_S : Still water pressure, in kN/m^2:

$p_S = p_{eq}$

p_W : Inertial pressure, in kN/m^2:

- for load case ”b”:

$$p_W = \gamma_{w2} p_{eq} \frac{a_{Z1}}{g}$$

- for load cases ”c” and ”d” (the inertial pressure in load case ”c” may be disregarded):

$$p_W = \gamma_{w2} p_{eq} \frac{a_{Z2}}{g}$$

where:

a_{Z1}, a_{Z2} : Reference value of the vertical acceleration to be determined in compliance with Pt B, Ch 3, Sec 3, [2.3.3]

γ_{w2} : Partial safety factor covering uncertainties regarding wave local loads:

- γ_{w2} = 1,20, in general
- γ_{w2} = 1, for buckling check according to Pt B, Ch 2, Sec 7

p_E : Design load, in kN/m^2, to be determined according to Pt B, Ch 3, Sec 4, [2.1]

σ_A : Axial stress, to be obtained, in N/mm^2, from the following formula:

$$\sigma_A = 10 \frac{F_A}{A}$$

F_A : Axial load transmitted to the vertical primary supporting members by the structures above

A : Net sectional area, in cm^2, of the vertical primary supporting members with attached plating of width b_P

m : Boundary coefficient, to be taken equal to 8.

K_{MZ} : Coefficient defined in Pt B, Ch 5, Sec 6.

SECTION 6 PASSENGER VESSELS

Symbols

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_{WL} : Breadth of waterline, in m, is the breadth of the vessel measured from the outside of the side plating at the scantling draught water line

C_B : Block coefficient, defined in Pt B, Ch 1, Sec 2, [2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

KG : Height, in m, of the centre of gravity above base line

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

L_{WL} : Length of waterline, in m, defined in Pt B, Ch 1, Sec 2, [2.6]

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

v : Maximum speed of the vessel in relation to the water, in km/h

Δ : Displacement, in tons, at scantling draught T.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Passenger vessel**, as defined in Pt A, Ch 1, Sec 3, [4.1.1].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to passenger vessels.

1.1.3 Various requirements of this Section are to be applied for safety of passengers according to Tab 1.

Where available, statutory Rules (dealing with safety) in the operating area of the vessel (e.g. European directive) are to take precedence over these requirements.

Table 1 : Requirements applicable for safety of passengers

Item	Articles
Vessel arrangement	[2]
Fire protection, detection and extinction	[3]
Machinery and systems	[4]
Electrical installations	[5]
Safety devices and equipment	[6]
Buoyancy and stability	[9]

1.2 Documentation to be submitted

1.2.1 In addition to the documents required in other parts of these Rules, the following drawings and documents are to be submitted where applicable, for review:

- ventilation plan
- safety plan (with escape way)
- fire divisions
- vessel arrangement plan
- details of fire protection, detection and extinction
- details of emergency electrical systems
- details of safety devices and equipment
- intact stability calculations
- damage stability calculations.

1.3 Definitions

1.3.1 A-class divisions

A-class divisions are defined in Pt C, Ch 4, Sec 1, [2.2].

1.3.2 B-class divisions

B-class divisions are defined in Pt C, Ch 4, Sec 1, [2.3].

1.3.3 Fire divisions other than steel

Fire divisions other than steel are defined in Pt C, Ch 4, Sec 1, [2.4].

Attention is drawn to the use of composite and/or plywood materials from the point of view of structural fire protection. Regulations of the country where the vessel is registered may entail in some cases a limitation in the use of composite and/or plywood materials.

1.3.4 Cabin vessel

A cabin vessel is a passenger vessel with overnight passenger cabins.

1.3.5 Day trip vessel

A day trip vessel is a passenger vessel without overnight passenger cabins.

1.3.6 Low flame-spread

Definition of low flame-spread is given in Pt C, Ch 4, Sec 1, [2.9].

1.3.7 Main fire zones

Main fire zones are those sections into which the hull, superstructures and deckhouses are divided by divisions of adequate fire integrity:

- the mean length and width of which on any deck does not, in general, exceed 40 m, or
- the area of which on any deck does not exceed 800 m^2.

1.3.8 Margin line

Margin line is an imaginary line drawn on the side plating not less than 10 cm below the bulkhead deck and not less than 10 cm below the lowest non watertight point of the vessel side. If there is no bulkhead deck, a line drawn not less than 10 cm below the lowest line up to which the outer plating is watertight shall be used.

1.3.9 Non-combustible material

Definition of a non-combustible material is given in Pt C, Ch 4, Sec 1, [2.14].

1.3.10 Safe area

Safe area is the area which is externally bounded by a vertical surface running at a distance of $B_{WL}/5$ parallel to the course of the hull in the line of maximum draught.

2 Vessel arrangement

2.1 Watertight subdivision

2.1.1 In addition to the bulkheads called for in Pt B, Ch 2, Sec 1, [1], the vessel is to be subdivided by further watertight transverse bulkheads in such a way that the requirements of Article [9] are met. All these bulkheads are to be extended upwards to the bulkhead deck.

The stepping of bulkheads is permitted only if this is located outside the penetration depths stated in [9.3.4].

2.1.2 The first compartment aft of the collision bulkhead may be shorter than the length of damage stated in [9.3.4] if the total length of the two foremost compartments measured in the plane of maximum draught is not less than this value.

2.1.3 Passenger spaces are to be separated by gastight bulkheads from machinery and boiler spaces.

2.2 Openings in watertight bulkheads

2.2.1 The number of openings in watertight bulkheads shall be as small as is compatible with the construction and proper operation of the vessel.

2.2.2 Open piping systems and ventilation ducts are to be routed in such a way that no further flooding can take place in any considered damaged condition.

Pipelines running within the safe area (see [1.3.10] for definition) and more than 0,5 m above the base line are to be regarded as undamaged.

Bulkhead openings below the margin line are to be made watertight.

2.3 Bulkhead doors

2.3.1 Bulkhead doors are not permitted in the bulkheads between passenger and machinery spaces or boiler spaces.

2.3.2 Bulkhead doors which are normally in the OPEN position must be locally operable from both sides of the bulkhead, must be capable of being closed from an accessible location above the bulkhead deck and must meet the following conditions:

- the closing time is not to be less than 30 s nor more than 60 s
- at the remote control position, indicator lights are to be mounted showing whether the door is open or closed
- during the closing operation, a local audible alarm must sound automatically
- the door drive and signalling systems must also be able to operate independently of the vessel's mains.

Bulkhead doors without remote control are permitted only outside the passenger area. They are to be kept closed and may only be briefly opened to allow passageway.

Bulkhead doors and their systems must be situated within the safe area defined in [1.3.10].

2.4 Bulwark and railing

2.4.1 Parts of the deck intended for passengers, and which are not enclosed, shall comply with the following requirements:

a) They shall be surrounded by a fixed bulwark or guard rail in compliance with Pt B, Ch 7, Sec 2.
b) Openings and equipment for embarking or disembarking and also openings for loading or unloading shall be such that they can be secured.
c) Guard rails and bulwarks are to be at least 1 m high above the decks open to passengers. In way of the aft deckhouse, a similar height is to be arranged. Guard rails and bulwarks intended for use by persons with reduced mobility shall be at least 1,1 m high.
d) For guard rails in passenger areas, deflection without permanent deformation is not permitted to exceed 25 mm in the centre between two stanchions when a load of 1000 N/m is acting on the railing.

3 Fire protection, detection and extinction

3.1 General

3.1.1 The requirements of this Article apply in addition to general requirements for fire protection, detection and extinction developed in Part C, Chapter 4.

3.2 Fire prevention

3.2.1 Sounding pipes

Sounding pipes of fuel tanks may not terminate in accommodation or passenger spaces.

3.3 Fire detection and alarm

3.3.1 All day rooms normally accessible to passengers and crew as well as galleys and machinery spaces are to be monitored by a type tested, automatic fire detection and alarm system.

3.3.2 Detectors are to be grouped into separate sections, each of which shall not comprise more than one main fire zone or one watertight division and not more than two vertically adjacent decks.

If the fire detection system is designed for remote and individual identification of detectors, several decks in one main fire zone respectively one watertight division may be monitored by the same detector loop. The detector loop shall be so arranged, that in the event of a damage (wire break, short circuit, etc.) only a part of the loop becomes faulty.

Smoke detectors shall be used in passage ways, stairways and escape routes. Heat detectors shall be used in cabins in the accommodation area. Flame detectors shall only be used in addition to the other detectors.

3.3.3 The blowout of a fire and the area concerned are to be signalled automatically to a permanently manned station.

3.3.4 Requirements [3.3.2] and [3.3.3] are deemed to be met in the case of spaces protected by an automatic pressure water-spraying system designed in accordance with Pt C, Ch 4, Sec 4, [3].

3.3.5 Manually operated call points are to be provided in addition to the automatic system:

- in passageways, enclosed stairways and at lifts
- in saloons, day rooms and dining rooms
- in machinery spaces, galleys and spaces with a similar fire hazard.

The manually operated call points shall be spaced not more than 10 m apart, however at least one call point shall be available in every watertight compartment.

3.3.6 The alarm set off by a manual call point shall be transmitted only to the rooms of the vessel's officers and crew and must be capable of being cancelled by the vessel's officers. Manual call points are to be safeguarded against unintended operation.

3.4 Control of smoke spread

3.4.1 Control centres, stairways and internal assembly stations shall be provided with a natural or a mechanical smoke extraction system.

Smoke extraction systems shall comply with [3.4.2] to [3.4.8].

3.4.2 They shall provide sufficient capacity and reliability.

3.4.3 They shall consider the operating conditions of passenger vessels.

3.4.4 When the normal ventilation system is used for this purpose, it shall be designed that its function will not be impaired by smoke.

3.4.5 They shall be provided with manual actuation.

3.4.6 It shall be possible to operate mechanical smoke extraction systems from a position permanently occupied by crew.

3.4.7 Natural smoke extraction systems shall be provided with an opening mechanism, operated either manually or by a power source inside the ventilator.

3.4.8 Manually operated actuators and opening mechanism shall be accessible from inside and outside of the protected space.

3.5 Fire containment

3.5.1 The following passenger areas shall be divided by vertical divisions complying with [3.6]:

a) passenger areas with a total surface area of more than 800 m^2

b) passenger areas in which there are cabins, at intervals of not more than 40 m.

The vertical divisions shall be smoke-tight under normal operating conditions and shall be continuous from deck to deck.

The doors shall be of self-closing type or shall be capable of remote release from the bridge and individually from both sides of the door. Status of each fire door (open/ closed position) shall be indicated on the bridge.

3.5.2 Hollows above ceilings, beneath floors and behind wall claddings shall be separated at intervals of not more than 14 m by non-combustible draught stops which, even in the event of fire, provide an effective fireproof seal.

3.6 Fire structural integrity

3.6.1 Integrity of bulkheads and decks

The minimum fire integrity of all bulkheads and decks shall be as shown in Tab 2.

3.6.2 For the purpose of determining the appropriate fire integrity standard to be applied to boundaries between adjacent spaces, such spaces are classified according to their fire risk described in the following categories.

The title of each category is intended to be typical rather than restrictive.

a) Control centres: defined in Pt C, Ch 4, Sec 1, [2.5]

   Wheelhouse, rooms containing the vessel’s radio equipment, rooms containing centralised fire alarm equipment, rooms containing centralised emergency public address system stations and equipment, etc.

b) Stairwells: defined in Pt C, Ch 4, Sec 1, [2.19]

   Interior stairwells, lifts, enclosed emergency escape trunks. In this connection a stairwell which is enclosed at one level only shall be regarded as part of the space from which it is not separated by a fire door, etc.

c) Muster areas: defined in Pt C, Ch 4, Sec 1, [2.13]

d) Lounges: defined in Pt C, Ch 4, Sec 1, [2.8]

   Cabins, public spaces, sale shops, barber shops and beauty parlours, saunas, pantries containing no cooking appliances, small lockers (deck area < 4 m^2), etc.

e) Machinery spaces: defined in Pt C, Ch 4, Sec 1, [2.11]

   Main propulsion machinery room, auxiliary machinery spaces, etc.

f) Galleys: defined in Pt C, Ch 4, Sec 1, [2.7]

g) Store rooms: defined in Pt C, Ch 4, Sec 1, [2.21]

   Miscellaneous stores, lockers having deck area exceeding 4 m^2, air conditioning rooms.

Table 2 : Fire integrity of bulkheads and decks

Spaces	Control centres	Stairwells	Muster areas	Lounges	Machinery spaces of Category A	Galleys	Store rooms
Control centres	–	A0	A0 / B0 **(1)**	B0	A30	A0	A0
Stairwells		–	A0	B0	A30	A0	A0
Muster areas			–	A0 / B0 **(2)**	A30	A0	A0
Lounges				– / B0 **(3)**	A30	A0	A0
Machinery spaces of Category A					A30 / A0 **(4)**	A15	A0
Galleys						–	A0 / B0 **(5)**
Store rooms							–

(1) Divisions between control centres and internal muster areas shall correspond to type A0, but external muster areas only to type B0.
(2) Divisions between lounges and internal muster areas shall correspond to type A0, but external muster areas only to type B0.
(3) Divisions between cabins, divisions between cabins and corridors and vertical divisions separating lounges according to [3.5.1] shall comply with B0.
(4) Divisions between machinery spaces of Category A shall comply with type A30; in other cases they shall comply with type A0.
(5) B0 is sufficient for divisions between galleys, on the one hand, and cold-storage rooms and food store rooms, on the other.

3.6.3 Fire protection materials

a) Insulation materials shall comply with Pt C, Ch 4, Sec 2, [2.3.1].

b) Ceilings and linings in accommodation spaces including their substructures shall be of non-combustible material, unless the space is protected with a sprinkler installation.

Primary deck coverings and surface materials shall be of an approved type.

3.6.4 All stairways are to be of steel frame or other equivalent non-combustible construction.

Stairways connecting more than two decks are to be enclosed by at least class B bulkheads. Stairways connecting only two decks need to be protected at least at one deck level by class B bulkheads. Doors shall have the same fire resistance as the bulkheads in which they are fitted.

Where class A and B divisions are penetrated for the passage of cables, pipes, trunks, ducts etc. or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements shall be made to ensure that the fire resistance is not impaired.

3.6.5 Ventilation system

All parts of the system shall be made of non-combustible material, except that short ducts applied at the end of the ventilation device may be made of a material which has low-flame spread characteristics.

The ventilation ducts shall be divided with closing appliances analogously to the requirements of [3.5.1].

When ventilation ducts with a cross-section of more than 0,02 m^2 are passed through partitions according to [3.6.1] of type A or partitions according to [3.5.1], they shall be fitted with approved fire dampers which can be operated from a location permanently manned by shipboard personnel or crew members.

3.7 Fire fighting

3.7.1 General water fire extinguishing system

Passenger vessels over 40 m L_{WL} and passenger vessels with cabins for passengers over 25 m L_{WL} are, in addition to applicable requirements of Pt C, Ch 4, Sec 4, subject to the following requirements:

a) It must be possible to project at least two jets of water simultaneously on any part of the vessel from two different hydrants using for each a single length of hose not more than 20 m long. The length of throw must be at least 12 m with a nozzle diameter of 12 mm.

b) The minimum capacity of the fire pump is to be 20 m^3/h.

c) If the fire pump is located in the engine room, a second power-driven fire pump must be provided outside the engine room. The pump drive must be independent of the engine room, and the pump capacity must conform to the preceding items a) and b).

   Connections in the piping system with the engine room must be capable of being shut off from outside at the point of entry into the engine room.

   A portable pump may be accepted, provided that a permanently installed pump is available in the engine room.

d) Two fire hoses with dual-purpose nozzles are to be located in hose boxes in both fore ship and aft ship. Further fire hoses may be required depending on the size and structural features of the vessel.

3.7.2 Portable fire extinguishers

a) One additional fire extinguisher is to be provided for:
   - each unit of 120 m^2, or part thereof, of the gross floor area in passenger areas
   - each group of 10 cabins, or part thereof.

b) Galleys and shops shall, depending on their size and contents, be provided with additional fire extinguishers.

c) These additional fire extinguishers are to be installed and distributed on the vessel so that, in the event of fire starting at any point and at any time, a fire extinguisher can be reached immediately.

3.7.3 Fixed gas fire extinguishing systems

Machinery spaces containing internal combustion engines and oil fired boilers shall be provided with a fixed gas fire extinguishing system in compliance with Pt C, Ch 4, Sec 4, [4].

3.7.4 Automatic pressure water spraying system

Where installed, automatic pressure water spraying systems for the passenger area must be ready for operation at all times when passengers are on board. No additional measures on the part of the crew must be needed to actuate the system.

3.8 Escape

3.8.1 Means of escape

The number and width of the exits of passenger rooms shall comply with the applicable statutory Regulations or recognized standards, e.g., ES-TRIN.

3.8.2 Doors of passenger rooms

Doors of passenger rooms shall comply with the following requirements:

a) With the exception of doors leading to connecting corridors, they shall be capable of being opened outwards or be constructed as sliding doors.

b) Cabin doors shall be made in such a way that they can also be unlocked from the outside at any time.

c) Powered doors shall open easily in the event of failure of the power supply to this mechanism.

3.8.3 Stairs

Stairs and their landings in the passenger areas shall comply with the following requirements:

a) They shall be designed and constructed in accordance with applicable statutory Regulations and/or recognized standards, e.g., EN 13056.

b) Where there is not at least one staircase on each side of the vessel in the same room, they shall lie in the safe area.

3.8.4 Escape routes

Escape routes shall comply with the following requirements:

a) Stairways, exits and emergency exits shall be so disposed that, in the event of a fire in any given area, the other areas may be evacuated safely.

b) The escape routes shall lead by the shortest route to muster areas.

c) Escape routes shall not lead through engine rooms or galleys. This requirement item does not apply to vessels with L_{WL} not exceeding 25 m, as long as a second escape route is available.

d) There shall be no rungs, ladders or the like installed at any point along the escape routes.

e) Doors to escape routes shall be constructed in such a way as not to reduce the minimum width of the escape route.

f) Escape routes and emergency exits shall be clearly signed. The signs shall be lit by the emergency lighting system.

3.8.5 Escape routes and emergency exits shall be provided with a suitable safety guidance system. Such a system shall take the form of low-location lighting (LLL), i.e., electrically powered lighting or photo-luminescent indicators placed along the escape routes so as to ensure that such routes can be easily identified.

4 Machinery and systems

4.1 Bilge system

4.1.1 General

Each watertight compartment shall be fitted with a bilge level alarm.

4.1.2 Number and capacity of bilge pumps

A bilge pumping system with permanently installed pipe work shall be available.

The number and capacity of bilge pumps are to be in compliance with Pt C, Ch 1, Sec 10, [6.7].

Further bilge pumps may be required according to size and propulsion power.

5 Electrical installations

5.1 General

5.1.1 Application

Cabin vessels and day trip vessels ($L_{WL} \geq 25$ m) are required to comply with this Article in addition to the requirements stated in Part C, Chapter 2.

Relaxations of these requirements may be allowed for ferries and day trip vessels, at the Society’s discretion.

5.2 Emergency power supply

5.2.1 General

An emergency source of electrical power independent of the main power supply is to be provided which is capable of feeding the electrical systems and consumers essential to the safety of passengers and crew. The feeding time depends on the purpose of the vessel and should be agreed with the national Authority, but shall not be less than half an hour. The power supply to the following systems is especially relevant to the safety of passengers and crew:

a) navigation and signalling lights

b) sound devices such as Tyfon

c) emergency lighting

d) radio installations

e) alarm systems for vessel safety

f) public address system (general alarm)

g) telecommunication systems essential to safety and the operation of the vessel

h) emergency searchlights

i) fire detection system

j) sprinkler systems and other safety installations.

5.2.2 Emergency source of electrical power

The following are admissible for use as an emergency power source:

a) auxiliary generator sets with their own independent fuel supply and independent cooling system which, in the event of a power failure, turn on and take over the supply of power within 45 seconds automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be turned on manually, or

b) storage batteries, which, in the event of a power failure, turn on automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be turned on manually. They shall be capable of powering the above mentioned power consumers throughout the prescribed period without recharging and without an unacceptable voltage reduction.

5.2.3 Installation

Emergency generator sets, emergency storage batteries and the relevant switchgear are to be installed outside the machinery space, the machinery casings and the main generator room. They are to be separated from these spaces by low flame-spread and watertight bulkheads so that the emergency power supply will not be impaired in the event of a fire or other accident in the machinery space.

Facilities are to be provided for the periodical operational testing of all items of equipment serving the emergency power supply system including especially the automatic switchgear and starting equipment. Such tests must be possible without interference with other aspects of the vessel operation.

5.3 Lighting systems

5.3.1 Construction and extent of the main lighting system

There is to be a main lighting system supplied by the main source of electrical power and illuminating all parts of the vessel normally accessible to the passengers and crew. This system is to be installed in accordance with Pt C, Ch 2, Sec 12.

5.3.2 Construction and extent of the emergency lighting system

a) Construction

An emergency lighting system is to be installed, the extent of which shall conform to item b).

The power supply and the duration of the supply shall conform to [5.2].

As far as practicable the emergency lighting system shall be installed in a manner, that it will not be rendered unserviceable by a fire or other incident in rooms in which the main source of electrical power, any associated transformers, the main switchboard and the main lighting distribution panel are installed.

The emergency lighting system shall be cut in automatically following a failure of the main power supply. Local switches are to be provided only where it may be necessary to switch off the emergency lighting (e.g. in the wheelhouse).

Emergency lights must be marked as such for ease of identification.

b) Extent

Adequate emergency lighting must be provided in the following areas:

- positions at which collective life-saving appliances are stored and at which they are normally prepared for use
- escapes, exits, connecting passageways, lifts and stairways in the accommodation area
- marking indicating escapes and exits
- machinery spaces and their exits
- wheelhouse
- space of the emergency power source
- locations of fire extinguishers and fire pumps
- rooms in which passengers and crew assemble in an emergency.

c) If a vessel is divided into main fire zones, at least two circuits are to be provided for the lighting of each main fire zone, and each of these must have its own power supply line. One circuit shall be supplied from the emergency power source. The supply lines are to be so located that, in the event of a fire in one main fire zone, the lighting in the other zones is as far as practicable maintained.

5.3.3 Final subcircuits

In the important spaces mentioned below the lighting shall be supplied by at least two different circuits:

- passageways
- stairways leading to the boat deck, and public spaces and day rooms for passengers and crew
- large galleys.

The lamps are to be so arranged that adequate lighting is maintained even if one of the circuits fails.

6 Safety devices and equipment

6.1 General

6.1.1 Application

The requirements of this Article apply to cabin vessels and day trip vessels with length L_{WL} exceeding 25 m.

Relaxations of these requirements may be allowed for ferries and day trip vessels, at the Society's discretion.

6.2 Alarm and communication systems

6.2.1 Passenger alarm system

Passenger vessels with cabins must be equipped with a passenger alarm system. This must be capable of being actuated from the wheelhouse and a permanently manned station. The alarm must be clearly perceptible in all rooms accessible to passengers. The alarm actuator has to be safeguarded against unintended operation.

6.2.2 Crew alarm system

Passenger vessels with cabins must be equipped with a crew alarm system in each cabin, in alleyways, lifts and stairwells, such that the distance to the next actuator is not more than 10 m, but at least one actuator every watertight compartment; in crew mess rooms, engine rooms, kitchens and similar fire hazard rooms.

6.2.3 Engineer’s alarm

An engineer's alarm is to be provided enabling the machinery personnel to be summoned in their quarters from the engine room should this be rendered necessary by the arrangement of the machinery space in relation to the engineers' accommodation.

6.3 Intercommunications

6.3.1 Intercommunications from the bridge

Where no direct means of communication exist between the bridge and the:

- crew's day rooms
- service spaces
- engine room (control platform)
- foreship and aftship,

a suitable intercommunications system is to be provided.

The general telephone system can be approved for this purpose provided it is guaranteed that the bridge/engine link always has priority and that existing calls on this line between other parties can be interrupted.

Where a telephone system is used, the engineer's alarm may be dispensed with provided that two-way communication is possible between the machinery space and the engineers' accommodation.

6.3.2 Public address systems

Vessels with a length L_{WL} greater than or equal to 40 m and vessels intended for more than 75 passengers must be equipped with loudspeakers capable of reaching all the passengers.

6.4 Fire door and watertight door closure indicators

6.4.1 The door release panel on the bridge or in the permanently manned safety station shall be equipped with indicators signalling the closure and the opening of fire doors or watertight doors.

7 Design loads

7.1 General

7.1.1 The design loads are to be determined in compliance with Part B, Chapter 3.

7.2 Loads due to list and wind action

7.2.1 The following loads inducing racking in the vessel superstructures are to be considered:

a) Structural and non-structural still water horizontal loads under list or roll angle to be taken not less than 0,21 rad (12°)

b) Structural and non-structural inertial horizontal loads under vessel acceleration to be determined according to Pt B, Ch 3, Sec 3, [2.1.4], where the roll amplitude is to be taken not less than 0,21 rad (12°)

c) Wind force, corresponding to a lateral pressure determined according to Pt B, Ch 3, Sec 4, [2.1.3].

7.3 Loads induced by collision

7.3.1 In the case of sensitive superstructures, the Society may require the structure to be checked against collision induced loads.The values of the longitudinal and transverse accelerations, in m/s^2, are to be taken not less than:

- longitudinal acceleration: $a = 3{,}0$ m/s^2
- transverse acceleration: $a = 1{,}5$ m/s^2.

8 Scantlings

8.1 General

8.1.1 The hull scantlings are to be as specified in Part B, Chapter 5 and relevant Sections of Part B, Chapter 6.

A thicker sheerstrake may be waived if an efficient fender is fitted in way of the main deck.

8.2 Additional requirements

8.2.1 Hull girder section modulus

The hull girder section modulus to be used for the scantling of hull and contributing superstructures/deckhouses, is to be determined in compliance with Pt B, Ch 4, Sec 1, taking into account the strength deck or the contributing deck up to which the considered superstructure/deckhouse extends.

8.2.2 Catamarans

Scantlings of primary structural members contributing to the transverse bending strength and torsional strength are to be supported by direct calculations.

Special attention is to be paid to the staggering of resistant members in the two hulls.

A method for the determination of scantlings of deck beams connecting the hulls of a catamaran subject to pitching torsional moment is given in Pt B, Ch 4, Sec 2, [2]. Any other agreed method of calculation may be accepted by the Society.

8.3 Superstructures and deckhouses

8.3.1 The arrangement and scantlings of superstructures and deckhouses are to be in compliance with Pt B, Ch 6, Sec 4.

8.3.2 Transverse strength

The existing constructive arrangements must ensure an effective transverse strength of the superstructures and deckhouses notably, by means of end bulkheads, partial or complete intermediate bulkheads and appropriate number of continuous and complete gantries.

Scantlings of primary structural members contributing to the transverse strength of superstructures and deckhouses are to be supported by racking direct analysis, to be performed according to Pt B, Ch 2, Sec 8, [2], considering loads due to list and wind action defined in [7.2]. The partial safety factor covering uncertainties regarding resistance, γ_R, is to be taken equal to 1,20.

8.3.3 Window stiles

The strength of stiles of windows fitted in superstructures contributing to the hull girder strength is to be ensured in all operating conditions.

The scantling of window stiles is to be supported by direct calculation performed according to Pt B, Ch 2, Sec 8, [2]. The partial safety factor covering uncertainties regarding resistance, γ_R, is to be taken equal to 1,20. The strength analysis, including the details of load in the window stiles calculation, is to be submitted to the Society.

9 Buoyancy and stability

9.1 General

9.1.1 General requirements of Pt B, Ch 2, Sec 2 are to be complied with.

9.2 Intact stability

9.2.1 General

Proof of appropriate intact stability of the vessel shall be furnished. All calculations shall be carried out free to trim and sinkage.

The lightship data taken into account for the stability calculation shall be determined by means of an inclining test.

9.2.2 Standard load conditions

The intact stability shall be proven for the following standard load conditions:

a) at the start of the voyage:

   100% passengers, 98% fuel and fresh water, 10% waste water

b) during the voyage:

   100% passengers, 50% fuel and fresh water, 50% waste water

c) at the end of the voyage:

   100% passengers, 10% fuel and fresh water, 98% waste water

d) unladen vessel:

   no passengers, 10% fuel and fresh water, no waste water.

For all standard load conditions, the ballast tanks shall be considered as either empty or full in accordance with normal operational conditions.

As a precondition for changing the ballast whilst under way, the requirement of [9.2.3], item d), shall be proven for the following load condition:

- 100% passengers, 50% fuel and fresh water, 50% waste water, all other liquid (including ballast) tanks are considered filled to 50%.

9.2.3 Intact stability criteria

The proof of adequate intact stability by means of a calculation shall be produced using the following intact stability criteria, for the standard load conditions mentioned in [9.2.2], items a) to d):

a) The maximum righting lever arm h_{max} shall occur at a list angle of $\varphi_{max} \geq (\varphi_{mom} + 3°)$ and must not be less than 0,20 m. However, in case $\varphi_f < \varphi_{max}$ the righting lever arm at the downflooding angle φ_f must not be less than 0,20 m.

b) The downflooding angle φ_f must not be less than $\varphi_{mom} + 3°$.

c) The area A under the curve of the righting lever arm shall, depending on the position of φ_f and φ_{max}, reach at least the values given in Tab 3, where:

   φ : List angle

   φ_f : List angle, at which openings in the hull, in the superstructure or deck houses which cannot be closed so as to be weathertight, submerge

   φ_{max} : List angle at which the maximum righting lever arm occurs

   φ_{mom} : Maximum list angle defined under item e)

   A : Area beneath the curve of the righting lever arms.

d) The metacentric height at the start, GM_0, corrected by the effect of the free surfaces in liquid tanks, shall not be less than 0,15 m.

e) In each of the following two cases, the list angle φ_{mom} shall not be in excess of the value of 12°:

   - in application of the heeling moment due to persons and wind according to [9.2.4] and [9.2.5]
   - in application of the heeling moment due to persons and turning according to [9.2.4] and [9.2.6].

f) For a heeling moment resulting from moments due to persons, wind and turning according to [9.2.4], [9.2.5] and [9.2.6], the residual freeboard shall be not less than 200 mm.

g) For vessels with windows or other openings in the hull located below the bulkhead decks and not closed watertight, the residual safety clearance shall be at least 100 mm on the application of the heeling moments resulting from item f).

9.2.4 Moment due to crowding of persons

The heeling moment M_P , in kN.m, due to one-sided accumulation of persons is to be calculated according to the following formula:

$$M_P = 9,81 P y = 9,81 \sum P_i y_i$$

where:

- P : Total weight of persons on board, in t, calculated by adding up the maximum permitted number of passengers and the maximum number of shipboard personnel and crew under normal operating conditions, assuming an average weight per person of 0,075 t
- y : Lateral distance, in m, of center of gravity of total weight of persons P from center line
- y_i : Lateral distance, in m, of geometrical center of area A_i from center line
- P_i : Weight of persons accumulated on area A_i, in t:

  $P_i = 0,075\ n_i\ A_i$
- A_i : Area, in m², occupied by persons
- n_i : Number of persons per square meter

  for free deck areas and deck areas with movable furniture: $n_i = 3,75$

  for deck areas with fixed seating furniture such as benches, n_i shall be calculated by assuming an area of 0,50 m in width and 0,75 m in seat depth per person.

Table 3 : Area A under the curve of righting lever arm

Case		A, in m·rad
1	$\varphi_{max} \le 15°$ or $\varphi_f \le 15°$	0,05 up to MIN(φ_{max} , φ_f)
2	$15° < \varphi_{max} < 30°$ and $\varphi_{max} \le \varphi_f$	0,035 + 0,001 (30 − φ_{max}) up to angle φ_{max}
3	$15° < \varphi_f < 30°$ and $\varphi_{max} > \varphi_f$	0,035 + 0,001 (30 − φ_f) up to angle φ_f
4	$\varphi_{max} \ge 30°$ and $\varphi_f \ge 30°$	0,035 up to angle φ = 30°

The calculation shall be carried out for an accumulation of persons both to starboard and to port.

The distribution of persons shall correspond to the most unfavorable one from the point of view of stability. Cabins shall be assumed unoccupied for the calculation of the person moment.

For calculation of the loading cases, the centre of gravity of a person should be taken as 1 m above the lowest point of the deck at 1/2 L_{WL} , ignoring any deck curvature and assuming a weight of 0,075 t per person.

A detailed calculation of deck areas which are occupied by persons may be dispensed with if the following values are used:

- y = B / 2
- $P = 1,1 \cdot n_{max} \cdot 0,075$ for day trip vessels

  $P = 1,5 \cdot n_{max} \cdot 0,075$ for cabin vessels

  where:

  n_{max} : Maximum permitted number of persons.

9.2.5 Moment due to lateral wind pressure

The moment M_W , in kN.m, due to lateral wind pressure is to be determined by the following formula:

$M_W = p_{WD}\ A_W\ (\ell_W + T / 2)$

where:

- p_{WD} : Wind pressure, in kN/m², defined in Pt B, Ch 3, Sec 4, [2.1.3]
- A_W : Lateral area above water, in m²
- ℓ_W : Distance, in m, of the centre of gravity of area A_W , from the draught mark.

9.2.6 Turning circle moment

The moment M_{dr} , in kN.m, due to centrifugal force caused by the turning circle, is to be determined by the following formula:

$$M_{dr} = \frac{0,0347 C_B v^2 \Delta}{L_{WL}}\left(KG - \frac{T}{2}\right)$$

If not known, the block coefficient C_B is to be taken as 1,0.

For passenger vessels with special propulsion systems (rudder-propeller, water-jet, cycloidal-propeller and bow-thruster), M_{dr} shall be derived from full-scale or model tests or else from corresponding calculations.

9.3 Damage stability

9.3.1 Proof of appropriate damage stability of the vessel shall be furnished by means of a calculation based on the method of lost buoyancy. All calculations shall be carried out free to trim and sinkage.

Relaxations of these requirements may be allowed for ferries and day trip vessels, at the Society's discretion.

9.3.2 Buoyancy of the vessel in the event of flooding shall be proven for the standard load conditions specified in [9.2.2]. Accordingly, mathematical proof of sufficient stability shall be determined for the three intermediate stages of flooding (25%, 50% and 75% of flood build-up) and for the final stage of flooding.

9.3.3 Passenger vessels shall comply with the one-compartment status.

9.3.4 Assumptions

In the event of flooding, assumptions concerning the extent of damage given in Tab 4 shall be taken into account.

a) The bulkheads can be assumed to be intact if the distance between two adjacent bulkheads is greater than the damage length. Longitudinal bulkheads at a distance of less than B / 3 measured rectangular to centre line from the shell plating at the maximum draught plane shall not be taken into account for calculation purposes.

b) The lowest point of every non-watertight opening (e.g. doors, windows, access hatchways) shall lie at least 0,10 m above the damage waterline. The bulkhead deck shall not be immersed in the final stage of flooding.

c) Permeability is assumed to be 95%. If it is proven by a calculation that the average permeability of any compartment is less than 95%, the calculated value can be used instead.

   The values to be adopted shall not be less than those given in Tab 5.

d) If damage of a smaller dimension than specified above produces more detrimental effects with respect to listing or loss of metacentric height, such damage shall be taken into account for calculation purposes.

9.3.5 Damage stability criteria

a) For all intermediate stages of flooding referred to in [9.3.2], the following criteria shall be met:

   - the angle of heel φ at the equilibrium position of the intermediate stage of flooding in question shall not exceed 15°
   - beyond the inclination in the equilibrium position of the intermediate stage of flooding in question, the positive part of the righting lever arm curve shall display a righting lever arm value of GZ ≥ 0,02 m before the first unprotected opening becomes immersed or in any case before reaching an angle of heel φ of 25°
   - non-watertight openings shall not be immersed before the inclination in the equilibrium position of the intermediate stage of flooding in question has been reached
   - the calculation of the free surface effect in all intermediate stages of flooding shall be based on the gross surface area of the damaged compartments.

b) During the final stage of flooding, the following criteria shall be met (see Fig 1) taking into account the heeling moment due to persons in accordance with [9.2.4]:

   - the angle of heel φ_E shall not exceed 10°
   - beyond the equilibrium position the positive part of the righting lever arm curve shall display a righting lever arm value of GZ_R ≥ 0,02 m with an area A ≥ 0,0025 m·rad. These minimum values for stability shall be met until the immersion of the first unprotected opening or in any case before reaching an angle of heel φ_m ≤ 25°
   - non-watertight openings shall not be immersed before the trimmed position has been reached; if such openings are immersed before this point, the rooms affording access are deemed to be flooded for damage stability calculation purposes.

Table 4 : Extent of damage

Dimension of the damage		Extent of damage, in m
Side damage	longitudinal ℓ	0,1 L_{WL} ≥ 4 **(1)**
	transverse b	B / 5
	vertical h	from vessel bottom to top without delimitation
Bottom damage	longitudinal ℓ	0,1 L_{WL} ≥ 4 **(1)**
	transverse b	B / 5
	vertical h	0,59; pipework shall be deemed intact **(2)**

(1) For vessels with L_{WL} ≤ 25, smaller values of the damage extent may be accepted by the Society on a case-by-case basis.
(2) Where a pipework system has no open outlet in a compartment, the pipework shall be regarded as intact in the event of this compartment being damaged, if it runs within the safe area and is more than 0,50 m off the bottom of the vessel.

Table 5 : Permeability values

Spaces	μ, in %
Lounges	95
Engine and boiler rooms	85
Luggage and store rooms	75
Double bottoms, fuel bunkers and other tanks, depending on whether, according to their intended purpose, they are to be assumed to be full or empty for the vessel floating at the plane of maximum draught	0 or 95

Note 1: For vessels with L_{WL} ≤ 25, smaller values of permeability may be accepted by the Society on a case-by-case basis, if it is proven by a calculation.

9.3.6 The shut-off devices which shall be able to be closed watertight shall be marked accordingly.

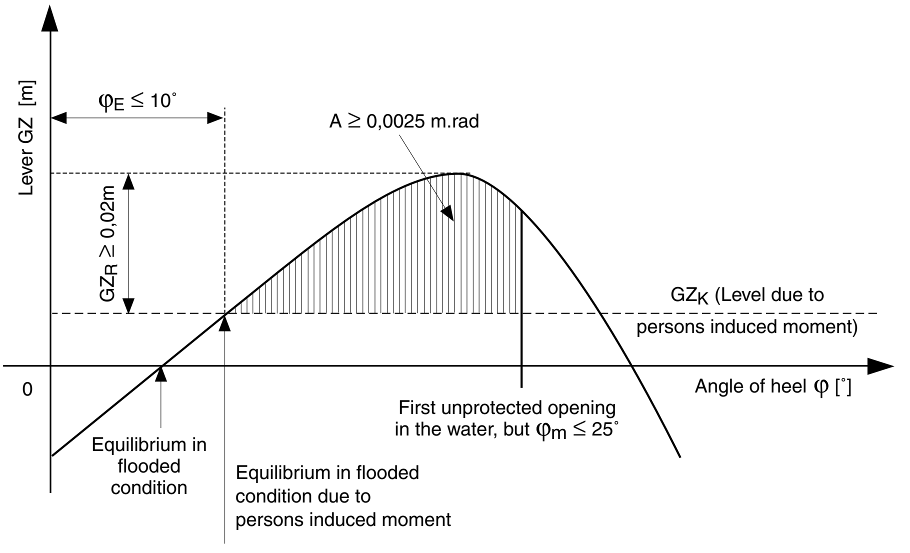
9.3.7 If cross-flood openings to reduce asymmetrical flooding are provided, they shall meet the following conditions:

a) for the calculation of cross-flooding, IMO Resolution A.266 (VIII) shall be applied
b) they shall be self-acting
c) they shall not be equipped with shut-off devices
d) the total time allowed for compensation shall not exceed 15 minutes.

9.3.8 As an alternative to the requirements set out in [9.3.5] to [9.3.7], proof of adequate stability after damage of passenger vessels authorised to carry up to a maximum of 50 passengers and with a length L_{WL} not exceeding 25 m, may be furnished by the compliance with the following criteria after symmetrical flooding:

a) the immersion of the vessel shall not exceed the margin line, and
b) the metacentric height G_{MR} shall not be less than 0,10 m.

Figure 1 : Proof of damage stability (final stage of flooding)



9.4 Safety clearance and freeboard

9.4.1 General

The requirements of this sub-article do not apply to vessels authorised to carry up to a maximum of 50 passengers and with a length L_{WL} not exceeding 25 m.

9.4.2 Safety clearance

The safety clearance shall be at least equal to the sum of:

a) the additional lateral immersion, which, measured on the outside plating, is produced by the permissible angle of heel according to [9.2.3], item e), and

b) the residual safety clearance according to [9.2.3], item g).

For vessels without a bulkhead deck, the safety clearance shall be at least 500 mm.

9.4.3 Freeboard

The freeboard shall correspond to at least the sum of:

a) the additional lateral immersion, which, measured on the outside plating, is produced by the angle of heel according to [9.2.3], item e), and

b) the residual freeboard according to [9.2.3], item f).

The freeboard shall be at least 300 mm.

9.4.4 The plane of maximum draught is to be set so as to ensure compliance with the safety clearance according to [9.4.2], and the freeboard according to [9.4.3].

9.4.5 For safety reasons, the Society may stipulate a greater safety clearance or a greater freeboard.

SECTION 7 TUGS AND PUSHERS

Symbols

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2]

t : Net thickness, in mm, of plating.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Tug** or **Pusher**, as defined in Pt A, Ch 1, Sec 3, [6.1.4] or Pt A, Ch 1, Sec 3, [6.1.3].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated in Part A, Part B and Part C, as applicable, and with the requirements of this Section, which are specific to tugs and pushers.

In particular, when pushed convoy or side-by-side formation comprises a vessel carrying dangerous goods, vessels used for propulsion shall meet the requirements of Ch 3, Sec 8, [2] and Ch 3, Sec 9, [2], as applicable.

1.2 Documents to be submitted

1.2.1 In addition to the documentation requested in Pt B, Ch 1, Sec 3, a drawing showing the towing/pushing devices and their installation is to be submitted to the Society for review. The maximum towing/pushing force contemplated is to be mentioned on that drawing.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

2.1.3 For tugs, the additional stability requirements in [2.2] are to be complied with in all intended loading conditions.

2.2 Additional intact stability for tugs

2.2.1 All intended loading conditions are also to be checked in order to investigate the vessel's capability to support the effect of the towing force in the beam direction.

A tug may be considered as having sufficient stability, according to the effect of the towing force in the beam direction, if the following condition is complied with:

$A \geq 0,011$

where:

A : Area, in m·rad, contained between the righting lever and the heeling arm curves, measured from the heeling angle φ_C to the heeling angle φ_D

φ_C : Heeling angle of equilibrium, corresponding to the first intersection between heeling and righting arms

φ_D : Heeling angle, to be taken as the lowest of:
- the angle φ_M , corresponding to the position of GZ_{MAX} (see Fig 1)
- the angle of downflooding.

The heeling arm curve is to be calculated as follows:

$$b_H = \frac{THc}{9,81\Delta}\cos\varphi$$

where:

b_H : Heeling arm, in m

T : Maximum towing pull, in kN

Where T is unknown, it can be assumed equal to:
- 0,179 P for propellers not fitted with nozzles
- 0,228 P for propellers fitted with nozzles

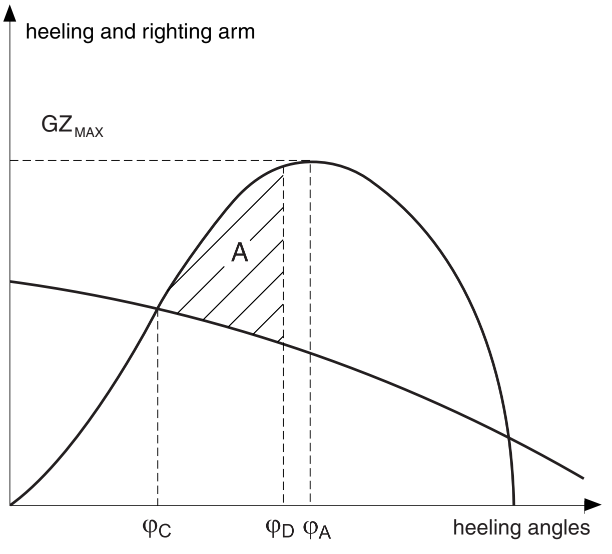
P : Maximum continuous power, in kW, of the propulsion engine

H : Vertical distance, in m, between the towing hook, or equivalent fitting, and half draught corresponding to Δ

c : Coefficient equal to:
- 1,00 for vessels with azimuth propulsion
- 0,65 for vessels with non-azimuth propulsion

Δ : Loading condition displacement, in t.

Figure 1 : Heeling and righting arm curves



3 Arrangement

3.1 Towing devices

3.1.1 Connection with hull structures

On tugs towing astern, the connection of the towing hook to the hull structure is to be strengthened by means of sufficient framing.

On tugs using a broadside tow, the towing bitts are to be secured to stools adequately supported by web frames or bulkheads, the latter being located on either side of the bitts.

3.2 Pushing devices

3.2.1 Transom plate

Pushers are to be arranged with an efficient flat transom plate or any other equivalent device at the fore end of the vessel the structure of which is to be in compliance with Pt B, Ch 7, Sec 6.

3.3 Hull protection

3.3.1 Fenders

A strong fender for the protection of the tug's sides is to be fitted at deck level.

Alternatively, loose side fenders may be fitted, provided that they are supported by vertical ordinary stiffeners extending from the lightship waterline to the fenders themselves.

4 Hull scantlings

4.1 General

4.1.1 The scantlings of the hull structure are to be determined in compliance with Part B, Chapter 5, taking into account additional requirements defined in [4.2].

4.2 Additional requirements

4.2.1 Minimum net thickness of plating

The minimum thickness of the shell plating and deck plating are to be obtained from Tab 1.

Table 1 : Minimum net thickness t of plating

Plating	t, in mm
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	$t = 3,3 + 0,048\ L\ (k_0 k)^{0,5}$
Keel plate	t = thickness of adjacent bottom plating

4.2.2 Topside structure

The topside structure scantlings are to be determined according to Pt B, Ch 5, Sec 4, [3], where the minimum net thickness is to be taken equal to $5(k_0 k)^{0,5}$ mm.

4.2.3 Primary supporting members

The design pressure of bottom primary supporting members is to be determined using $\gamma = 1$ for the draught coefficient.

5 Other structures

5.1 Sternpost

5.1.1 Irrespective of the range of navigation assigned to the vessel, the scantlings of the sternpost are not to be less than those determined according to requirements applicable to range of navigation **IN(1,2)**.

6 Hull outfitting

6.1 Rudder

6.1.1 Irrespective of the range of navigation assigned to the vessel, the rudder scantlings are not to be less than those determined according to the requirements applicable to range of navigation **IN(1,2)**.

7 Machinery

7.1 Propelling machinery

7.1.1 Propulsion systems under the bottom of the vessel are to be protected against damage by an effective structure around the propulsion system.

SECTION 8 PONTOONS

Symbols

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2]

t : Net thickness, in mm, of plating.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of one of the service notations **Pontoon** and **Pontoon-crane** as defined in Pt A, Ch 1, Sec 3, [6.1.2].

Specific requirements which apply only to vessels with th service notation **Pontoon** or vessels with the service notation **Pontoon-crane** are indicated.

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to type and service notations **Pontoon** and **Pontoon-crane**.

1.1.3 Main characteristics of considered units

The requirements of this Section are based on the following assumptions:
- considered units are of normal structural configuration and proportions
- cargo is homogeneously distributed.

The scantlings of units with unusual shapes and dimensional proportions or carrying cargoes which are not homogeneously distributed, such as containers or heavy loads concentrated in limited areas, are to be considered by the Society on a case-by-case basis, taking into account the results of direct calculations, to be carried out according to Pt B, Ch 2, Sec 8, [2].

1.2 Documents to be submitted

1.2.1 In addition to the documentation requested in Pt B, Ch 1, Sec 3, the following documents are to be submitted to the Society:
- cargo load and distribution on the deck
- equipment weight and distribution.

1.2.2 Where wheeled vehicles are intended to be carried, a wheeled load arrangement plan, including the following details:
- type of vehicles
- axle load
- configuration and number of wheels per axle
- distance between axles
- distance between wheels
- tyre print area,

is also to be submitted to the Society.

2 Stability

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions.

2.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

2.2 Documentation to be submitted

2.2.1 In addition to the documentation referred to in Pt B, Ch 2, Sec 2, [2.1], stability confirmation shall include the following data and documents:

a) scale drawings of the pontoon and working gear and the detailed data relating to these that are needed to confirm stability, such as content of the tanks, openings providing access to the inside of the vessel, etc.

b) hydrostatic data or curves

c) righting lever curves for static stability to the extent required in accordance with [2.4]

d) description of the operating conditions together with the corresponding data concerning weight and centre of gravity, including its unladen state and the equipment situation as regards transport

e) calculation of the heeling, trimming and righting moments, with specification of the list and trim angles and the corresponding residual freeboard and residual safety clearances

f) all of the results of the calculation with a specification of the use and load limits.

2.3 Heeling moments

2.3.1 Load induced moment

The load induced moment is to be defined by the Designer.

2.3.2 Asymmetric structure induced moment

The asymmetric structure induced moment is to be defined by the Designer.

2.3.3 Moment due to wind pressure

The moment caused by the wind pressure, in kN.m, shall be calculated in accordance with the following formula:

$M_W = c\ P_{WD}\ A_W\ (\ell_W + T / 2)$

where:

- c : Shape-dependent coefficient of resistance taking account of gusts:
  - for frameworks: c = 1,2
  - for solid section beam: c = 1,6
- P_{WD} : Wind pressure, in kN/m², defined in Pt B, Ch 3, Sec 4, [2.1.3]
- A_W : Side surface area of the floating installation, in m²
- ℓ_W : Distance, in m, of centre of gravity of area A_W , from waterline.

2.3.4 Cross current induced moment

The moment resulting from the cross current must only be taken into account for a vessel which is anchored or moored across the current while operating.

2.3.5 Ballast and supplies induced moment

The least favourable extent of tank filling from the point of view of stability shall be determined and the corresponding moment introduced into the calculation when calculating the moments resulting from the liquid ballast and the liquid provisions.

2.3.6 Moment due to inertia forces

The moment resulting from the inertia forces must be taken into account if the movements of the load and the working gear are likely to affect its stability.

2.3.7 Moment due to other mechanical equipment

The moment due to other mechanical equipment is to be defined by the Designer.

2.4 Calculation of the righting moments

2.4.1 The righting moments, in kN.m, for pontoons with vertical side walls may be calculated using the formula:

$Ma = 10\ \Delta\ GM \sin\varphi$

where:

- GM : Metacentric height, in m
- φ : List angle.

2.4.2 The formula in [2.4.1] shall apply up to list angles of 10° or up to a list angle corresponding to immersion of the edge of the deck or emergence of the edge of the bottom. In this instance the smallest angle shall be decisive. The formula may be applied to oblique side walls up to list angles of 5°.

If the particular shape of the vessel does not permit such simplification, the righting lever curves referred to in [2.2.1] item c) shall be required.

2.5 Intact stability

2.5.1 It shall be confirmed that, when account has been taken of the loads applied during the use and operation of the working gear, the residual freeboard defined in and the residual safety clearance defined in are adequate, i.e.:

- The residual safety clearance value is, at least:
  - 0,30 m for weathertight aperture
  - 0,40 m for unprotected openings.
- The residual freeboard value is at least 0,30 m.

  The residual freeboard may be reduced if it is proven that the requirements of [2.6] have been met.

For that purpose the list angle shall not exceed 10° and the base of the hull shall not emerge.

2.5.2 Stability checking shall take into account all the heeling moments defined in [2.3].

The moments which may act simultaneously shall be added up.

2.6 Intact stability in case of reduced residual freeboard

2.6.1 If a reduced residual freeboard is taken into account, it shall be checked, for all operating conditions, that:

a) after correction for the free surfaces of liquids, the metacentric height GM is not less than 0,15 m

b) for list angles between 0° and 30°, there is a righting lever, in m, of at least:

   $h = 0,30 - 0,28\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values (stability limit); it may not be less than 20° or 0,35 rad and shall not be inserted into the formula for more than 30° or 0,52 rad:

   $20° \leq \varphi_n \leq 30°$

c) the list angle does not exceed 10°

d) the residual safety clearance value is, at least:
   - 0,30 m for weathertight openings
   - 0,40 m for unprotected openings

e) the residual freeboard is at least 0,05 m

f) for list angles between 0° and 30°, the residual righting lever arm, in m, is at least:

   $h = 0,20 - 0,23\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values; this should not be inserted into the formula for more than 30° or 0,52 rad.

   Residual righting lever arm means the maximum difference existing between 0° and 30° list between the righting lever and the heeling lever curves. If an opening towards the inside of the vessel is immersed at a list angle less than the one corresponding to the maximum difference between the lever arm curves, the lever arm corresponding to that list angle shall be taken into account.

3 Structure design principles

3.1 Hull structure

3.1.1 Framing

In general, vessels with one of the service notations **Pontoon** and **Pontoon-crane** are to be longitudinally framed. Longitudinal stiffening members are to be supported by transverses arranged to form ring systems.

3.1.2 Supports for docking

Adequate supports are to be fitted on the longitudinal centreline in order to carry loads acting on the structure when the pontoons are in dry dock.

3.1.3 Truss arrangement supporting deck loads

Where truss arrangements may be used as supports of the deck loads, including top and bottom girders in association with pillars and diagonal bracing, the diagonal members are generally to have angles of inclination with respect to the horizontal of about 45° and cross-sectional area of about 50% that of the adjacent pillars.

3.2 Lifting appliances

3.2.1 Crane or derrick position during navigation

For vessels with the type and service notation **Pontoon-crane**, it is to be possible to lower the crane boom or the derrick structure and to secure them to the pontoon during the voyage.

4 Hull girder strength

4.1 Yielding check

4.1.1 Vessels less than 40 m in length lifted by crane

For vessels less than 40 m in length intended to be lifted on board ships by crane, the hull girder strength is to be checked, in the condition of fully-loaded vessel lifted by crane, through criteria to be agreed upon with the Society on a case-by-case basis.

4.1.2 Vessels with type and service notation Pontoon carrying special cargoes

For vessels with the type and service notation **Pontoon** intended for the carriage of special cargoes, such as containers or heavy loads concentrated in limited areas, the hull girder strength is to be checked through criteria to be agreed upon with the Society on a case-by-case basis.

4.1.3 Vessels with type and service notation Pontoon-crane

For vessels with the type and service notation **Pontoon-crane** having a length greater than or equal to 40 m, the hull girder strength is to be checked when the lifting appliance, such as a crane or derrick, is operated, taking into account the various loading conditions considered, through criteria to be agreed upon with the Society on a case-by-case basis.

5 Hull scantlings

5.1 General

5.1.1 The scantlings of the hull structure are to be determined in compliance with Part B, Chapter 5 and relevant Sections of Part B, Chapter 6, taking into account the following additional requirements.

5.1.2 Minimum net thickness of plating

The minimum thickness of the shell plating and deck plating are to be obtained from Tab 1.

Table 1 : Minimum net thickness t of plating

Plating	t, in mm
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	• for $L \leq 40$ m: $t=3,3+0,048\ L(k_0k)^{0,5}$ • for $L > 40$ m: $t=4,8+0,019\ L(k_0k)^{0,5}$
Keel plate	t = thickness of adjacent bottom plating

5.1.3 Plating and stiffeners subjected to wheeled loads are to comply with Ch 1, Sec 5.

5.1.4 Primary supporting members

In the case of primary supporting members forming a grillage, the scantlings are to be determined by direct calculation as specified in Ch 1, Sec 4, [8].

5.2 Hull scantlings of vessels with type and service notation Pontoon-crane

5.2.1 Loads transmitted by the lifting appliances

The forces and moments transmitted by the lifting appliances to the vessel structures, during both lifting service and navigation, are to be obtained by means of criteria to be considered by the Society on a case-by-case basis.

5.2.2 Vessel structures

The vessel structures, subjected to the forces transmitted by the lifting appliances, are to be reinforced to the Society's satisfaction.

5.2.3 Lifting appliances

The check of the behaviour of the lifting appliances during operation is outside the scope of the classification and is under the responsibility of the Designer. However, where the requirements in [3.2.1] may not be complied with (i.e. sailing with boom or derrick up) or where, exceptionally, trips with suspended load are envisaged, the Designer is to submit the check of the lifting appliances during navigation to the Society for information.

5.3 Reinforcements

5.3.1 Reinforcements are to be provided at places where the hull is heavily stressed, as the securing points of the towing ropes.

SECTION 9 VESSELS FOR DREDGING ACTIVITIES

Symbols

a : Distance from the bottom to the sealing joint located at the lower part of the hopper well, in m

C : Wave parameter defined in Pt B, Ch 3, Sec 2

C_{FA} : Combination factor, to be taken equal to:
- C_{FA} = 0,7 for load case "c"
- C_{FA} = 1,0 for load case "d"

g : Gravitational acceleration:

$$g = 9,81 \ m/s^2$$

h_0 : Distance, in m, from spoil level to base line in working conditions (see Fig 7)

h_4 : Distance, in m, from the lowest weir level to base line

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Pt B, Ch 3, Sec 2, [2]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Pt B, Ch 3, Sec 2, [2]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Pt B, Ch 3, Sec 2, [3.2]

P_D : Maximum mass, in t, of the spoil contained in the hopper space

P_{WD} : Wind pressure, in kN/m^2, defined in Pt B, Ch 3, Sec 4, [2.1.3]

T_D : Maximum draught in working conditions, in m

T_4 : Navigation draught, in m, with well filled with water up to the lowest weir level.

V_D : Volume of the hopper space, in m^3, limited to the highest weir level

δ : Density of the mixture of water and spoil, taken equal to:

$$\delta = \frac{P_D}{V_D}$$

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads
- γ_{W1} = 1,0 for **IN**
- γ_{W1} = 1,15 for **IN(x ≤ 2)**

γ_{W2} : Partial safety factor covering uncertainties regarding wave local loads
- γ_{W2} = 1,0 for **IN**
- γ_{W2} = 1,2 for **IN(x ≤ 2)**

γ_W : Coefficient taken equal to:
- γ_W = 1,0 for **IN**
- γ_W = 0,625 for **IN(x ≤ 2)**

ℓ_p : Maximum length, in m, of the hopper well.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of one of the following service notations, as defined in Pt A, Ch 1, Sec 3, [5.1.1] to Pt A, Ch 1, Sec 3, [5.1.5]:
- **Dredger**
- **Hopper dredger**
- **Hopper barge**
- **Split hopper dredger**
- **Split hopper barge**.

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to vessels for dredging activities.

1.1.3 Dredging equipment and installations are not covered by these Rules.

1.2 Documents to be submitted

1.2.1 In addition to the documentation requested in Pt B, Ch 1, Sec 3, the plans and documents listed in Tab 1 are to be submitted to the Society.

2 Stability for dredgers

2.1 General

2.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions

2.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

2.2 Documentation to be submitted

2.2.1 In addition to the documentation referred to in Pt B, Ch 2, Sec 2, [2.1], stability confirmation shall include the following data and documents:

a) scale drawings of the pontoon and working gear and the detailed data relating to these that are needed to confirm stability, such as content of the tanks, openings providing access to the inside of the vessel, etc.

b) hydrostatic data or curves

c) righting lever curves for static stability to the extent required in accordance with [2.4]

d) description of the operating conditions together with the corresponding data concerning weight and centre of gravity, including its unladen state and the equipment situation as regards transport

e) calculation of the heeling, trimming and righting moments, with specification of the list and trim angles and the corresponding residual freeboard and residual safety clearances

f) all of the results of the calculation with a specification of the use and load limits.

2.3 Heeling moments

2.3.1 Load assumptions

Stability assessment is to be based at least on the following load assumptions:

a) Density of dredged material:
- sands and gravels: 1,5 t/m^3
- very wet sands: 2,0 t/m^3
- soil, on average: 1,8 t/m^3
- mixture of sand and water in the ducts: 1,3 t/m^3

b) Clamshell dredgers:
the values given in a) are to be increased by 15%

c) Hydraulic dredgers:
the maximum lifting power shall be considered.

2.3.2 Load induced moment

The load induced moment is to be defined by the Designer.

2.3.3 Asymmetric structure induced moment

The asymmetric structure induced moment is to be defined by the Designer.

2.3.4 Moment due to wind pressure

The moment caused by the wind pressure, in kN.m, shall be calculated in accordance with the following formula:

$$M_W = c\, P_{WD}\, A_W\, (\ell_W + T / 2)$$

where:

c : Shape-dependent coefficient of resistance taking account of gusts:
- for frameworks: c = 1,2
- for solid section beam: c = 1,6

A_W : Side surface area of the floating installation, in m^2

ℓ_W : Distance, in m, of centre of gravity of area A_W, from waterline.

2.3.5 Turning circle induced moment

For self-propelled vessels, the moment resulting from the turning of the vessel in kN.m, is to be determined by the following formula:

$$M_{dr} = \frac{0,0347 C_B v^2 \Delta}{L_{WL}}\left(KG - \frac{T}{2}\right)$$

Table 1 : Plans and documents to be submitted depending on type and service notations

Service notations	Plans or documents
Dredger	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures Closing arrangements, if any Connection of dredging machinery with the hull structure
Hopper dredger **Hopper barge**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure
Split hopper dredger **Split hopper barge**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures, including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure Superstructure hinges and connections to the vessel structure, including mass and location of the superstructure centre of gravity Structure of hydraulic jack spaces Deck hinges, including location of centre of buoyancy and of centre of gravity of each half-hull, mass of equipped half-hull, half mass of spoil or water, supplies for each half-hull and mass of superstructures supported by each half-hull Hydraulic jacks and connections to vessel structure including operating pressure and maximum pressure of the hydraulic jacks (cylinder and rod sides) and corresponding forces Longitudinal chocks of bottom and deck Transverse chocks Hydraulic installation of jacks, with explanatory note

2.3.6 Cross current induced moment

The moment resulting from the cross current must only be taken into account for a vessel which is anchored or moored across the current while operating.

2.3.7 Ballast and supplies induced moment

The least favourable extent of tank filling from the point of view of stability shall be determined and the corresponding moment introduced into the calculation when calculating the moments resulting from the liquid ballast and the liquid provisions.

2.3.8 Moment due to inertia forces

The moment resulting from the inertia forces must be taken into account if the movements of the load and the working gear are likely to affect its stability.

2.3.9 Moment due to other mechanical equipment

The moment due to other mechanical equipment is to be defined by the Designer.

2.4 Calculation method

2.4.1 The calculation of the righting lever curves is to take into account the change of trim due to heel.

2.4.2 The righting moments, in kN.m, for floating installations with vertical side walls may be calculated via the formula:

$Ma = 10\ \Delta\ GM \sin \varphi$

where:

GM : Metacentric height, in m

φ : List angle.

2.4.3 The formula in [2.4.2] shall apply up to list angles of 10° or up to a list angle corresponding to immersion of the edge of the deck or emergence of the edge of the bottom. In this instance the smallest angle shall be decisive. The formula may be applied to oblique side walls up to list angles of 5°.

If the particular shape of the vessel does not permit such simplification the lever-effect curves referred to in [2.2.1] item c) shall be required.

2.5 Intact stability

2.5.1 It shall be confirmed that, when account has been taken of the loads applied during the use and operation of the working gear, the residual freeboard defined in Pt B, Ch 2, Sec 2, [1.2.4] and the residual safety clearance defined in Pt B, Ch 2, Sec 2, [1.2.6] are adequate, i.e.:

- The residual safety clearance value is, at least:
  - 0,30 m for weathertight aperture
  - 0,40 m for unprotected openings.
- The residual freeboard value is at least 0,30 m.

  The residual freeboard may be reduced if it is proven that the requirements of [2.6] have been met.

For that purpose the list angle shall not exceed 10° and the base of the hull shall not emerge.

2.5.2 Stability checking shall take into account the heeling moments defined in [2.3.2] to [2.3.9].

The moments which may act simultaneously shall be added up.

2.6 Intact stability in case of reduced residual freeboard

2.6.1 If a reduced residual freeboard is taken into account, it shall be checked, for all operating conditions, that:

a) after correction for the free surfaces of liquids, the metacentric height GM is not less than 0,15 m

b) for list angles between 0° and 30°, there is a righting lever, in m, of at least:

   $h = 0{,}30 - 0{,}28\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values (stability limit); it may not be less than 20° or 0,35 rad and shall not be inserted into the formula for more than 30° or 0,52 rad:

   $20° \leq \varphi_n \leq 30°$

c) the list angle does not exceed 10°

d) the residual safety clearance value is, at least:
   - 0,30 m for weathertight openings
   - 0,40 m for unprotected openings

e) the residual freeboard is at least 0,05 m

f) for list angles between 0° and 30°, the residual righting lever arm, in m, is at least:

   $h = 0{,}20 - 0{,}23\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values; this should not be inserted into the formula for more than 30° or 0,52 rad.

   Residual righting lever arm means the maximum difference existing between 0° and 30° list between the righting lever and the heeling lever curves. If an opening towards the inside of the vessel is immersed at a list angle less than the one corresponding to the maximum difference between the lever arm curves, the lever arm corresponding to that list angle shall be taken into account.

3 Stability for hopper dredgers and hopper barges Vessels without bottom doors

3.1 General

3.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions

3.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

3.2 Documentation to be submitted

3.2.1 Stability confirmation shall include the following data and documents:

a) scale drawings of the vessel and the detailed data relating to these that are needed to confirm stability, such as content of the tanks, openings providing access to the inside of the vessel, etc.

b) hydrostatic data or curves

c) righting lever curves for static stability

d) description of the situations of use together with the corresponding data concerning weight and centre of gravity, including its unladen state and the equipment situation as regards transport

e) calculation of the list, trim and righting moments, with statement of the list and trim angles and the corresponding residual freeboard and residual safety clearances

f) all of the results of the calculation with a statement of the use and load limits.

3.3 Heeling moments

3.3.1 Load assumptions

Stability assessment is to be based at least on the following load assumptions:

a) Density of dredged material for dredgers:
   - sands and gravels: 1,5 t/m^3
   - very wet sands: 2,0 t/m^3
   - soil, on average: 1,8 t/m^3
   - mixture of sand and water in the ducts: 1,3 t/m^3

b) Clamshell dredgers:

   the values given in a) are to be increased by 15%

c) Hydraulic dredgers:

   the maximum lifting power shall be considered.

3.3.2 The moments which may act simultaneously shall be added up.

3.3.3 Load induced moment

The load induced moment is to be defined by the Designer.

3.3.4 Asymmetric structure induced moment

The asymmetric structure induced moment is to be defined by the Designer.

3.3.5 Moment due to wind pressure

The moment caused by the wind pressure, in kN.m, shall be calculated in accordance with the following formula:

$M_W = c\ P_{WD}\ A_W\ (\ell_W + T / 2)$

where:

c : Shape-dependent coefficient of resistance taking account of gusts:
- for frameworks:

  c = 1,2
- for solid section beam:

  c = 1,6

A_W : Side surface area of the floating installation, in m^2

ℓ_W : Distance, in m, of centre of gravity of area A_W, from waterline.

3.3.6 Turning circle induced moment

For self-propelled vessels, the moment resulting from the turning of the vessel in t.m, is to be determined by the following formula:

$$M_{dr} = \frac{0,0347 C_B v^2 \Delta}{L_{WL}}\left(KG - \frac{T}{2}\right)$$

3.3.7 Cross current induced moment

The moment resulting from the cross current must only be taken into account for vessel which is anchored or moored across the current while operating.

3.3.8 Ballast and supplies induced moment

The least favourable extent of tank filling on stability shall be determined and the corresponding moment introduced into the calculation when calculating the moments resulting from the liquid ballast and the liquid provisions.

3.3.9 Moment due to inertia forces

The moment resulting from the inertia forces must be taken into account if the movements of the load and the working gear are likely to affect its stability.

3.3.10 Moment due to other mechanical equipment

The moment due to other mechanical equipment is to be defined by the Designer.

3.4 Calculation method

3.4.1 The calculation of the righting lever curves is to take into account:
- the change of trim due to heel
- the inflow of river water or outflow of liquid cargo at the upper edge of the hopper coaming in the case of an open hopper
- the inflow of water at the lower edge of the overflow, located at cargo level or at the lowest possible position above cargo level, or at the lower edge of the lowest overflow ports or spillways.

3.5 Intact stability

3.5.1 It shall be confirmed that, when account has been taken of the loads applied during the use and operation of the working gear, the residual freeboard defined in Pt B, Ch 2, Sec 2, [1.2.4] and the residual safety clearance defined in Pt B, Ch 2, Sec 2, [1.2.6] are adequate, i.e.:
- The residual safety clearance value is, at least:
  - 0,30 m for weathertight aperture
  - 0,40 m for unprotected openings.
- The residual freeboard value is at least 0,30 m.

  The residual freeboard may be reduced if it is proven that the requirements of [3.6] have been met.

For that purpose the list angle shall not exceed 10° and the base of the hull shall not emerge.

3.5.2 Stability checking shall take into account the heeling moments defined in [3.3.3] to [3.3.10].

The moments which may act simultaneously shall be added up.

3.6 Intact stability in case of reduced residual freeboard

3.6.1 If a reduced residual freeboard is taken into account, it shall be checked, for all operating conditions, that:

a) after correction for the free surfaces of liquids, the metacentric height GM is not less than 0,15 m

b) for list angles between 0° and 30°, there is a righting lever, in m, of at least:

   $h = 0{,}30 - 0{,}28\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values (stability limit); it may not be less than 20° or 0,35 rad and shall not be inserted into the formula for more than 30° or 0,52 rad:

   $20° \le \varphi_n \le 30°$

c) the list angle does not exceed 10°

d) the residual safety clearance value is, at least:
   - 0,30 m for weathertight openings
   - 0,40 m for unprotected openings

e) the residual freeboard is at least 0,05 m

f) for list angles between 0° and 30°, the residual righting lever arm, in m, is at least:

   $h = 0{,}20 - 0{,}23\ \varphi_n$

   where:

   φ_n : List angle, in radian, from which the righting lever arm curve displays negative values; this should not be inserted into the formula for more than 30° or 0,52 rad.

   Residual righting lever arm means the maximum difference existing between 0° and 30° list between the righting lever and the heeling lever curves. If an opening towards the inside of the vessel is immersed at a list angle less than the one corresponding to the maximum difference between the lever arm curves, the lever arm corresponding to that list angle shall be taken into account.

4 Stability for hopper dredgers and hopper barges Vessels fitted with bottom doors

4.1 General

4.1.1 The Society may waive the requirements of this Article depending on the vessel design and operating conditions

4.1.2 The general requirements of Pt B, Ch 2, Sec 2 are to be complied with.

4.2 Documentation to be submitted

4.2.1 Stability confirmation shall include the following data and documents:

a) scale drawings of the vessel and the detailed data relating to these that are needed to confirm stability, such as content of the tanks, openings providing access to the inside of the vessel, etc.

b) hydrostatic data or curves

c) righting lever curves for static stability

d) description of the situations of use together with the corresponding data concerning weight and centre of gravity, including its unladen state and the equipment situation as regards transport

e) calculation of the list, trim and righting moments, with statement of the list and trim angles and the corresponding residual freeboard and residual safety clearances

f) all of the results of the calculation with a statement of the use and load limits.

4.3 Heeling moments

4.3.1 The heeling moments are to be calculated in compliance with [3.3]. The moments which may act simultaneously shall be added up.

4.4 Calculation method

4.4.1 The calculation of the righting lever curves is to take into account:

- the change of trim due to heel
- the inflow of river water or outflow of liquid cargo at the upper edge of the hopper coaming in the case of an open hopper
- the inflow of water at the lower edge of the overflow, located at cargo level or at the lowest possible position above cargo level, or at the lower edge of the lowest overflow ports or spillways.

4.5 Intact stability

4.5.1 The intact stability of the vessel is to be sufficient to comply with the criteria indicated in [3.5] and [4.5.2] for all intended operational loading conditions.

4.5.2 Using the calculation method given in [4.4], vessels with bottom doors or similar means at port side and at starboard side are to comply with the following criteria considering an asymmetric discharging:

- the angle of equilibrium is not to exceed 27°
- the righting lever GZ within the 30° range beyond the angle of equilibrium is to be at least 0,10 m
- the range of stability is not to be less than 30°.

The dredger is assumed loaded up to the dredging draught with solid cargo of a density defined in [3.3.1], when discharging, 20% of the total hopper load is assumed to be discharged only at one side of the longitudinal centreline of the hopper, horizontally equally distributed at the discharging side.

5 Structure design principles

5.1 General

5.1.1 The attention of Designers is drawn to the fact that the structural arrangement of vessels for dredging activities involves discontinuities and that particular care is to be taken to avoid cracks or fractures.

5.1.2 Where dredgers are likely to work in association with hopper barges, the sheerstrake is to be protected, slightly below the deck, by a fender efficiently secured to the shell plating and extending over at least two thirds of the vessel length. Compensation is to be provided in way of the gangway port in raised deck, if fitted.

5.1.3 Where dredgers are likely to work in association with hopper barges, the shell plating is to be protected by a fender extending from the load waterline to the lowest waterline.

Additional structural reinforcements are to be provided in way of fenders and submitted to the Society for approval.

5.1.4 On bucket dredgers, in order to prevent dangerous flooding in the event of damage to the shell plating by metal debris (e.g. anchors), a watertight compartment is to be provided at the lower part of the caissons on either side of the bucket well in the area of the buckets. The compartment is to be of adequate size to allow surveys to be carried out.

5.1.5 Reinforcements are to be provided at locations where the hull is heavily stressed, such as:

- beneath the suction pipe gallows
- in way of the gallow frame on bucket dredgers
- at the points where tow ropes are secured
- at connections of piles, etc.

5.1.6 The strengthening of the flat bottom at the ends is to be examined by the Society on a case-by-case basis.

5.1.7 Weirs are to be provided in the hopper spaces. Their sectional area is to be large enough, taking into account the density of the water-spoil mixture to be drained off.

The disposition and location of the weirs are to be such that:

- they prevent the maximum authorised draught from being exceeded during loading
- draining off is made without any overflowing on the decks.

5.1.8 The corners of the cut-outs in the bottom plating are to be rounded and the radius is to be as large as possible, especially near the bottom doors.

The shape and the radius of cut-out corners are to be in accordance with Pt B, Ch 6, Sec 7.

5.2 Longitudinal members in the area of the hopper well

5.2.1 The scantlings of the midship region are generally to be kept over the full length of the hopper well.

5.2.2 Attention is to be paid to the structural continuity of longitudinal members, especially coaming and hopper well bulkheads.

5.2.3 The upper deck stringer plate is to extend to the inner side over the full length of the hopper well.

5.2.4 The fore and aft ends of the inner side of the hopper spaces are to be extended by large brackets generally having a length and a width equal to D/4. It is recommended that a swept shape should be provided for these brackets (see Fig 1).

The upper bracket is to be welded to the deck and extended by a longitudinal deck girder.

The lower bracket, which is generally oblique, is to be welded to the bottom or to the tank top. In the latter case, the lower bracket is to be extended inside the double bottom by means of a solid keelson extending at least over three frame spaces beyond the end of the bracket.

5.2.5 The fore and aft ends of the centreline cellular keel are to be extended by means of brackets having a length at least equal to the depth of this keel.

In areas where a double bottom is provided, the brackets may be arranged in accordance with Fig 2.

5.2.6 The vertical sides of the trunks are to be extended beyond the end of the hopper spaces over a distance of at least 1,5 times their height.

5.2.7 The Society may, on a case-by-case basis, require that longitudinal members of the double bottom structure are extended, by means of brackets, inside the side compartments bounding the hopper spaces.

5.2.8 Arrangements other than those described in [5.2.4] to [5.2.7] are to be considered by the Society on a case-by-case basis.

Figure 1 : Brackets at fore and aft ends of longitudinal bulkheads of the hopper spaces

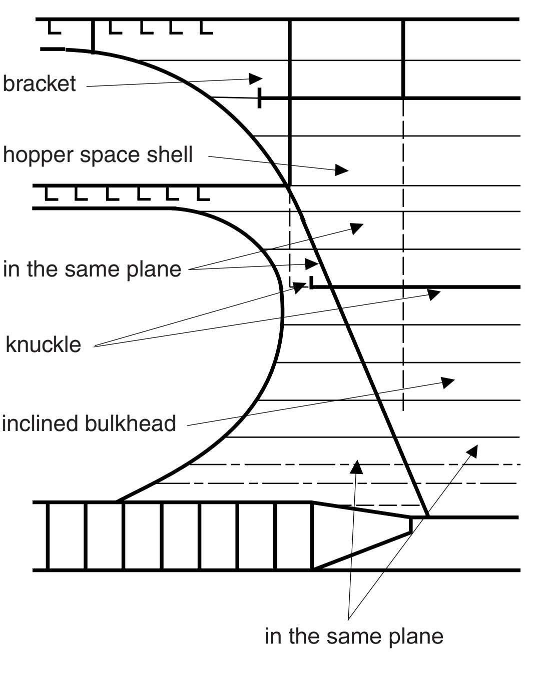
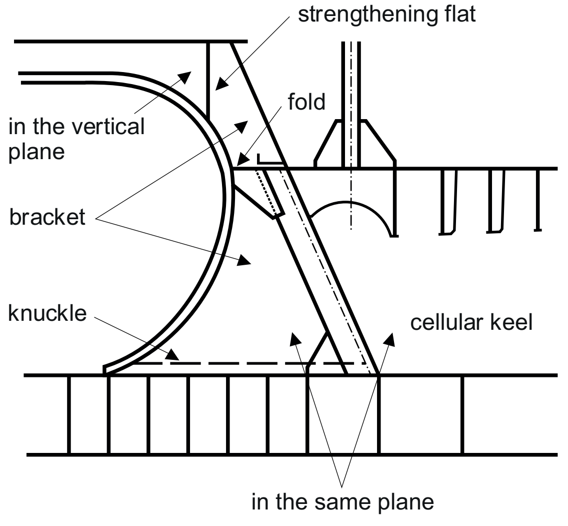


Figure 2 : Brackets at fore and aft ends of cellular keel



5.3 Transverse members in the area of the hopper well

5.3.1 Transverse primary supporting rings

Within the hopper well area, transverse primary supporting rings are to be provided and are to involve:

- deep floors inside hopper spaces
- side vertical primary supporting members
- hopper well vertical primary supporting members
- strong beams inside hopper spaces, at deck or trunk level
- where necessary, cross-ties connecting either the side vertical primary supporting members to the hopper well vertical primary supporting members or the floor to the hopper well vertical primary supporting members.

The spacing of the transverse rings is generally to be taken not greater than five frame spaces.

5.3.2 The cellular keel is to be rigidly connected to the transverse rings required in [5.3.1].

5.3.3 The upper part of the cellular keel may be connected to the deck or trunk structure by means of axial or inclined pillars in association with strong beams, or by a centreline wash bulkhead.

5.3.4 The connection of hopper space floors with the longitudinal bulkheads and the cellular keel is to be arranged such that the continuity of the strength is ensured.

Where the floor is made of a box with sloping sides, particular attention is to be paid to the continuity of the lower flange. Fig 3 shows an example of possible connection.

5.3.5 The connection between the flanges of the strong beams and the adjacent structure is generally to be made by means of brackets having the thickness of these flanges and extending inside the adjacent structure.

5.4 Arrangements relating to suction pipes

5.4.1 Where a cut-out is necessary in the side shell plating to fit the suction pipe guides, continuity of members is to be restored, for example by means of knuckled plates as thick as the side shell plating and with a knuckle angle as small as possible.

The knuckles are to be stiffened by reinforced vertical primary supporting members and intercostal girders of the same web height (see Fig 4 and Fig 5).

The fillet welding between the web of vertical primary supporting members and the knuckled plates is not to be made onto the knuckles, but about 50 mm apart.

Figure 3 : Example of connection with floor made of box with sloping sides

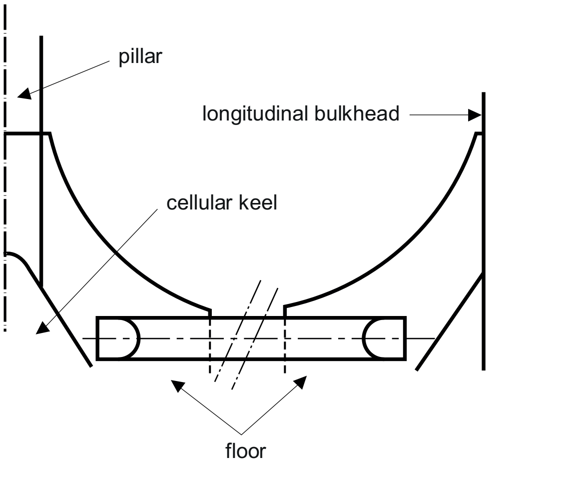


Figure 4 : Transversely framed side Cut-out reinforced by means of knuckled plate

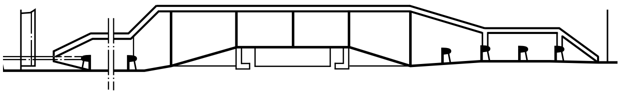
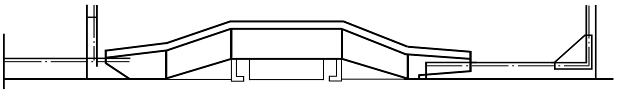


Figure 5 : Longitudinally framed side Cut-out reinforced by means of knuckled plate



5.4.2 The suction pipe guides are to be fitted as far as possible from the hopper space ends or from any cut-out in the bottom or deck plating.

A 60% reinforced deck plate, not exceeding 38 mm, is to be provided in way of the cut-out of the guides. This plate is to extend over at least one frame space forward and aft of the vertical primary supporting members provided for in [5.4.1].

5.4.3 In areas where, during suction pipe operations, the drag head and the joint may run against the hull, one or several of the following arrangements are generally to be provided:

- thickness plating in excess of thickness obtained according to Pt B, Ch 5, Sec 2 and Pt B, Ch 5, Sec 3 for bilge and side shell

- reinforcement of the structure by means of vertical primary supporting members, girders, intermediate frames or longitudinals, depending on the construction type
- fenders to be provided outside the hull; these fenders together with the bilge shape are not to impede the suction pipe operation
- cofferdam to be provided to limit the possible flooding of side compartments.

5.4.4 The suction pipes are generally to be fitted with:

- auxiliary devices able to lift the suction pipe, in addition to the suction pipe davits
- a sufficient number of attachment points on the suction pipe itself, to facilitate handling
- a load limiting device to avoid any overload, if the suction pipe is equipped with cutting teeth
- accessories fitted onto the suction pipe built in several parts to facilitate partial replacements in case of damage.

5.5 Chafing areas

5.5.1 Some parts of the structure subjected to heavy wear, such as inner sides of hopper spaces, may be protected or reinforced to avoid frequent replacement.

5.5.2 If protection is provided by means of removable plates, called chafing plates, attention is to be paid to avoid corrosion between the facing sides of these plates and the hopper space plating.

5.5.3 If reinforcement is made by increasing the thickness, the section moduli may be determined taking into account the extra thickness, provided that the chafing limits, beyond which the plates are to be replaced, are determined according to the extra thickness values.

If this extra thickness is disregarded in the section moduli calculation, this is to be clearly indicated on the midship section drawing.

5.6 Reinforcements for grounding

5.6.1 If grounding is considered for normal operation of the vessel, the bottom plating and the bottom structure are to be reinforced as indicated in [5.6.2] to [5.6.5].

5.6.2 Along the full length of the vessel, in the area of flat bottoms, the bottom net thickness obtained according to Pt B, Ch 5, Sec 2, as applicable, is to be increased by 2,5 mm.

5.6.3 Where the vessel has a transversely framed double bottom, floors are to be fitted at each frame space and associated with intercostal longitudinal girders, the mean spacing of which is to be not greater than 2,10 m.

Moreover, intercostal longitudinal ordinary stiffeners located at mid-spacing of bottom girders are to be provided.

5.6.4 Where the vessel has a longitudinally framed double bottom, the floor spacing may not exceed three frame spaces and the bottom girder spacing may not exceed three longitudinal ordinary stiffener spaces.

Intercostal transverse stiffeners are to be provided at mid-span of longitudinal ordinary stiffeners.

Floors are to be stiffened by vertical stiffeners having the same spacing as the longitudinal ordinary stiffeners.

5.6.5 Where the vessel is built with open hopper spaces (bottom doors provided on the bottom), reinforcements as required in [5.6.3] or [5.6.4] are to be provided within the side compartments, the cellular keel and, in general, within the limits of the flat bottom area.

5.7 Bolted structures

5.7.1 Where the dredger is made of several independent members connected by bolting, the connection is to be examined by the Society on a case-by-case basis.

6 Design loads

6.1 External pressure

6.1.1 Still water pressure

The river still water pressure to be used in connection with the wave pressure is to be determined in compliance with Pt B, Ch 3, Sec 4, [2.1.1], using the values of draught T_1 given in Tab 2.

Table 2 : Draught T_1

Load case	Loading condition	T_1	
		River counter pressure	River design pressure
Working	**1R** and **Nonhomload**	0,20D	T
	2R	0,575T	0,575T
Navigation	Full load	T	T
	Lightship	0,20D	0,20D

6.1.2 River wave pressure

The river wave pressure is to be obtained from Pt B, Ch 3, Sec 4, [2.1.2].

6.2 Internal pressure for hopper well

6.2.1 Still water pressure for hopper well

The still water pressure to be used in connection with the inertial pressure in [6.2.2] is to be obtained, in kN/m², from the following formula:

$p_S = g\ \delta_1\ d_D$, to be taken not less than 11,0

where:

δ_1 : Coefficient equal to:

$\delta_1 = \delta$ for $\delta < 1,4$

$\delta_1 = \delta + (1,4 - \delta) \sin^2\alpha$ for $\delta \geq 1,4$

d_D : Vertical distance, in m, from the calculation point to the highest weir level with the corresponding specific gravity of the mixture of sea water and spoil α : Angle, in degrees, between the horizontal plane and the surface of the hull structure to which the calculation point belongs.

6.2.2 Inertial pressure for hopper well

The inertial pressure is to be obtained from Tab 3.

Table 3 : Vessels for dredging activities Inertial pressure for hopper well

Ship condition	Load case	Inertial pressure p_W, in kN/m²
Upright condition	"a"	No inertial pressure
	"b"	$\gamma_{W2}\dfrac{p_S}{g}\sqrt{a_{X1}^2 + a_{Z1}^2}$
Inclined condition	"c" and "d"	$C_{FA}\gamma_{W2}\dfrac{p_S}{g}\sqrt{a_{Y2}^2 + a_{Z2}^2}$
Note 1: The accelerations a_{X1}, a_{Z1}, a_{Y2} and a_{Z2} are to be determined according to Pt B, Ch 3, Sec 3, [2.3], considering the ship in dredging situation, i.e. considering the draught equal to the dredging draught T_D.		

6.3 Hull girder loads for dredgers, hopper dredgers and hopper barges

6.3.1 The total vertical bending moments M_{TH} and M_{TS}, in kN·m, to be applied in navigation and working conditions are to be determined as specified in Tab 4.

Table 4 : Total vertical bending moments

Condition	In general	H.G.yielding & buckling and ultimate strength of stiffeners and stiffened panels
Hogging	$M_{TH} = M_H + \gamma_W\gamma_{W1} M_{WV}$	$M_{TH} = M_H + M_{WV}$
Sagging	$M_{TS} = M_S + \gamma_W \gamma_{W1}M_{WV}$	$M_{TS} = M_S + M_{WV}$

6.4 Hull girder loads for split hopper dredgers and split hopper barges

6.4.1 Application

The provisions in [6.4.2] to [6.4.6] apply.

6.4.2 General

Horizontal bending moments are to be calculated assuming that the hopper well is simply supported at each end.

The clearance between the two half-hulls is to be large enough not to be suppressed when the hopper well is full up.

However, the calculation of the horizontal moments is carried out assuming that both ends of the hopper well are partly clamped, on condition that at deck and bottom level chocks are provided forward and aft of the well so that:

- the clearance between the two half-hulls is nil
- the chocks are long enough to withstand the end moments due to the horizontal forces developed along the hopper well.

6.4.3 The total vertical bending moments M_{TH} and M_{TS}, in kN·m, to be applied on one half-hull in navigation and working conditions are to be determined as specified in Tab 5.

Table 5 : Total vertical bending moments applied on half-hulls

Condition	In general	H.G. yielding & buckling and ultimate strength of stiffeners and stiffened panels
Hogging	$M_{TH} = \dfrac{M_H + \gamma_W\gamma_{W1}M_{WV}}{2}$	$M_{TH} = \dfrac{M_H + M_{WV}}{2}$
Sagging	$M_{TS} = \dfrac{M_S + \gamma_W\gamma_{W1}M_{WV}}{2}$	$M_{TS} = \dfrac{M_S + M_{WV}}{2}$

6.4.4 Horizontal still water bending moments

The horizontal still water bending moment M_{SHH} to be applied on one half-hull in navigation and working conditions are to be obtained, in kN.m, from the formulae given in Tab 6, assuming that the hopper well is simply supported at each end.

If the hopper well may not be considered as simply supported at each end, the horizontal still water bending moments to be applied on one half-hull in navigation and working conditions are to be determined on a case-by-case basis.

Table 6 : Horizontal still water bending moment M_{SHH} applied on half-hulls

Hopper well mid-section	Hopper well ends
$-\left(\dfrac{1}{8} + \dfrac{c_1}{2\,\ell_p}\right) p\,\ell_p^2$	0
Note 1: Between hopper well mid-section and ends, the values of the horizontal still water bending moment are to be obtained by linear interpolation. **Note 2:** p : Load per metre, in kN/m, applied along the hopper well, defined in Tab 7 depending on the loading condition c_1 : Distance, in m, from deck hinges to ends of hopper well (see Fig 6).	

Figure 6 : Definitions of dimensions in hopper well area

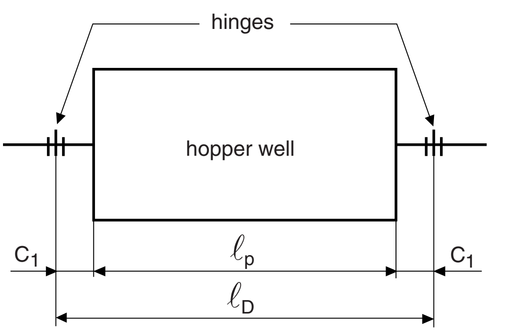


Table 7 : Load per metre applied along the hopper well

Loading condition	Load per metre p, in kN/m
Maximum loading at working draught	$4{,}9\ [\rho\ (h_0 - a)^2 - (T_D - a)^2]$
Service condition with well filled with water up to the waterline	0
Service condition with well filled with water up to the lowest weir level	$4{,}9\ [(h_4 - a)^2 - (T_4 - a)^2]$

Note 1:
h_4 : Distance, in m, from the lowest weir level to base line
T_4 : Navigation draught, in m, with well filled with water up to the lowest weir level
a, h_0, T_D : Distances, in m, defined in Fig 7.

6.4.5 Horizontal wave bending moments

The horizontal wave bending moment M_{WHH} to be applied on one half-hull in navigation and working conditions are to be obtained, in kN.m, from the formulae given in Tab 8, assuming that the hopper well is simply supported at each end.

If the hopper well may not be considered as simply supported at each end, the horizontal still water bending moments to be applied on one half-hull in navigation and working conditions are to be determined on a case by case basis.

Figure 7 : Definitions of distances for calculation of the load applied along the hopper well

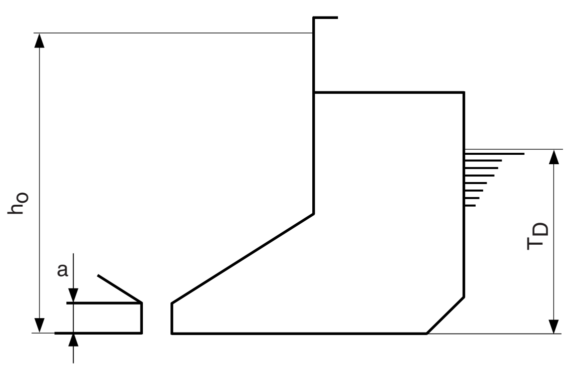


Table 8 : Horizontal wave bending moment M_{WHH} applied on half-hulls

Hopper well mid-section	Hopper well ends
Navigation: $\left[T_4 + 0,077C\left(2\frac{\ell_D}{L} - 1\right)(C_B + 0,7)\right]\frac{M_{WV}}{B}$	0
Working: $\left[T_D + 0,077C\left(2\frac{\ell_D}{L} - 1\right)(C_B + 0,7)\right]\frac{M_{WV}}{B}$	0

Note 1: Between hopper well mid-section and ends, the values of the horizontal wave bending moment is to be obtained by linear interpolation.
Note 2:
C_B : Block coefficient, defined in Pt B, Ch 1, Sec 2, [2]

6.4.6 Total horizontal bending moment

The total horizontal bending moment M_{HH} applied on half-hull at hopper well mid-section and at hopper well ends, in navigation and working conditions, is to be obtained, in kN.m, from the following formulae:

- in general:

  $M_{HH} = M_{SHH} + \gamma_W\ \gamma_{W1} M_{WHH}$

- for hull girder yielding check according to Pt B, Ch 4, Sec 1, [4] and buckling and ultimate strength of stiffeners and stiffened panels according to Pt B, Ch 2, Sec 7:

  $M_{HH} = M_{SHH} + M_{WHH}$

where:

M_{SHH} : Horizontal still water bending moment, defined in [6.4.4] at hopper well mid-section and at hopper well ends, in navigation and working conditions

M_{WHH} : Horizontal wave bending moment, defined in [6.4.5] at hopper well mid-section and at hopper well ends, in navigation and working conditions

7 Hull girder strength of dredgers, hopper dredgers and hopper barges

7.1 General

7.1.1 The hull girder strength is to be checked for the navigation and working conditions according to the criteria of Pt B, Ch 4, Sec 2.

7.2 Midship section modulus

7.2.1 In the determination of the midship section modulus according to Pt B, Ch 4, Sec 1, account is to be taken of 85% and 100% effectiveness of the sectional area of the cellular keel.

However the 85% and 100% effectiveness of the sectional area of the cellular keel may be replaced by the actual effectiveness of the cellular keel determined by a three dimensional finite element analysis.

7.2.2 Where cut-outs in the side shell are needed to fit the suction pipe guides, a section modulus calculation not taking account of the side shell plating may be required by the Society on a case-by-case basis, if the structural continuity is not correctly achieved.

8 Hull girder strength of split hopper dredgers and split hopper barges

8.1 General

8.1.1 The yielding check is to be carried out for the navigation and working conditions according to [8.2] to [8.4], considering:

- each half-hull as being subjected to independent bending
- the deck hinges and the hydraulic jacks acting as supports at the ends of the hopper well.

Both the vertical bending moment and horizontal bending moment acting within the well area are to be taken into account.

8.1.2 The hull section modulus, considered with the two half-hulls connected, is to be checked for the navigation and working conditions according to the criteria of Pt B, Ch 4, Sec 2. See also [7.2] for the determination of the midship section modulus.

8.2 Definitions

8.2.1 Co-ordinate system

The hull girder strength is defined with reference to the following co-ordinate system, as shown in Fig 8.

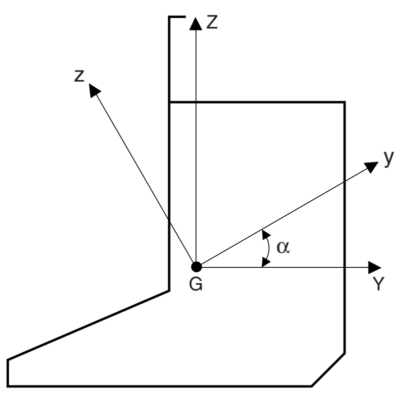
G : Centre of gravity of the transverse section

GY : Transverse axis, parallel to Y defined in Pt B, Ch 1, Sec 2, [3.1.1] and crossing through G

GZ : Vertical axis, parallel to Z defined in Pt B, Ch 1, Sec 2, [3.1.1] and crossing through G

Gy, Gz : Main axes of the transverse section, defined in [8.2.2].

Figure 8 : Half-hull co-ordinate system



8.2.2 Main axes

The main axes Gy and Gz are obtained from the axes GY and GZ by a rotation around the centre of gravity G of an angle α obtained from the following formula:

$$\alpha = \frac{1}{2}\operatorname{atan}\left(\frac{2 I_{YZ}}{I_Z - I_Y}\right)$$

where:

I_Y : Moment of inertia, in cm^4, of the transverse section around the axis GY

I_Z : Moment of inertia, in cm^4, of the transverse section around the axis GZ

I_{YZ} : Inertia product, in cm^4, of the transverse section, in the reference (G, GY, GZ).

8.2.3 Bending moments

The bending moments M_y and M_z in relation to the main axes Gy and Gz, respectively, are to be obtained, in kN.m, from the following formulae:

$$M_y = M_V \cos\alpha + M_{HH} \sin\alpha$$

$$M_z = -M_V \sin\alpha + M_{HH} \cos\alpha$$

where:

M_V : Vertical bending moment defined in [6.4.3], in kN.m, to be considered in hogging (M_{TH}) and sagging (M_{TS}) conditions, for the navigation and working conditions

M_{HH} : Horizontal bending moment defined in [6.4.6], in kN.m, to be considered for the navigation and working conditions

α : Angle defined in [8.2.2].

As the main inertia axes of each half-hull are oblique, the bending of each half-hull is a deviated bending.

8.3 Hull girder stress

8.3.1 At any point of the transverse section of each half-hull, the hull girder normal stresses are to be obtained, in N/mm^2, from the following formula:

$$\sigma_1 = \left(z\frac{M_y}{I_{yM}} - y\frac{M_z}{I_{zM}}\right)10^5$$

where:

M_y, M_z : Bending moments, in kN.m, in hogging and sagging conditions, for the navigation and working conditions, defined in [8.2.3]

I_{yM}, I_{zM} : Moments of inertia, in cm^4, of the transverse section around its main axes

y, z : Coordinates, in m, of the calculation point with respect to the main axes G_y and G_z.

8.3.2 In the case of partly clamped ends of the hopper well (see [6.4.2]), the hull girder normal stresses are to be calculated in the hopper well mid-section and at hopper well ends.

In this case, the stresses are also to be calculated in the midship area assuming the ends supported as regards the horizontal moment. This calculation relates to the beginning of the hopper well drainage by opening of the two half-hulls.

8.3.3 In the case of supports at hopper well ends, the calculation of the hull girder normal stress is to be carried out in the hopper well mid-section.

8.3.4 For each section of calculation, the most unfavourable combination of moments is to be considered.

8.4 Checking criteria

8.4.1 It is to be checked that the normal stresses calculated according to [8.3.1] are in compliance with the criteria of Pt B, Ch 4, Sec 2.

9 Hull scantlings

9.1 General

9.1.1 Hull scantlings are to be checked according to the applicable requirements of Ch 1, Sec 2 or Ch 1, Sec 8, as applicable, for the following two conditions:

- navigation condition
- working condition.

For vessels with one of the type and service notations **split hopper dredger** or **split hopper barge**, the hull girder normal stresses to be used are defined in [9.2].

9.2 Hull girder normal stress for split hopper dredgers and split hopper barges

9.2.1 Strength check of plating and yielding check of ordinary stiffeners and primary supporting members

The hull girder normal stress σ_{X1} to be considered for the strength check of plating, for the yielding check of ordinary stiffeners and for the yielding check of primary supporting members analysed through an isolated beam structural model is to be obtained, in N/mm^2, from Tab 9 (see [8.2] for the definitions).

Table 9 : Hull girder normal stress for hull scantlings

Structural element	Normal stress σ_{X1} , in N/mm^2
Plating and structural members contributing to the hull girder longitudinal strength	$\left(z\frac{M_y}{I_{yM}} - y\frac{M_z}{I_{zM}}\right)10^5$
Plating and structural members not contributing to the hull girder longitudinal strength	0

9.2.2 Buckling check of plating, ordinary stiffeners and primary supporting members

The hull girder normal stress σ_{X1} to be considered for the buckling check of plating, for the buckling check of ordinary stiffeners and for the buckling check of plate panels constituting primary supporting members is to be taken as the maximum compressive stress obtained according to [9.2.1].

9.3 Bottom plating

9.3.1 Where the bottom is longitudinally framed and the bilge is made of a transversely framed sloped plate, the bottom is to be assumed as being transversely framed when calculating the plating thickness.

9.3.2 The net thickness of the bottom strake, to which the longitudinal bulkheads of the hopper space are connected, is to be not less than the greater of the following thicknesses:

- bottom plating thickness increased by 15%
- keel thickness.

9.4 Well bulkhead and cellular keel platings

9.4.1 The net thickness of hopper well bulkhead plating and cellular keel plating is to be not less than the net thickness obtained:

- in the working condition, considering the internal pressures defined in [6.2]
- in the navigation condition, where the hopper well bulkheads limit tank compartments, considering the internal pressures defined in Pt B, Ch 3, Sec 4.

9.4.2 The net thickness of the longitudinal bulkhead above the deck or within 0,1 D below the deck is to be not less than the net thickness of the strength deck abreast of the hatchways.

9.4.3 The net thickness of the transverse and longitudinal bulkhead of a dredge pipe well is to be determined as for the side shell net thickness.

9.5 Transverse rings

9.5.1 The scantlings of transverse rings are to be obtained from a direct calculation, according to Pt B, Ch 2, Sec 5, taking into account the following:

- floors or bottom transverses are simply supported at ends
- local discontinuities in strength, due to the presence of wells, are to be considered.

9.5.2 The gusset stays for coamings are to have a section modulus at the lower end level not less than the one of the web frames or side transverses.

10 Additional checking for hopper dredgers and hopper barges

10.1 hopper well structure

10.1.1 The check of hopper well structure of hopper dredgers and hopper barges is to be carried out according to applicable Society's Rules.

11 Additional checking for split hopper dredgers and split hopper barges

11.1 Superstructure hinges

11.1.1 The check of superstructure hinges is to be carried out according to applicable Society's Rules.

11.2 Deck hinges, hydraulic jack connections and chocks

11.2.1 Arrangements and scantlings of the deck hinges and the hydraulic jack attachments connecting the two half-hulls are to be in compliance with applicable Society's Rules.

11.3 Hydraulic jacks and associated piping systems

11.3.1 Arrangements and checks of hydraulic jacks and associated piping systems are to be in compliance with applicable Society's Rules.

12 Rudders

12.1 General

12.1.1 The rudder stock diameter obtained from Pt B, Ch 7, Sec 1 is to be increased by 5%.

12.2 Additional requirements for split hopper dredgers and split hopper barges

12.2.1 Each half-hull of vessels with one of the type and service notations **split hopper barge** or **split hopper dredger** is to be fitted with a rudder complying with the requirements of Pt B, Ch 7, Sec 1.

12.2.2 An automatic system for synchronising the movement of both rudders is to be fitted.

SECTION 10 LAUNCHES

Symbols

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2]

t : Net thickness, in mm, of plating.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Launch**, as defined in Pt A, Ch 1, Sec 3, [6.1.1].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to launches.

2 Stability

2.1 General

2.1.1 Proof of sufficient intact stability according to Pt B, Ch 2, Sec 2 is to be furnished.

The Society may waive this requirement, depending on the vessel design and operating conditions.

3 Hull scantlings

3.1 General

3.1.1 The scantlings of the hull structure are to be determined in compliance with Part B, Chapter 5 and relevant Sections of Part B, Chapter 6, taking into account additional requirements defined in [3.2].

3.2 Additional requirements

3.2.1 Minimum net thickness of plating

The minimum thickness of the shell plating and deck plating are to be obtained from Tab 1.

3.2.2 Topside structure

The topside structure scantlings are to be determined according to Pt B, Ch 5, Sec 4, [3], where the minimum net thickness, in mm, is to be taken equal to $5(k_0k)^{0,5}$.

Table 1 : Minimum net thickness of plating

Plating	t, in mm
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	$t = 3,3 + 0,048\ L\ (k_0k)^{0,5}$
Keel plate	t = thickness of adjacent bottom plating

SECTION 11 PLEASURE VESSELS

Symbols

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2]

t : Net thickness, in mm, of plating.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the service notation **Pleasure vessel**, as defined in Pt A, Ch 1, Sec 3, [7.1.1].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to pleasure vessels.

2 Stability

2.1 General

2.1.1 Proof of sufficient intact stability according to Pt B, Ch 2, Sec 2 is to be furnished.

The Society may waive this requirement, depending on the vessel design and operating conditions.

3 Hull scantlings

3.1 General

3.1.1 The scantlings of the hull structure are to be determined in compliance with Part B, Chapter 5 and relevant Sections of Part B, Chapter 6, taking into account additional requirements defined in [3.2].

3.2 Additional requirements

3.2.1 Minimum net thickness of plating

The minimum thickness of the shell plating and deck plating are to be obtained from Tab 1.

3.2.2 Topside structure

The topside structure scantlings are to be determined according to Pt B, Ch 5, Sec 4, [3], where the minimum net thickness, in mm, is to be taken equal to $5(k_0k)^{0,5}$.

Table 1 : Minimum net thickness of plating

Plating	t, in mm
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	$t = 3,3 + 0,048\ L\ (k_0k)^{0,5}$
Keel plate	t = thickness of adjacent bottom plating

Part D
Additional Requirements for Notations

Chapter 2
ADDITIONAL CLASS NOTATIONS

SECTION 1	NAVIGATION IN ICE
SECTION 2	TRANSPORT OF HEAVY CARGOES
SECTION 3	EQUIPPED FOR TRANSPORT OF CONTAINERS
SECTION 4	EQUIPPED FOR TRANSPORT OF WHEELED VEHICLES
SECTION 5	FERRY
SECTION 6	DAMAGE STABILITY
SECTION 7	FIRE
SECTION 8	UNATTENDED MACHINERY SPACES (AUT-UMS)
SECTION 9	ANNUAL SURVEY
SECTION 10	GRABLOADING
SECTION 11	POLLUTION PREVENTION
SECTION 12	ESTUARY PLUS

SECTION 1 NAVIGATION IN ICE

Symbols

h : Height, in m, of load area defined in [2.5.4]

k : Material factor defined in:
- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:
- k_0= 1 for steel
- k_0= 2,35 for aluminium alloys

LWL : Lower waterline, defined in [1.3.2]

p : Design ice pressure, in N/mm², defined in [2.5.5]

R_{eH} :
- for hull structural steels:

  R_{eH} is the nominal yield point, in N/mm²
- for aluminium alloys:

  R_{eH} is the minimum specified yield stress of the parent model in welded condition $R'_{P0,2}$, in N/mm²

S : Spacing, in m, of primary supporting members

s : Spacing, in m, of ordinary stiffeners.

UWL : Upper waterline, defined in [1.3.1]

ℓ : Span, in m, of ordinary stiffeners or primary supporting members, as applicable

1 General

1.1 Application

1.1.1 The following additional class notations are assigned, in accordance with Pt A, Ch 1, Sec 3, [11.13] to vessels strengthened for navigation in ice and complying with the relevant requirements of this Section:

- **Ice**
- **Ice-30**
- **Ice-40**
- **Ice-40+**

1.1.2 The ice strengthening requirements for **Ice-40+** in this Section are equivalent to those corresponding to **ICE CLASS IC** in the "Finnish-Swedish Ice Class Rules 2010 as amended".

1.1.3 The ice strengthening requirements for **Ice-40** are those of the fore region, rudder and steering arrangements of the additional class notation **Ice-40+**.

1.1.4 The ice strengthening requirements for the additional class notations **Ice** and **Ice-30** cover vessels operated in drift ice of thickness not exceeding the values defined in Tab 1.

1.2 Owner's responsibility

1.2.1 It is the responsibility of the Owner to decide which ice class notation is the most suitable in relation to the expected service conditions of the vessel.

For vessels intended to operate under more severe ice conditions, the Society's Rules for navigation in ice for seagoing vessels must be applied for the corresponding/required ice class.

These Rules are not applicable to vessels intended for ice breaking.

1.3 Definitions

1.3.1 Upper waterline

The upper waterline (UWL) is the highest waterline at which the vessel is intended to operate in ice. The line may be a broken line.

1.3.2 Lower waterline

The lower waterline (LWL) is the lowest waterline at which the vessel is intended to operate in ice.

1.3.3 Ice belt

The ice belt is that portion of the side shell which is to be strengthened. Its vertical extension is equal to the required extension of strengthenings. See Tab 2.

1.4 Draught limitations in ice

1.4.1 Maximum draught

The draught and trim limited by the UWL are not to be exceeded when the vessel is navigating in ice.

1.4.2 Minimum draught

The vessel is always to be loaded down to at least the LWL when navigating in ice. Any ballast tank situated above the LWL and needed to load down the vessel to this water line is to be equipped with devices to prevent the water from freezing.

1.4.3 Minimum forward draught

In determining the LWL, due regard is to be paid to the need to ensure a reasonable degree of ice going capability in ballast condition. The propeller is to be fully submerged, if possible entirely below the ice.

1.5 Documentation to be submitted

1.5.1 The plans relevant to the shell expansion and fore and aft part structures are to define, at midship, fore and aft ends, the upper waterline (UWL) and the lower waterline (LWL). The borderlines of fore, midship and aft regions, according to [2.2], are also to be defined on the shell expansion plans.

1.6 Ice thickness

1.6.1 Height of the ice load area

a) An ice strengthened vessel is assumed to operate in conditions corresponding to an ice level with a thickness not exceeding the value h_G .

b) The design height of the area actually under ice pressure at any time is, however, assumed to be only a fraction h, of the ice thickness h_G .

c) The values for h_G and h, in m, are given in Tab 1.

Table 1 : Ice load height

Additional class notation	h_G , in m	h, in m
Ice	0,2	0,075
Ice-30	0,3	0,10
Ice-40 **Ice-40+**	0,4	0,22

1.7 Output of propulsion machinery

1.7.1 For vessels assigned **Ice-40+**, the engine output is to be not less than that determined according to NR467, Pt F, Ch 8, Sec 1, [3.1.3].

2 Hull

2.1 Ice strengthened area vertical extension

2.1.1 The ice strengthened area extends:

- for plating: as defined in Tab 2
- for ordinary stiffeners and primary supporting members: from the deck down to the bilge turn.

Table 2 : Vertical extension of ice strengthened area for plating

Additional class notation	above UWL	below LWL
Ice **Ice-30**	0,3 m	0,3 m
Ice-40 **Ice-40+**	0,4 m	0,5 m

2.2 Ice strengthened area and regions

2.2.1 General

The ice strengthened area defined in [2.1.1] is divided into three regions defined in [2.2.2], [2.2.3] and [2.2.4] (see Fig 1).

2.2.2 Fore region

The fore region is the region from the stem to a line parallel to and 0,04 L aft of the forward borderline of the part of the hull where the waterlines run parallel to the centreline.

The overlap with the borderline need not exceed 5 m.

2.2.3 Midship region

The midship region is the region from the aft boundary of the fore region to a line parallel to and 0,04 L aft of the aft borderline of the part of the hull where the waterlines run parallel to the centreline.

The overlap with the borderline need not exceed 5 m.

2.2.4 Aft region

The aft region is the region from the aft boundary of the midship region to the stern.

2.3 General framing arrangement

2.3.1 The frame spacings and spans in this Section are normally assumed to be measured along the plate and perpendicular to the axis of the stiffener for plates, along the flange for members with a flange, and along the free edge for flat bar stiffeners. For curved members the span (or spacing) is defined as the chord length between span (or spacing) points. The span points are defined by the intersection between the flange or upper edge of the member and the supporting structural element (stringer, web frame, deck or bulkhead).

2.3.2 The effective breadth of the attached plate to be used for calculating the combined section modulus of the stiffener, stringer and web frame and attached plate is to be taken as specified in Pt B, Ch 2, Sec 4.

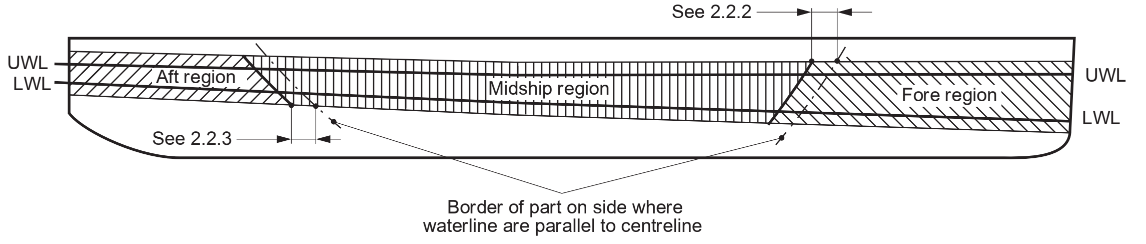
2.3.3 The requirements for the section modulus and shear area of the ordinary stiffeners and the primary supporting members in [2.6] are with respect to effective member cross section. For such cases where the member is not normal to the plating, the section properties are to be adjusted in accordance with Pt B, Ch 2, Sec 4, [3.1.1].

2.3.4 Within the ice-strengthened area defined in [2.1.1], all ordinary stiffeners are to be effectively attached to all the supporting structures. A longitudinal ordinary stiffener is to be attached to all the supporting web frames and bulkheads by brackets. When a transverse ordinary stiffener terminates at a stringer or a deck, a bracket or a similar construction is to be fitted. Brackets are to have at least the same thickness as the web plate of the ordinary stiffener and the edge is to be appropriately stiffened against buckling.

When an ordinary stiffener is running through the supporting structure, both sides of the web plate of the ordinary stiffener are to be connected to the structure (by direct welding or collar plate, see example in Fig 2).

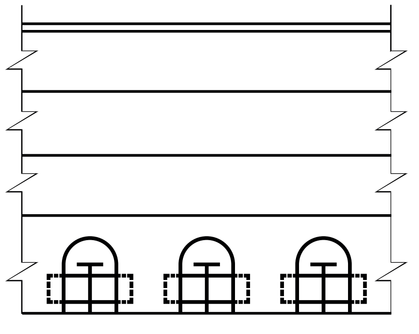
2.3.5 For the fore region of ice strengthened area of vessels with additional class notations **Ice-40** and **Ice-40+**, the following requirements are to be complied with:

Figure 1 : Ice strengthened area and regions



- ordinary stiffeners are to be attached to the shell by double continuous welds; no scalloping is allowed (except when crossing shell plate butts).
- the web thickness of the ordinary stiffeners are to be at least half that of the shell plating; where there is a deck, tank top or bulkhead in lieu of an ordinary stiffener the plate thickness is to be as above, to a depth corresponding to the height of adjacent ordinary stiffeners.
- frames that are not normal to the plating or the profile is unsymmetrical, and the span exceeds 4,0 m, are to be supported against tripping by brackets, intercostals, stringers or similar at a distance not exceeding 1,3 m. If the span is less than 4,0 m, the supports against tripping are required for unsymmetrical profiles and stiffeners the web of which is not normal to plating.

Figure 2 : End connection of ordinary stiffener Two collar plates



2.4 Transverse framing arrangement

2.4.1 Upper end of transverse framing

Upper end of the strengthened part of a main ordinary stiffener and an intermediate ice ordinary stiffener is to be attached to a deck or to an ice side girder, as required in [2.6.6].

Where an intermediate ordinary stiffener terminates above a deck or an ice side girder which is situated at or above the upper limit of the ice strengthened area, the part above the deck or side girder may have the scantlings required for an unstrengthened vessel and the upper end may be connected to the adjacent main ordinary stiffeners by an horizontal member of the same scantlings as the main ordinary stiffener.

2.4.2 Lower end of transverse framing

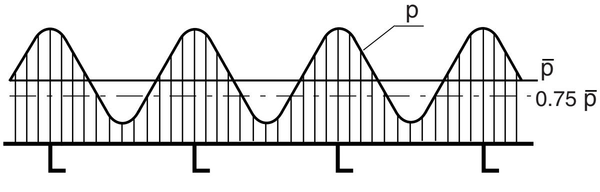
The lower end of the strengthened part of a main ordinary stiffener and intermediate ice ordinary stiffener is to be attached to a tank top or an ice side girder as required in [2.6.6].

Where an intermediate ordinary stiffener terminates below a tank top or an ice side girder which is situated at or below the lower limit of the ice strengthened area, the lower end may be connected to the adjacent main ordinary stiffeners by an horizontal member of the same scantlings as the ordinary stiffeners.

2.5 Design loads

2.5.1 Because of the different flexural stiffness of plating, ordinary stiffeners and primary supporting members, the ice load distribution is to be assumed to be as shown in Fig 3.

Figure 3 : Ice load distribution on vessel side



2.5.2 The formulae and values given in this Section may be substituted by direct analysis if they are deemed by the Society to be invalid or inapplicable for a given structural arrangement or detail. Otherwise, direct analysis is not to be utilized as an alternative to the analytical procedures prescribed by explicit requirements.

Direct analyses are to be carried out using the load patch (p, h and ℓ_a). The pressure to be used is 1,8p. The load patch is to be applied at locations where the capacity of the structure under the combined effects of bending and shear are minimized. In particular, the structure is to be checked with load centred at the UIWL, 0,5 h_i below the LIWL, and positioned several vertical locations in between. Several horizontal locations are also to be checked, especially the locations centred at the mid-span or mid-spacing. Further, if the load length ℓ_a cannot be determined directly from the arrangement of the structure, several values of ℓ_a are to be checked using corresponding values for c_a.

Acceptance criterion for designs is that the combined stresses from bending and shear, using the von Mises yield criterion, are lower than the yield point R_{eH}. When the direct calculation is using beam theory, the allowable shear stress is not to be larger than 0,9 τ_Y, where:

$$\tau_Y = \frac{R_{eH}}{\sqrt{3}}$$

2.5.3 If scantlings obtained from the requirements of this Article are less than those required for the unstrengthened vessel, the latter are to be used.

2.5.4 Height of load area

The height of the area under ice pressure at any particular point of time is to be obtained, in m, from Tab 3 depending on the additional class notation assigned to the vessel.

2.5.5 Design ice pressure

The value of the design ice pressure p, in N/mm², to be considered for the scantlings check, is obtained from the following formula:

$p = c_d \, c_P \, c_a \, p_0$

where:

c_d : Coefficient taking account of the influence of the size and engine output of the vessel, to be obtained from the following formula:

$$c_d = \frac{a\, f + b}{1000}$$

a, b : Coefficients defined in Tab 4

f : Coefficient to be obtained from the following formula:

$$f = \frac{\sqrt{\Delta\, P}}{1000}$$

Δ : Displacement, in t, at the maximum draught

P : Actual continuous output of propulsion machinery, in kW

c_P : Coefficient taking account of the probability of the design ice pressure occurring in a particular region of the hull for the additional class notation considered, defined in Tab 5

Table 3 : Height of load area

Additional class notation	h, in m
Ice	0,075
Ice-30	0,100
Ice-40 **Ice-40+**	0,220

Table 4 : Coefficients a and b

Region	a	b
Fore	30	230
Midship and aft	8	214

Table 5 : Coefficient c_P

Region	Additional class notation	
	Ice, **Ice-30**, **Ice-40**	**Ice-40+**
Fore	1,00	1,00
Midship	NA	0,50
Aft	NA	0,25

Table 6 : Distance ℓ_a

Structure	Type of framing	ℓ_a
Shell plating	transverse	1 spacing of ordinary stiffeners
	longitudinal	1,7 spacings of ordinary stiffeners
Ordinary stiffeners	transverse	1 spacing of ordinary stiffeners
	longitudinal	1 span of ordinary stiffeners
Vertical primary supporting members		2 spacings of vertical primary supporting members
Ice side girders		1 span of side girders

c_a : Coefficient taking account of the probability that the full length of the area under consideration will be under pressure at the same time, to be obtained from the following formula:

$$c_a = \sqrt{\frac{0,6}{\ell_a}}$$

without being taken less than 0,35 nor greater than 1,0

ℓ_a : Distance, in m, defined in Tab 6

p_0 : Nominal ice pressure, in N/mm², to be taken equal to 5,6.

2.6 Hull scantlings

2.6.1 Plating scantling - general

The plating thickness is to be strengthened according to [2.6.2] within the strengthened area for plating defined in [2.1.1].

2.6.2 Plating thickness in the ice strengthened area

The gross thickness of the shell plating is to be not less than the value obtained, in mm, from the following formulae:

- for transverse framing:

$$t = 667 s \sqrt{\frac{F_1 p_{PL}}{R_{eH}}} + t_c$$

- for longitudinal framing:

$$t = 667 s \sqrt{\frac{p_{PL}}{F_2 R_{eH}}} + t_c$$

where:

p_{PL} : Ice pressure on the shell plating to be obtained, in N/mm², from the following formula:

$p_{PL} = 0,75\, p$

F_1 : Coefficient to be obtained from the following formula:

$$F_1 = 1,3 - \frac{4,2}{\left[\frac{h}{s} + 1,8\right]^2}$$

without being taken greater than1,0

F_2 : Coefficient to be obtained from the following formula:

$$F_2 = 0,6 + 0,4\frac{s}{h}$$

t_C : Abrasion and corrosion addition, in mm, to be taken equal to 4 mm.

- 2 mm for steel
- 4 mm for aluyminium alloys

Where a special surface coating, by experience shown capable to withstand the abrasion of ice, is applied, a lower value of t_C may be accepted by the Society on a case by case basis.

2.6.3 Ordinary stiffeners scantling - general

Ordinary stiffeners are to be strengthened according to [2.6.4] and [2.6.5] within the strengthened area for ordinary stiffeners defined in [2.1.1].

2.6.4 Scantlings of transverse ordinary stiffeners

The gross section modulus w, in cm³ and the gross effective shear area A_{sh}, in cm², of transverse ordinary stiffeners are to be not less than the values obtained from the following formulae:

$$w = \frac{7 - 5(h/\ell)}{7m_0} \cdot \frac{psh\ell}{R_{eH}} \cdot 10^6$$

$$A_{sh} = \frac{\sqrt{3}F_3phs}{2R_{eH}} 10^4$$

where:

F_3 : Coefficient taking account of the maximum shear force versus the load location and the shear stress distribution, and to be taken equal to 1,20

m_0 : Coefficient defined in Tab 7.

2.6.5 Scantlings of longitudinal ordinary stiffeners

The gross section modulus w, in cm³ and the gross effective shear area A_{Sh} , in cm², of longitudinal ordinary stiffeners with or without brackets are to be not less than the values obtained from the following formulae:

$$w = \frac{F_4ph\ell^2}{m_1R_{eH}} 10^6$$

$$A_{Sh} = \frac{\sqrt{3}F_4F_5ph\ell}{2R_{eH}} 10^4$$

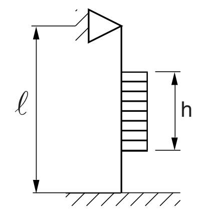
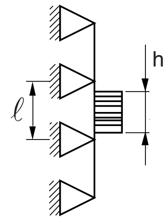
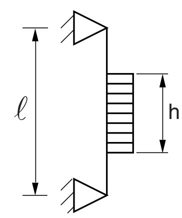
where:

F_4 : Coefficient taking account of the load distribution on adjacent ordinary stiffeners and to be obtained from the following formula:

$$F_4 = 1 - 0{,}2\frac{h}{s}$$

F_5 : Coefficient taking account of the pressure definition and maximum shear force versus load location and also shear stress distribution, and to be taken equal to 2,16

Table 7 : Coefficient m_0

Boundary condition	Example	m_0
Type 1 	Ordinary stiffeners extending from the tank top to a single deck	6,0
Type 2 	Continuous ordinary stiffeners between several decks or side girders	5,7
Type 3 	Ordinary stiffeners extending between two decks only	5,0
Note 1: The boundary conditions are those for the main and intermediate ordinary stiffeners. **Note 2:** Load is applied at mid-span.		

m_1 : Boundary condition coefficient for the ordinary stiffener considered, to be taken equal to 13,3 for a continuous beam. Where the boundary conditions deviate significantly from those of a continuous beam, e.g. in an end field, a smaller value of m_1 may be required. In such a case, for ordinary stiffeners without brackets, m_1 = 11,0 is to be used.

Note 1: In calculating the actual shear area of longitudinal ordinary stiffeners, the area of the brackets is not to be taken into account.

2.6.6 Ice stringers

The section modulus w, in cm³ and the effective section area A_{Sh} , in cm², of a stringer located within the ice strengthened area defined in [2.1.1] are to be not less than the values obtained from the following formulae:

$$w = \frac{F_6F_7ph\ell^2}{m_SR_{eH}} 10^6$$

$$A_{Sh} = \frac{\sqrt{3}F_6F_7F_8ph\ell}{2R_{eH}} 10^4$$

where:

h : Height, in m, of load area defined in [2.5.4], without the product p·h being taken less than 0,15

m_S : Boundary condition coefficient for the ordinary stiffener considered, to be taken equal to 13,3 for a continuous beam. Where the boundary conditions deviate significantly from those of a continuous beam, e.g. in an end field, a smaller value of m_S may be required. In such a case, for girders without brackets, m_S = 11,0 is to be used

F_6 : Factor taking account of the distribution of load to the transverse frames:

- F_6 = 0,90 for ice stringers within the ice strengthened area
- $F_6 = 0{,}80\ (1 - h_S / \ell_S)$ for ice stringers outside the ice strengthened area

F_7 : Factor taking account of the design point of girders and to be taken equal to 1,8

F_8 : Factor taking account of the maximum shear force versus load location and the shear stress distribution, and to be taken equal to 1,20

h_S : Distance to the ice strengthened area, in m

ℓ_S : Distance to the adjacent ice stringer, in m.

2.6.7 Vertical primary supporting member checked through simplified model

For vertical primary supporting members which may be represented by the structure model represented in Fig 4, the gross section modulus w, in cm^3, and the gross effective shear area A_{Sh} , in cm^2, are to be not less than the values obtained from the following formulae:

$$w = \frac{M}{R_{eH}}\left(\frac{1}{1-(\nu A_{Sh1}/A_a)^2}\right)^{\frac{1}{2}} 10^3$$

$$A_{Sh} = 10\frac{\sqrt{3}F_9\alpha Q}{R_{eH}}$$

where:

M : Maximum calculated shear force under the ice load, to be taken equal to:

$M = 0{,}193\ F\ \ell$

F : Load transferred to a vertical primary supporting member from a stringer or from longitudinal ordinary stiffeners, to be obtained, in kN, from the following formula:

$F = F_{10}\ p\ h\ s\ 10^3$

F_{10} : Factor taking account of the design point of girders:

- F_{10} = 1,80 for vertical primary supporting members within the ice belt
- $F_{10} = 1{,}80\ (1 - h_S / \ell_S)$ for vertical primary supporting members outside the ice belt, where:

  h_S , ℓ_S : o be taken as defined in [2.6.6]

Q : Maximum calculated shear force under the ice load F

F_9 : Factor taking account of the shear force distribution and to be taken equal to 1,1

ν, α : Coefficients defined in Tab 8

p : Design ice pressure, in N/mm^2, defined in [2.5.5], where the value of c_a is to be calculated assuming ℓ_a equal to 2 S

S : Distance between web frames, in m

h : Height, in m, of load area defined in [2.5.4], without the product p·h being taken less than 0,15

A_{Sh1} : Required shear area, in cm^2

A_a : Actual cross-sectional area, in cm^2, of the vertical primary supporting member, to be taken equal to $A_F + A_W$.

Figure 4 : Reference structure model

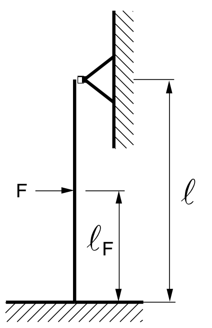


Table 8 : Coefficients α and ν

A_F/A_W	α	ν
0,20	1,23	0,44
0,40	1,16	0,62
0,60	1,11	0,71
0,80	1,09	0,76
1,00	1,07	0,80
1,20	1,06	0,83
1,40	1,05	0,85
1,60	1,05	0,87
1,80	1,04	0,88
2,00	1,04	0,89

Note 1:
A_F : Cross-sectional area of the face plate
A_W : Cross-sectional area of the web.

2.7 Fore part

2.7.1 Stem

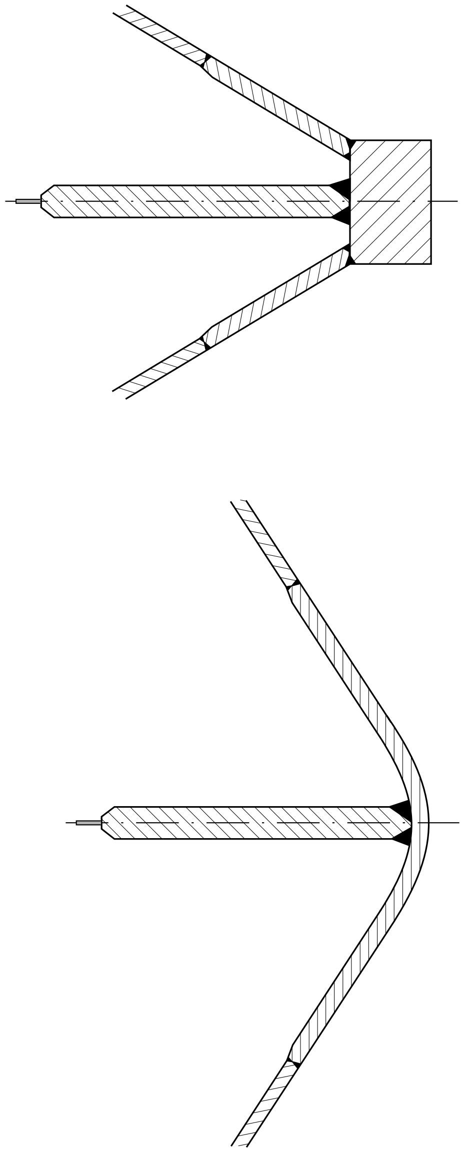
The stem may be made of rolled, cast or forged steel (bar stem) or of shaped steel plates (see Fig 5).

A sharp edged stem improves the manoeuvrability of the vessel in ice.

The plate thickness of a shaped plate stem, is to be not less than that calculated in [2.6.2] assuming that:

- s is the spacing of elements supporting the plate, in m
- p_{PL}, in N/mm^2, is to be taken equal to p, defined in [2.5.5], with ℓ_a being the spacing of vertical supporting elements, in m.

Figure 5 : Example of suitable stems



The horizontal diaphragms foreseen in Pt B, Ch 6, Sec 1, [7.2.3] are to have a reduced spacing not exceeding 0,5m. Their thickness is not to be less than 2/3 of the stem plate thickness.

A centreline web is to be provided from the forefoot to a horizontal diaphragm located at least 0,5m above the load waterline. Its thickness and depth are not to be, respectively, less than 0,67 t and 10 t, t being the stem plate thickness.

2.7.2 Bar stem

The gross sectional area, in cm², of the bar stem, where fitted, is to be not less than:

$A = 1,6\ f\ k_0\ k\ (0,006\ L^2 + 12)$

where:

- $f = 1,0$ for **IN(1,2 < x ≤ 2)**
- $f = 0,9$ for **IN(x ≤ 1,2)**
- $f = 0,8$ for **IN**

The gross thickness, in mm, is not to be less than:

$t = 1,25\ (0,33\ L\ (k_0 k)^{0,5} + 10)$

2.8 Aft part

2.8.1 An extremely narrow clearance between the propeller blade tip and the sternframe is to be avoided so as not to generate very high loads on the blade tip.

2.8.2 Shafting and stern tubes of side propellers, in general, are to be enclosed within plated bossings. If detached struts are used, their design, strength and attachment to the hull are to be examined by the Society on a case by case basis.

2.8.3 Stern frame

The section modulus of the stern sole piece is not to be less than 1,25 times the rule value laid down in Pt B, Ch 7, Sec 1, [7.2].

2.9 Side scuttles and freeing ports

2.9.1 Sidescuttles are to be not located in the ice strengthened area.

Special consideration is to be given to the design of the freeing ports.

3 Hull outfitting

3.1 Rudders and steering arrangements

3.1.1 The scantlings of rudder post, rudder stock, pintles, steering gear, etc. as well as the capacity of the steering gear are to be determined according to Pt B, Ch 7, Sec 1, taking the coefficient r_2, defined in Pt B, Ch 7, Sec 1, [2.1.2], equal to 1,10 independently of the rudder profile type.

The maximum ahead service speed of the vessel to be used in these calculations, however, is to be not taken less than that stated in Tab 9.

Where the actual maximum ahead service speed of the vessel is higher than that stated in Tab 9, the higher speed is to be used.

Within the ice strengthened zone, the thickness of rudder plating and diaphragms is to not less than that required for the shell plating of the aft region, i.e., according to [2.6], with $C_P = 0,25$.

Table 9 : Maximum ahead service speed

Notation	Maximum ahead service speed (km/h)
Ice	20
Ice-30	22
Ice-40 **Ice-40+**	26

4 Propulsion

4.1 General

4.1.1 Application

The requirements developed in [4.2] to [4.4] apply to the propulsion machinery of vessels assigned one of the following additional class notations:

- **Ice**
- **Ice-30**
- **Ice-40**

4.1.2 Propulsion machinery requirements for vessels with notation Ice-40+

Regarding the propulsion machinery, vessels assigned the additional class notation **Ice-40+**, are to comply with the applicable ice class **IC** requirements of NR467, Pt E, Ch 8, Sec 3, [1].

4.2 Ice torque

4.2.1 For the scantlings of propellers and shafting, the effect of the impact of the propeller blades against ice is also to be taken into account.

The ensuing torque, hereinafter defined as ice torque, shall be taken equal to the value M_G, in N m, calculated by the following formula:

$$M_G = m\,D^2$$

where:

m : Coefficient whose value is given in Tab 10, depending upon the class notation requested

D : Propeller diameter, in m.

In the cases of propellers with nozzles or of considerably submerged propellers, the value of the ice torque may be taken equal to that corresponding to the ice class notation next lower than that requested for the vessel, at the discretion of the Society.

Table 10 : Variables m and x

Ice class notation	**Ice**	**Ice-30**	**Ice-40**
m	1500	2500	10000
x	12	13	15

4.3 Propellers

4.3.1 Material

The elongation after fracture, measured with a proportional type tensile specimen, of the material used for propellers, is not to be less than 19%. Materials other than copper alloys are to be Charpy V-notch impact tested at a temperature of – 10°C with a minimum average energy not less than 20 J.

4.3.2 Scantlings

The width l and the maximum thickness t of the cylindrical sections of the propeller blades are to be such as to satisfy the conditions stated in items a), b) and c):

a) CYLINDRICAL SECTIONS AT THE RADIUS OF 0,125 D for fixed pitch propellers:

$$l \cdot t^2 \geq \frac{26,5}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,24 M_G\right)$$

b) CYLINDRICAL SECTIONS AT THE RADIUS OF 0,175 D for controllable pitch propellers:

$$l \cdot t^2 \geq \frac{21,1}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,35 M_G\right)$$

c) CYLINDRICAL SECTIONS AT THE RADIUS OF 0,30 D both for fixed and controllable pitch propellers:

$$l \cdot t^2 \geq \frac{9,3}{R_m \cdot \left[0,65 + \left(\frac{0,7}{\rho}\right)\right]} \cdot \left(\frac{2,85 M_T}{z} + 2,83 M_G\right)$$

where:

l : Width of the expanded cylindrical section of the blade at the radius in question, in cm

t : Corresponding maximum blade thickness, in cm

$\rho = D / H$

D : Propeller diameter, in m

H : Blade pitch of propeller, in m, to be taken equal to:

- the pitch at the radius considered, for fixed pitch propellers
- 70% of the nominal pitch, for controllable pitch propellers

P : Maximum continuous power of propulsion machinery for which the classification has been requested, in kW

n : Speed of rotation of propeller, in rev/min, corresponding to the power P

M_T : Value, in N·m, of torque corresponding to the above power P and speed n, calculated as follows:

$$M_T = 9550 \cdot \frac{P}{n}$$

z : Number of propeller blades

M_G : Value, in N·m, of the ice torque, calculated according to the formula given in [4.2]

R_m : Value, in N/mm², of the minimum tensile strength of the blade material.

4.3.3 Minimum thickness of blades

When the blade thicknesses, calculated by the formulae given in Pt C, Ch 1, Sec 8, [2.2.1] and Pt C, Ch 1, Sec 8, [2.3.1], are higher than those calculated on the basis of the formulae given in [4.3.2], the higher values are to be taken as rule blade thickness.

4.3.4 Minimum thickness at top of blade

The maximum thickness of the cylindrical blade section at the radius 0,475 D is not to be less than the value t_1, in mm, obtained by the following formula:

$$t_1 = (x + 2D) \cdot \left(\frac{490}{R_m}\right)^{0,5}$$

where:

x : Variable defined in Tab 10.

4.3.5 Blade thickness at intermediate sections

The thickness of the other sections of the blade shall be determined by means of a smooth curve connecting the points defined by the blade thicknesses calculated by the formulae given in [4.3.2] and [4.3.4].

4.3.6 Thickness of blade edge

The thickness of the whole blade edge, measured at a distance from the edge itself equal to 1,25 t_1 (t_1 being the blade thickness as calculated in [4.3.4]), is to be not less than 0,5 t_1.

For controllable pitch propellers, this requirement is applicable to the leading edge only.

4.3.7 Controllable pitch propellers actuating mechanism

The strength of the blade-actuating mechanism located inside the controllable pitch propeller hub is to be not less than x . 10^{-1} times that of the blade when a force is applied at the radius 0,45 D in the weakest direction of the blade, where x is defined in Tab 10.

4.4 Shafting

4.4.1 Propeller shaft

a) The diameter of the propeller shaft at its aft bearing is not to be less than the value d_P, in mm, calculated by the following formula:

$$d_P = K_E \cdot \left(\frac{W \cdot R_m}{R_{S,MIN}}\right)^{\frac{1}{3}}$$

where:

K_E : For propellers having hub diameter:

- not greater than 0,25 D: $K_E = 10,8$
- greater than 0,25 D: $K_E = 11,5$

W : Value, in cm^3, equal to $l \cdot t^2$, proposed for the section at the radius:

- 0,125 D for propellers having the hub diameter not greater than 0,25 D
- 0,175 D for propellers having the hub diameter greater than 0,25 D

R_m : Value, in N/mm^2, of the minimum tensile strength of the blade material

$R_{S,MIN}$: Value, in N/mm^2, of the minimum yield strength (R_{eH}) or 0,2% proof stress ($R_{p\ 0,2}$) of the propeller shaft material.

b) Where the diameter of the propeller shaft, as calculated by the formula given in Pt C, Ch 1, Sec 7, [2.2], is greater than that calculated according to the formula given in a) above, the former value is to be adopted.

c) Where a cone-shaped length is provided in the propeller shaft, it is to be designed and arranged in accordance with the applicable requirements of Pt C, Ch 1, Sec 7.

d) Propeller shafts are to be in steel having impact strength as specified in NR216 Materials and Welding.

5 Miscellaneous requirements

5.1 River water inlets and cooling water systems of machinery

5.1.1

a) The cooling water system is to be designed to ensure the supply of cooling water also when navigating in ice.

b) For this purpose, at least one river water inlet chest is to be arranged and constructed as indicated hereafter:

1) the river water inlet is to be situated near the centreline of the vessel and as aft as possible
2) the chest is to be sufficiently high to allow ice to accumulate above the inlet pipe
3) a pipe for discharging the cooling water, having the same diameter of the main overboard discharge line, is to be connected to the inlet chest
4) the area of the strum holes is to be not less than 4 times the inlet pipe sectional area.

c) Where there are difficulties in satisfying the requirements of b) 3) above, two smaller chests may be accepted, alternatively, provided that they are located and arranged as stated in the other provisions above.

d) Heating coils may be installed in the upper part of the chests.

e) Arrangements for using ballast water for cooling purposes may be accepted as a reserve in ballast conditions but are not acceptable as a substitute for the river inlet chests as described above.

5.2 Steering gear

5.2.1

a) Effective relief valves shall be provided to protect the steering gear against hydraulic overpressure.

b) The scantlings of steering gear components are to be such as to withstand the yield torque of the rudder stock.

c) Where possible, rudder stoppers working on the blade or rudder head are to be fitted.

5.3 Transverse thrusters

5.3.1 The tunnels of transverse thrusters are to be fitted with grids for protection against ice impacts.

SECTION 2 TRANSPORT OF HEAVY CARGOES

Symbols

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2]

t : Net thickness, in mm, of plating

s : Spacing, in m, of ordinary stiffeners

ℓ : Span, in m, of ordinary stiffeners or primary supporting members

k : Material factor defined in:

- Pt B, Ch 2, Sec 3, [2.3] for steel
- Pt B, Ch 2, Sec 3, [3.5] for aluminium alloys

k_0 : Coefficient to be taken equal to:

- $k_0 = 1$ for steel
- $k_0 = 2,35$ for aluminium alloys

1 All vessels

1.1 Application

1.1.1 The additional class notation **Heavycargo (AREAi, x_i kN/m²)**, is assigned, in accordance with Pt A, Ch 1, Sec 3, [11.11.1] to vessels intended to carry heavy unit cargoes.

1.1.2 Unless otherwise mentioned, these vessels are to comply, as applicable, with the requirements stated under Part A, Part B, Part C and Ch 1, Sec 1.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, the following information is to be submitted to the Society:

- unit cargo arrangement in holds, on decks and on hatch covers, indicating size and gross mass of cargoes
- drawings of load bearing structures indicating the design loads and including the connections to the hull structures and the associated structural reinforcements.

1.3 Design load

1.3.1 The value of design pressure p_S , in kN/m², is to be specified by the designer for each $area_i$, according to [1.1.1], and introduced as x_i values.

1.4 Hull scantlings

1.4.1 General

In general, the hull scantlings are to be not less than required in Part B, Chapter 5.

1.4.2 Primary supporting members

Strength check of primary supporting members is to be carried out by direct calculation, in compliance with Ch 1, Sec 4, [8].

2 Bulk cargo vessels

2.1 Application

2.1.1 The additional class notation **Heavycargo** is assigned, in accordance with Pt A, Ch 1, Sec 3, [11.11.1] to vessels with service notation **Bulk cargo vessel** intended to carry heavy bulk dry cargoes.

2.1.2 Unless otherwise mentioned, these vessels are to comply, as applicable, with the requirements stated under Part A, Part B, Part C and Ch 1, Sec 2.

2.2 Design loads

2.2.1 The still water bending moment and internal local loads are to be determined according to Pt B, Ch 3, Sec 2, [2.5] and Pt B, Ch 3, Sec 4, [3.2], respectively, where the cargo properties are not to be taken less than:

- cargo density, in t/m³:

  $\rho_B \geq 2,5$

- angle of repose of the bulk cargo:

  $\varphi_B \geq 35°$

2.3 Bottom or inner bottom plating thickness

2.3.1 The net thickness of bottom or inner bottom plating subjected to heavy bulk dry cargo, is to be determined according to Pt D, Ch 1, Sec 2, taking into account the additional requirement stated under [2.2.1].

This thickness, in mm, is not to be less than the value derived from the following formula:

$t_1 = 2\ L^{1/3}\ (k_0 k)^{0,5} + 3,6\ s$

SECTION 3 EQUIPPED FOR TRANSPORT OF CONTAINERS

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional class notation **Equipped for transport of containers**, as defined in Pt A, Ch 1, Sec 3, [11.6.1].

1.1.2 These vessels are to comply with the requirements stated under Part A, Part B, Part C and Ch 1, Sec 1, as far as applicable.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, the following information is to be submitted to the Society:

- container arrangement in holds, on decks and on hatch covers, indicating size and gross mass of containers
- drawings of load bearing structures indicating the design loads and including the connections to the hull structures and the associated structural reinforcements.

2 Structure arrangements

2.1 Strength principles

2.1.1 Local reinforcements

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

The forces applied on the fixed cargo securing devices are to be indicated by the Designer.

2.1.2 Structural continuity

For double hull vessels, the inner side is to extend as far aft as possible and be tapered at the ends.

2.2 Bottom structure

2.2.1 Floor and girder spacing

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

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

2.2.2 Strength continuity

Adequate strength continuity of floors and bottom transverses is to be ensured in way of the side tank by means of brackets.

2.2.3 Reinforcements in way of cell guides

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

2.3 Hatch covers carrying containers

2.3.1 Efficient retaining arrangements are to be provided to prevent translation of the hatch cover under the action of the longitudinal and transverse forces exerted by the stacks of containers on the cover. These retaining arrangements are to be located in way of the hatch coaming side brackets.

Solid fittings are to be welded on the hatch cover where the corners of the containers are resting. These parts are intended to transmit the loads of the container stacks onto the hatch cover on which they are resting and also to prevent horizontal translation of the stacks by means of special intermediate parts arranged between the supports of the corners and the container corners.

3 Design loads

3.1 Design torsional torque

3.1.1 Where no specific data are provided by the Designer, the design still water torsional torque induced by the non-uniform distribution of cargo, consumable liquids and ballast is to be obtained at the midship section, in kN.m, from the following formula:

$M_T = 31{,}4\ F_T\ n_S\ n_T\ B$

where:

F_T : Distribution factor defined in Tab 1 as a function of the x co-ordinate of the hull transverse section with respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2, [3]

n_S : Number of container stacks over the breadth B

n_T : Number of container tiers in cargo hold amidships (including containers on hatch covers).

Table 1 : Distribution factor F_T

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

3.2 Forces on containers

3.2.1 Still water and inertial forces

The force F_i applied to one container located at the level "i", as defined in Fig 2, is to be determined in compliance with Pt B, Ch 3, Sec 4, [3.4].

The mass m_i of the containers is to be defined by the Designer.

Where the mass of loaded containers is not known, the following values may be used:

- for 40 feet containers: m_i = 27 t
- for 20 feet containers: m_i = 17 t.

Where empty containers are stowed at the top of a stack, the following values may be used:

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

3.2.2 Wind forces applied to one container

The forces due to the effect of the wind, applied to one container stowed above deck at level i (see Fig 1), are to be obtained, in kN, from the following formulae:

- in x direction:

  $F_{X, WD, i} = p_{WD}\, h_C\, b_C$
- in y direction:

  $F_{Y, WD, i} = p_{WD}\, h_C\, \ell_C$

where:

h_C	:	Height, in m, of a container
ℓ_C, b_C	:	Dimension, in m, of the container stack in the vessel longitudinal and transverse directions, respectively
p_{WD}	:	Wind pressure, in kN/m^2, defined in Pt B, Ch 3, Sec 4, [2.1.3].

These forces are only acting on the stack exposed to wind.

In the case of M juxtaposed and connected stacks of the same height, the wind forces are to be distributed over the M stacks.

In the case of juxtaposed and connected stacks of different heights, the wind forces are to be distributed taking into account the number of stacks at the level considered (see example in Fig 4.

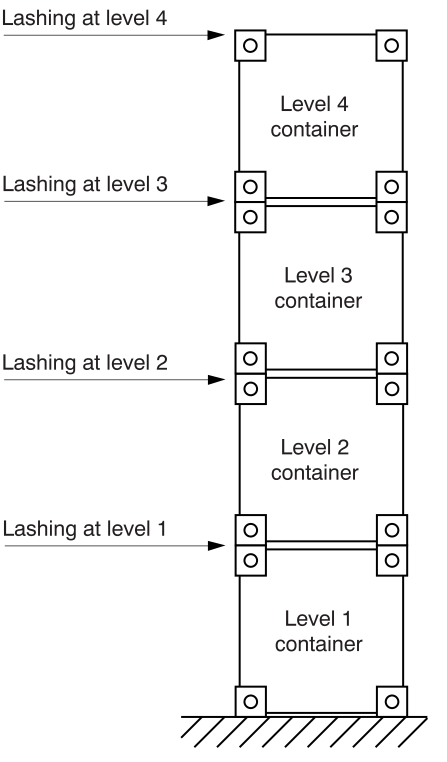
3.2.3 Stacks of containers

The still water, inertial and wind forces to be considered as being applied at the centre of gravity of the stack, and those transmitted at the corners of such stack is to be obtained, in kN, as specified in Tab 2.

3.2.4 Securing load

The scantling load of securing devices is to be determined assuming an angle of list of 12°.

Figure 1 : Containers level in a stack



4 Hull scantlings

4.1 General

4.1.1 In general, the hull scantlings are to be not less than required in Part B, Chapter 5.

4.1.2 Scantlings of structural members subjected to concentrated loads are to be determined by direct calculation according to Pt B, Ch 2, Sec 8, [2]**. In particular, the requirements of** [5] **are to be complied with.**

4.1.3 Where the operating conditions (loading / unloading sequence as well as consumable and ballast distribution) are likely to induce excessive torsional torque, the torsional strength is to be checked, using the design torsional torque derived from [3.1.1].

5 Direct calculation

5.1 General

5.1.1 These requirements apply to the grillage analysis of primary supporting members subjected to concentrated loads.

Direct calculation is to be carried out in compliance with Pt B, Ch 2, Sec 8, [2].

Table 2 : Containers - Still water, inertial and wind forces

Ship condition	Still water force F_S and inertial and wind force F_W, in kN, acting on each container stack	Vertical still water force R_S and inertial and wind force R_W, in kN, transmitted at the corners of each container stack
Still water condition	$F_S = \sum_{i=1}^{N} F_{S,i}$	$R_S = \frac{F_S}{4}$
Upright condition (see Fig 2)	• in x direction: $F_{W,X} = \sum_{i=1}^{N} (F_{W,X,i} + F_{X,WD,i})$ • in z direction: $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,X}}{4\ell_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,X}}{4\ell_C}$
Inclined condition (negative roll angle) (see Fig 3)	• in y direction: $F_{W,Y} = \sum_{i=1}^{N} (F_{W,Y,i} + F_{Y,WD,i})$ • in z direction: $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,Y}}{4b_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,Y}}{4b_C}$

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

Figure 2 : Inertial and wind forces Upright vessel condition

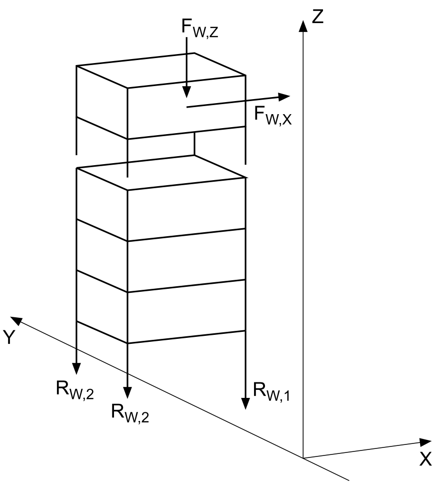


Figure 3 : Inertial and wind forces Inclined vessel condition

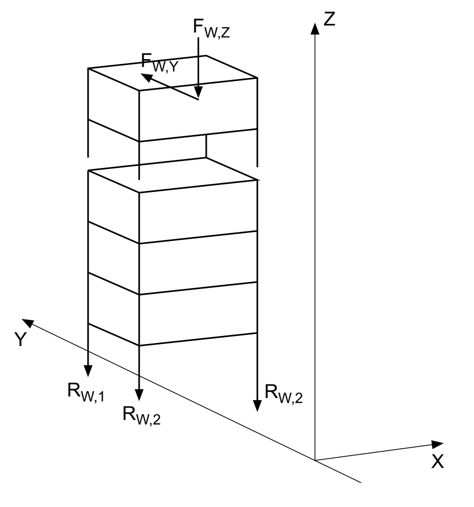
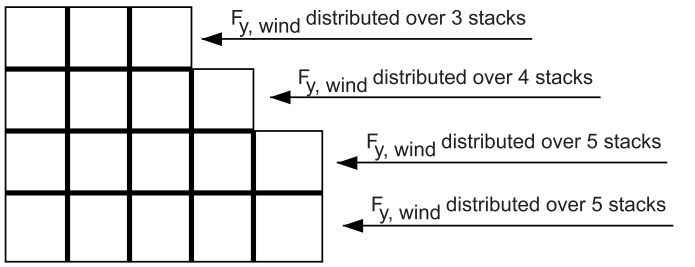


Figure 4 : Distribution of wind forces in the case of stacks of different heights



SECTION 4 EQUIPPED FOR TRANSPORT OF WHEELED VEHICLES

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional class notation **Equipped for transport of wheeled vehicles**, as defined in Pt A, Ch 1, Sec 3, [11.7.1].

1.1.2 These vessels are to comply with the requirements stated under Part A, Part B, Part C and Ch 1, Sec 1, as far as applicable.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, a wheeled vehicle arrangement plan including the following details:

- type of vehicles
- axle load
- configuration and number of wheels per axle
- distance between axles
- distance between wheels
- tyre print area,

is to be submitted to the Society.

2 Vessel arrangements

2.1 Sheathing

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

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

2.2 Hull structure

2.2.1 Framing

In general, RoRo cargo decks or platforms are to be longitudinally framed.

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

2.3 Drainage of cargo spaces, other than RoRo spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

2.3.1 Scupper draining

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

3 Scantlings

3.1 RoRo cargo spaces

3.1.1 Design loads

The wheeled loads induced by vehicles are defined in Pt B, Ch 3, Sec 4, [3.5].

3.1.2 The scantlings of RoRo cargo spaces are to be in compliance with Ch 1, Sec 5, [4].

3.2 Movable decks and inner ramps

3.2.1 The requirements applicable to movable decks and inner ramps are defined in Pt B, Ch 6, Sec 6, [1].

3.3 External ramps

3.3.1 The requirements applicable to external ramps are defined in Pt B, Ch 6, Sec 6, [2].

SECTION 5 FERRY

1 General

1.1 Application

1.1.1 Passenger vessels complying with the requirements of this Section are eligible for the assignment of the additional class notation **Ferry**, as defined in Pt A, Ch 1, Sec 3, [11.8].

1.1.2 These vessels are to comply with the requirements stated under Part A, Part B, Part C and Ch 1, Sec 6, as far as applicable.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt B, Ch 1, Sec 3, the following information is to be submitted:

a) Plans of ramps, elevators for cargo handling and movable decks, if any, including:
   - structural arrangements of ramps, elevators and movable decks with their masses
   - arrangements of securing and locking devices
   - connection of ramps, lifting and/or hoisting appliances to the hull structures, with indication of design loads (amplitude and direction)
   - wire ropes and hoisting devices in working and stowed position
   - hydraulic jacks
   - loose gear (blocks, shackles, etc.) indicating the safe working loads and the testing loads
   - test conditions

b) Plan of arrangement of motor vehicles, railway cars and/or other types of vehicles which are intended to be carried and indicating securing and load bearing arrangements

c) Characteristics of motor vehicles, railways cars and/or other types of vehicles which are intended to be carried: (as applicable) axle load, axle spacing, number of wheels per axle, wheel spacing, size of tyre print

d) Plan of dangerous areas, in the case of vessels intended for the carriage of motor vehicles with petrol in their tanks.

1.3 Definitions

1.3.1 RoRo spaces

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

1.3.2 Special category spaces

Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck.

2 Vessel arrangements

2.1 Sheathing

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

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

2.2 Hull structure

2.2.1 Framing

In general, car decks or platforms are to be longitudinally framed.

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

3 Scantlings

3.1 RoRo spaces

3.1.1 Design loads

The wheeled loads induced by vehicles are defined in Pt B, Ch 3, Sec 4, [3.5].

3.1.2 The scantlings of RoRo spaces are to be in compliance with Ch 1, Sec 5, [4].

3.2 Movable decks and inner ramps

3.2.1 The requirements applicable to movable decks and inner ramps are defined in Pt B, Ch 6, Sec 6, [1].

3.3 External ramps

3.3.1 The requirements applicable to external ramps are defined in Pt B, Ch 6, Sec 6, [2].

4 Protection of special category and RoRo spaces

4.1 Precaution against ignition of flammable vapours in closed RoRo spaces and special category spaces

4.1.1 Electrical installations

a) Installations in special category and closed RoRo spaces located above the bulkhead deck

On any deck or platform, if fitted, on which vehicles are carried and on which explosive vapours might be expected to accumulate, except for platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment and cables are to be installed at least 450 mm above the deck or platform.

Where the installation of electrical equipment and cables at less than 450 mm above the deck or platform is deemed necessary for the safe operation of the vessel, the electrical equipment is to be of a certified safe type as stated in Pt C, Ch 2, Sec 2, [5.2.3] and to have the minimum explosion group IIA and temperature class T3.

Electrical equipment is to be as stated in Pt C, Ch 2, Sec 2, [5.2.4].

b) Installations in special category and closed RoRo spaces located below the bulkhead deck

An electrical equipment installed is to be as stated in Pt C, Ch 2, Sec 2, [5.2.3] and to have the minimum explosion group IIA and temperature class T3.

c) Ventilation

Electrical equipment and cables in exhaust ventilation ducts are to be as stated in Pt C, Ch 2, Sec 2, [5.2.3] and to have the minimum explosion group IIA and temperature class T3.

4.1.2 Ventilation systems

There shall be provided an effective power ventilation system sufficient to give at least the following air changes:

- Special category spaces: 10 air changes per hour
- Closed RoRo spaces other than special category spaces: 10 air changes per hour.

4.1.3 Other ignition sources

Other equipment which may constitute a source of ignition of flammable vapours shall not be permitted.

4.1.4 Scuppers and discharges

Scuppers and discharges shall not be led to machinery or other spaces where sources of ignition may be present.

4.2 Detection and alarm

4.2.1 There shall be provided a fixed fire detection and fire alarm system complying with the requirements of Pt C, Ch 4, Sec 3. The fixed fire detection system shall be capable of rapidly detecting the onset of fire. The type of detectors and their spacing and location shall be to the satisfaction of the Society, taking into account the effects of ventilation and other relevant factors. After being installed, the system shall be tested under normal ventilation conditions and shall give an overall response time to the satisfaction of the Society.

Fire detectors are to be smoke detectors.

4.3 Structural protection

4.3.1 The boundary bulkheads and decks of special category spaces and RoRo spaces shall be insulated to A30 class standard. However, where:

- open deck space
- sanitary and similar space, or
- tanks, voids and auxiliary machinery spaces having little or no fire risk,

is on one side of the division, the standard may be reduced to A0.

Where fuel oil tanks are below a special category space or a RoRo space, the integrity of the deck between such spaces may be reduced to A0 standard.

4.4 Fire extinction

4.4.1 Fixed fire-extinguishing systems

RoRo spaces, which are not special category spaces and are capable of being sealed from a location outside of the cargo spaces, shall be fitted with a fixed gas fire-extinguishing system complying with the provisions of Pt C, Ch 4, Sec 4, [4].

RoRo spaces not capable of being sealed and special category spaces shall be fitted with a fixed water-based fire-fighting system complying with the provisions of NR467, Pt C, Ch 4, Sec 14, which shall protect all parts of any deck and vehicle platform in such spaces.

The Society may permit the use of any other fixed fire-extinguishing system that has been shown, by a full-scale test in conditions simulating a flowing petrol fire in a vehicle a RoRo space, to be not less effective in controlling fires likely to occur in such a space.

4.4.2 Portable fire extinguishers

Portable fire extinguishers shall be provided in compliance with Pt C, Ch 4, Sec 4, [2].

SECTION 6 DAMAGE STABILITY

Symbols

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

C_B : Block coefficient, defined in Pt B, Ch 1, Sec 2, [2]

D : Depth, in m, defined in Pt B, Ch 1, Sec 2, [2.3]

D_2 : Height of the double bottom, in m

KG : Height, in m, of the centre of gravity above base line

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.1]

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

L_{WL} : Length of waterline, in m, defined in Pt B, Ch 1, Sec 2, [2.6]

T : Scantling draught, in m, defined in Pt B, Ch 1, Sec 2, [2.4]

Δ : Displacement, in tons, at draught T

v : Maximum speed of the vessel in relation to the water, in km/h.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional class notation **Damage stability**, as defined in Pt A, Ch 1, Sec 3, [11.14].

1.1.2 The general requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

1.2 Documents to be submitted

1.2.1 The documents to be submitted are listed in Pt B, Ch 2, Sec 2, [2.1].

The Society may require any other necessary guidance for the safe operation of the vessel.

2 Cargo vessels

2.1 General

2.1.1 The requirements of this Article apply to the following dry cargo vessels:

- Bulk cargo vessels
- General cargo vessels
- RoRo cargo vessels.

2.2 Assumptions

2.2.1 The following assumptions shall be taken into consideration for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: $B_2 - 0{,}01$ m
   - vertical extent: from base line upwards without limit.

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to $D_2 - 0{,}01$ m, the sump excepted.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen so as to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

2.2.2 In general, permeability μ shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the values of permeability given in Tab 1 are the minimum values to be used.

For the main engine room only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Figure 1 : Proof of damage stability

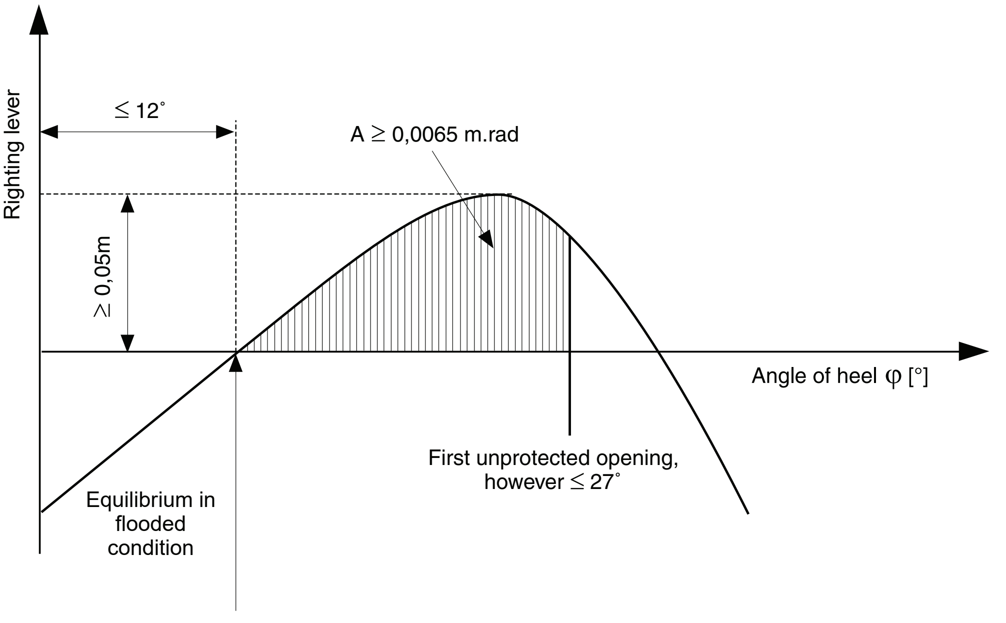


Table 1 : Minimum values of permeability

Spaces	μ, in %
Engine rooms	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

2.3 Damage stability criteria

2.3.1 The damage stability is generally regarded sufficient if (see Fig 1):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

  Non-weathertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.
- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m·rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.

2.3.2 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

2.3.3 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

3 Container vessels

3.1 General

3.1.1 The basic values for the stability calculation - the vessel's lightweight and location of the centre of gravity - shall be determined:

- either by means of an heeling experiment, or
- by detailed mass and moment calculation, in which case the lightweight of the vessel shall be verified by checking the draught, with a tolerance limit of ± 5% between the mass determined by calculation and the displacement determined by the draught readings.

3.1.2

a) Sufficient buoyancy and stability of the vessel in the event of flooding shall be proven with a cargo corresponding to its maximum draught and evenly distributed among all the holds and with maximum supplies and fully fuelled.

b) For diversified cargo, the stability calculation shall be performed for the most unfavourable loading condition.

c) For this purpose, mathematical proof of sufficient stability shall be determined for the intermediate stages of flooding (25%, 50% and 75% of flood build up, and, where appropriate, for the stage immediately prior to transverse equilibrium) and for the final stage of flooding, in the loading conditions specified in item a).

3.2 Assumptions

3.2.1 The following assumptions shall be taken into account for the damaged condition:

a) Extent of side damage:
   - longitudinal extent:
     at least 0,10 L_{OA}
   - transverse extent:
     B_2 – 0,01 m
   - vertical extent:
     from base line upwards without limit.

b) Extent of bottom damage:
   - longitudinal extent:
     at least 0,10 L_{OA}
   - transverse extent:
     3,00 m
   - vertical extent:
     from base line to D_2 – 0,01 m, the sump excepted.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the subdivision shall be chosen so that the vessel remains afloat after flooding of two or more adjacent compartments in the longitudinal direction.

   For the main engine room only the one-compartment status needs to be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

   For bottom damage, adjacent athwartship compartments shall also be assumed as flooded.

d) Permeability

   Permeability μ shall be assumed to be 95%.

   If a calculation proves that the average permeability of a compartment is less than 95%, the calculated value may be used instead.

   However, the values used shall not be less than those stated in Tab 2.

e) The calculation of free surface effect in intermediate stages of flooding shall be based on the gross surface area of the damaged compartments.

Table 2 : Minimum values of permeability

Spaces	μ, in %
Engine and service rooms	85
Cargo holds	70
Double bottoms, fuel tanks, ballast tanks, etc. depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

3.3 Damage stability criteria

3.3.1 For all intermediate stages of flooding referred to in [3.1.2], the following criteria shall be met:

a) the heeling angle φ at the equilibrium position of the intermediate stage in question shall not exceed 15° (5° where containers are not secured), see Fig 2

b) beyond the heel in the equilibrium position of the intermediate stage of flooding in question, the positive part of the righting lever curve shall display a righting lever value of GZ ≥ 0,02 m (0,03 m where containers are not secured) before the first unprotected (non-weathertight) opening becomes immersed or a heeling angle φ of 27° is reached (15° where containers are not secured)

c) non-watertight openings shall not be immersed before the heel in the equilibrium position of the intermediate stage in question has been reached.

3.3.2 During the final stage of flooding, the following criteria shall be met:

a) the lower edge of non-watertight openings (e.g., doors, windows, access hatches) shall be not less than 0,10 m above the damaged waterline

b) the heeling angle φ at the equilibrium position shall not exceed 12° (5° where containers are not secured)

c) beyond the heel in the equilibrium position of the intermediate stage of flooding in question, the positive part of the righting lever curve shall display a righting lever value of GZ ≥ 0,05 m and the area under the curve shall reach at least 0,0065 m.rad before the first unprotected opening becomes immersed or a heeling angle φ of 27° (10° where containers are not secured) is reached

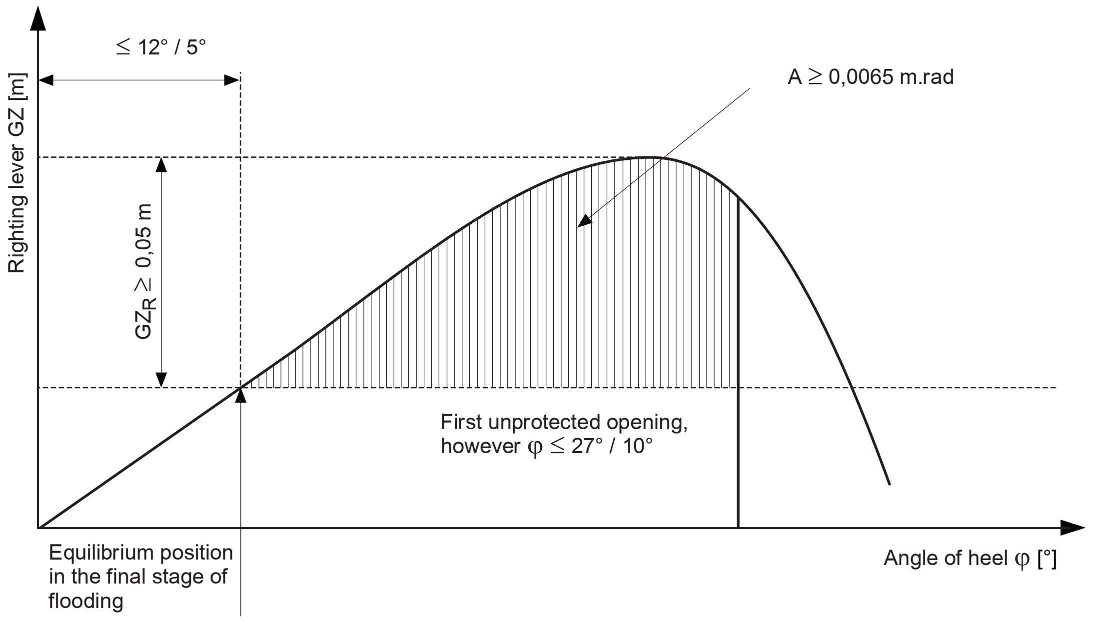
d) if non-watertight openings are immersed before the equilibrium position is reached, the rooms affording access shall be deemed flooded for the purposes of the damaged stability calculation.

3.3.3 When cross- or down-flooding openings are provided to reduce unsymmetrical flooding, the time for equalisation shall not exceed 15 minutes, if during the intermediate stages of flooding sufficient damaged stability has been demonstrated.

3.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked according to their operating instructions.

3.3.5 Where necessary in order to meet the requirements in [3.1.2], the plane of maximum draught shall be re-established.

Figure 2 : Proof of damage stability for container vessels (final stage of flooding)



4 Tankers

4.1 Assumptions

4.1.1 The following assumptions shall be taken into consideration for the damaged condition.

a) Extent of side damage:
- longitudinal extent:
  at least 0,10 L_{OA} but not less than 5,00 m
- transverse extent:
  B_2 – 0,01 m
- vertical extent:
  from base line upwards without limit.

b) Extent of bottom damage:
- longitudinal extent:
  at least 0,10 L_{OA} but not less than 5,00 m
- transverse extent:
  3,00 m
- vertical extent:
  from base line to D_2 – 0,01 m, the sump excepted.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen so as to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

The following provisions are applicable:
- for bottom damage, adjacent athwartship compartments shall also be assumed flooded
- the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

4.1.2 In general, permeability μ shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the values of permeability given in Tab 3 are the minimum values to be used.

For the main engine room only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Table 3 : Minimum values of permeability

Spaces	μ, in %
Engine rooms	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

4.2 Damage stability criteria

4.2.1 The damage stability is generally regarded sufficient if (see Fig 3):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

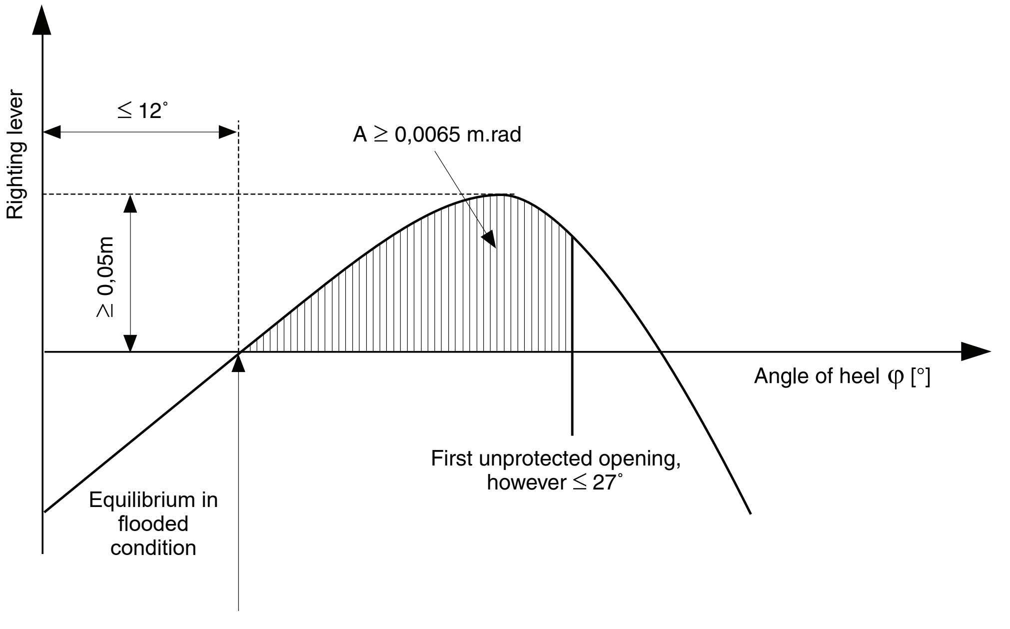
  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.

- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m·rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.

4.2.2 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

4.2.3 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Figure 3 : Proof of damage stability



SECTION 7 FIRE

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional class notation **Fire** as defined in Pt A, Ch 1, Sec 3, [11.9].

These vessels are to comply with the requirements stated under Part C, Chapter 4 and other relevant Sections of Part D.

The requirements of this Section applies to various vessel notations according to Tab 1.

Table 1 : Requirements applicable to vessels

<table>
<tr><td rowspan="2">Vessel types</td><td colspan="2">Articles</td></tr>
<tr><td>General</td><td>Specific</td></tr>
<tr><td>Vessels intended for the carriage of passengers
(Passenger vessels, Pleasure vessels (1))</td><td rowspan="3">[2]</td><td>[3]</td></tr>
<tr><td>Vessels intended for the carriage of dangerous goods
(Dry cargo, Tankers)</td><td>[4]</td></tr>
<tr><td>Other vessels</td><td>[5]</td></tr>
<tr><td colspan="3">(1) Where intended for the carriage of passengers</td></tr>
</table>

1.2 Documentation to be submitted

1.2.1 In addition to the documentation required in Pt C, Ch 4, Sec 1, [1.4], the following fire protection detail are to be submitted to the Society:

- Structural fire protection, showing the method of construction, purpose and category of the various spaces of the vessels, the fire rating of bulkheads and decks, means of closings of openings in A and B class divisions, draught stops
- Ventilation systems showing the penetrations on A class divisions, location of dampers, means of closing, arrangements of air conditioning rooms
- Protection of stairways and lifts in accommodation and service spaces
- Specifications of material properties with regards to fire protection.

1.3 Definitions

1.3.1 Non-combustible material

"Non-combustible material" is defined in Pt C, Ch 4, Sec 1, [2.14].

1.3.2 A-class divisions

"A-class divisions" is defined in Pt C, Ch 4, Sec 1, [2.2].

1.3.3 B-class divisions

"B-class divisions" is defined in Pt C, Ch 4, Sec 1, [2.3].

1.3.4 Fire divisions other than steel

Fire divisions other than steel are defined in Pt C, Ch 4, Sec 1, [2.4].

Attention is drawn to the use of composite and/or plywood materials from the point of view of structural fire protection. Regulations of the country where the vessel is registered may entail in some cases a limitation in the use of composite and/or plywood materials.

1.3.5 Low flame-spread

"Low flame-spread" is defined in Pt C, Ch 4, Sec 1, [2.9].

1.3.6 Not readily ignitable material

"Not readily ignitable material" is defined in Pt C, Ch 4, Sec 1, [2.15].

1.3.7 Machinery spaces of Category A

"Machinery spaces of Category A" is defined in Pt C, Ch 1, Sec 1, [1.4].

1.3.8 RoRo spaces

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

1.3.9 Special category spaces

Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck.

2 General provisions

2.1 Determination of fire integrity standards

2.1.1 For the purpose of determining the appropriate fire integrity standard to be applied to boundaries between adjacent spaces, such spaces are classified according to their fire risk described in the following categories.

The title of each category is intended to be typical rather than restrictive.

a) Control centres: defined in Pt C, Ch 4, Sec 1, [2.5]

Wheelhouse, rooms containing the vessel's radio equipment, rooms containing centralised fire alarm equipment, rooms containing centralised emergency public address system stations and equipment, etc.

b) Stairwells: defined in Pt C, Ch 4, Sec 1, [2.19]

Interior stairwells, lifts, enclosed emergency escape trunks. In this connection a stairwell which is enclosed at one level only shall be regarded as part of the space from which it is not separated by a fire door, etc.

c) Muster areas: defined in Pt C, Ch 4, Sec 1, [2.13]

d) Lounges: defined in Pt C, Ch 4, Sec 1, [2.8]

Cabins, public spaces, sale shops, barber shops and beauty parlours, saunas, pantries containing no cooking appliances, small lockers (deck area < 4 m^2), etc.

e) Machinery spaces: defined in Pt C, Ch 4, Sec 1, [2.11]

Main propulsion machinery room, auxiliary machinery spaces, etc.

f) Galleys: defined in Pt C, Ch 4, Sec 1, [2.7]

g) Store rooms: defined in Pt C, Ch 4, Sec 1, [2.21]

Miscellaneous stores, lockers having deck area exceeding 4 m^2, air conditioning rooms.

2.2 Openings in class A and class B divisions

2.2.1 The construction of all doors and door frames in class A and B divisions, with the means of securing them when closed, shall provide resistance to fire as well as to the passage of smoke (only for doors in class A divisions) and flames equivalent to that of the bulkheads in which the doors are fitted.

Such doors and door frames shall be of an approved type.

Watertight doors need not be insulated.

2.2.2 Fire doors in divisions required by Tab 2 and Tab 3 to machinery spaces, to galleys and to staircases shall be of self-closing type.

2.2.3 It shall be possible for each door to be opened and closed from each side of the bulkhead by one person only.

2.2.4 Self-closing doors, which are normally open, shall be capable of remote release from a continuously manned central control station and shall also be capable of release individually from a position at both sides of the door. Status of each fire door (open/ closed position) shall be indicated on the bridge.

2.3 Fire protection materials

2.3.1 Insulation materials shall comply with Pt C, Ch 4, Sec 2, [2.3.1].

2.3.2 Ceilings and linings in accommodation spaces including their substructures shall be of non-combustible material, unless the space is protected with a sprinkler installation.

2.3.3 The following surface materials shall have low flame spread characteristics:

- exposed surfaces in corridors and stairways and of bulkhead and ceiling linings in all spaces, except machinery spaces and store rooms, and
- surfaces and grounds in concealed and inaccessible spaces.

2.3.4 Paints, varnishings and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke and toxic gases (see Annex 1, Part 2 of FTP Code).

Note 1: FTP Code means Fire Test Procedures Code, as defined in Pt C, Ch 4, Sec 1, [2.6].

2.3.5 Fabrics, curtains and other hanging textiles (see Annex 1, Part 7 of FTP Code) as well as upholstered furniture (see Annex 1, Part 8 of FTP Code) and bedding components (see Annex 1, Part 9 of FTP Code) shall be fire retardant, unless the spaces are protected with a sprinkler installation. See Note 1 of [2.3.4].

2.3.6 Furniture and fittings in public spaces, which are also assembly station, shall be made of non-combustible material, unless the public spaces are protected with a sprinkler installation.

3 Passenger vessels

3.1 Fire integrity of bulkheads and decks

3.1.1 The minimum fire integrity of all bulkheads and decks shall be as shown in Tab 2 and Tab 3.

3.1.2 The following requirements shall govern the application of the Tables:

- Tab 3 shall apply to spaces in which a sprinkler installation is provided on both sides of bulkheads and deck.
- Tab 2 shall apply to spaces without an installed sprinkler installation.

3.1.3 On passenger vessels assigned additional class notation **Ferry**, the boundary bulkheads and decks of special category spaces and RoRo spaces shall be insulated to A60 class standard. However, where:

- open deck space
- sanitary and similar space, or
- tanks, voids and auxiliary machinery spaces having little or no fire risk,

is on one side of the division, the standard may be reduced to A0.

Where fuel oil tanks are below a special category space or a RoRo space, the integrity of the deck between such spaces may be reduced to A0 standard.

Table 2 : Fire integrity of bulkheads and decks in spaces without sprinkler installation

Spaces	Control centres	Stairwells	Muster areas	Lounges	Machinery spaces of Category A	Galleys	Store rooms
Control centres	–	A0	A0 / B15 **(1)**	A30	A60	A60	A30 / A60 **(5)**
Stairwells		–	A0	A30	A60	A60	A30
Muster areas			–	A30 / B15 **(2)**	A60	A60	A30 / A60 **(5)**
Lounges				– / A0 / B15 **(3)**	A60	A60	A30
Machinery spaces of Category A					A60 / A0 **(4)**	A60	A60
Galleys						A0	A30 / B15 **(6)**
Store rooms							–

(1) Divisions between control centres and internal muster areas shall correspond to type A0, but external muster areas only to type B15.
(2) Divisions between lounges and internal muster areas shall correspond to type A30, but external muster areas only to type B15.
(3) Divisions between cabins, divisions between cabins and corridors and vertical divisions separating lounges according to Ch 1, Sec 6, [3.5.1] shall comply with B15. Divisions between cabins and saunas shall comply with type A0.
(4) Divisions between machinery spaces of Category A shall comply with type A60; in other cases they shall comply with type A0.
(5) Divisions between store rooms for the storage of flammable liquids and control centres and muster areas shall comply with type A60, for rooms fitted with pressurised sprinkler systems A30.
(6) B15 is sufficient for divisions between galleys, on the one hand, and cold-storage rooms and food store rooms, on the other.

Table 3 : Fire integrity of bulkheads and decks in spaces with sprinkler installation

Spaces	Control centres	Stairwells	Muster areas	Lounges	Machinery spaces of Category A	Galleys	Store rooms
Control centres	–	A0	A0 / B15 **(1)**	A0	A60	A30	A0 / A30 **(5)**
Stairwells		–	A0	A0	A60	A30	A0
Muster areas			–	A30 / B15 **(2)**	A60	A30	A0 / A30 **(5)**
Lounges				– / B15 / B0 **(3)**	A60	A30	A0
Machinery spaces of Category A					A60 / A0 **(4)**	A60	A60
Galleys						–	A0 / B15 **(6)**
Store rooms							–

(1) Divisions between control centres and internal muster areas shall correspond to type A0, but external muster areas only to type B15.
(2) Divisions between lounges and internal muster areas shall correspond to type A30, but external muster areas only to type B15.
(3) Divisions between cabins, divisions between cabins and corridors and vertical divisions separating lounges according to Ch 1, Sec 6, [3.5.1] shall comply with B0. Divisions between cabins and saunas shall comply with type B15.
(4) Divisions between machinery spaces of Category A shall comply with type A60; in other cases they shall comply with type A0.
(5) Divisions between store rooms for the storage of flammable liquids and control centres and muster areas shall comply with type A60, for rooms fitted with pressurised sprinkler systems A30.
(6) B15 is sufficient for divisions between galleys, on the one hand, and cold-storage rooms and food store rooms, on the other.

3.2 Means of escape

3.2.1 Dead-end corridors

Dead ends in connecting corridors shall be not longer than 2 m.

3.3 Ventilation systems

3.3.1 They shall be so designed as to prevent the spread of fire and smoke through the system.

3.3.2 The main inlets and outlets of all ventilation system shall be capable of being closed from outside the respective spaces in the event of a fire.

3.3.3 Ducts shall be constructed of steel or other equivalent non-combustible material.

3.3.4 Ducts exceeding 0,02 m^2 and passing through partitions complying with [3.1.1] shall be fitted with fire dampers. The fire dampers shall operate automatically but shall also be capable of being manually closed from both sides of the penetrated division.

3.3.5 Ventilation systems for galleys and machinery spaces shall be independent of the ventilation system serving other spaces.

3.3.6 Exhaust ducts are to be provided with suitably arranged hatches for inspection and cleaning. The hatches shall be located near the fire dampers.

3.3.7 All power ventilation systems shall be capable of being stopped from a central place outside the machinery space.

3.3.8 Galleys have to be provided with separate ventilation systems and exhaust ducts from galley ranges.

Exhaust ducts from galley ranges shall comply with [3.3.1] to [3.3.7] and shall in addition be provided with a manually operated fire damper located in the lower end of the duct.

3.4 Protection of stairways and lifts in accommodation and service spaces

3.4.1 Internal stairs and lifts shall be encapsulated at all levels by walls according to Tab 2 or Tab 3, with effective means of closure for all openings.

3.4.2 The following exceptions are admissible:

a) A staircase connecting only two decks does not need to be encapsulated, if on one of the decks the staircase is enclosed according to Tab 2 or Tab 3.

b) In a lounge, stairs need not be encapsulated if they are located entirely within the interior of this room, and

- if this room extends over only two decks, or
- if there is a pressurised sprinkler system installed in this room on all decks, this room has a smoke extraction system and the room has access on all decks to a stairwell.

4 Vessels intended for the carriage of dangerous goods

4.1 Fire structural integrity

4.1.1 The minimum fire integrity of all bulkheads and decks shall be as shown in Tab 4.

4.1.2 All stairways are to be of steel frame or other non-combustible construction.

Stairways connecting more than two decks are to be enclosed by at least class B bulkheads. Stairways connecting only two decks need to be protected at least at one deck level by class B bulkheads. Doors shall have the same fire resistance as the bulkheads in which they are fitted.

Where class A and B divisions are penetrated for the passage of cables, pipes, trunks, ducts etc. or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements shall be made to ensure that the fire resistance is not impaired.

4.1.3 Ventilation system

All parts of the system shall be made of non-combustible material, except that short ducts applied at the end of the ventilation device may be made of a material which has low-flame spread characteristics.

When ventilation ducts with a cross-section of more than 0,02 m^2 are passed through partitions according to [4.1.1] of type A, they shall be fitted with approved fire dampers which can be operated from a location permanently manned by shipboard personnel or crew members.

Table 4 : Fire integrity of bulkheads and decks

Spaces	Control centres	Stairwells	Muster areas	Lounges	Machinery spaces of Category A	Galleys	Store rooms
Control centres	–	A0	A0 / B0 **(1)**	B0	A30	A0	A0
Stairwells		–	A0	B0	A30	A0	A0
Muster areas			–	A0 / B0 **(2)**	A30	A0	A0
Lounges				– / B0 **(3)**	A30	A0	A0
Machinery spaces of Category A					A30 / A0 **(4)**	A15	A0
Galleys						–	A0 / B0 **(5)**
Store rooms							–

(1) Divisions between control centres and internal muster areas shall correspond to type A0, but external muster areas only to type B0.
(2) Divisions between lounges and internal muster areas shall correspond to type A0, but external muster areas only to type B0.
(3) Divisions between cabins, divisions between cabins and corridors and vertical divisions separating lounges according to Ch 1, Sec 6, [3.5.1] shall comply with B0.
(4) Divisions between machinery spaces of Category A shall comply with type A30; in other cases they shall comply with type A0.
(5) B0 is sufficient for divisions between galleys, on the one hand, and cold-storage rooms and food store rooms, on the other.

5 Other vessels

5.1 Fire structural integrity

5.1.1 The minimum fire structural integrity shall comply with [4.1].

5.2 Fire fighting

5.2.1 Fixed gas fire extinguishing systems

Machinery spaces containing internal combustion engines and oil fired boilers shall be provided with a fixed gas fire extinguishing system in compliance with Pt C, Ch 4, Sec 4, [4].

SECTION 8 UNATTENDED MACHINERY SPACES (AUT-UMS)

1 General

1.1 Application

1.1.1 The additional class notation **AUT-UMS** is assigned in accordance with Pt A, Ch 1, Sec 3, [11.2] to vessels fitted with automated installations enabling periodically unattended operation of machinery spaces, and complying with the requirements of this Section.

Machinery spaces are defined in Pt C, Ch 1, Sec 1, [1.5].

1.1.2 Applicable requirements stated under Part C, Chapter 3, are to be complied with too.

1.1.3 The arrangements provided shall be such as to ensure that the safety of the vessel in all sailing conditions, including manoeuvring, is equivalent to that of a vessel having the machinery spaces manned.

1.2 Exemptions

1.2.1 To vessels whose deadweight is less than 500 t, the requirements of [6.4.3] do not apply.

1.2.2 For cargo carriers, the Society may wave the requirements laid down in [3.3.1], insofar as the arrangements of the machinery space access make it unnecessary.

1.3 Communication system

1.3.1 A reliable means of vocal communication shall be provided between the main machinery control room or the propulsion machinery control position as appropriate, the navigation bridge and the engineer officers' accommodation.

This means of communication is to be foreseen in collective or individual accommodation of engineer officers.

1.3.2 Means of communication are to be capable of being operated even in the event of failure of supply from the main source of electrical power.

1.4 Monitoring and control of equipment

1.4.1 Monitoring and control of unattended machinery space equipment is to be performed according to Tab 2.

2 Documentation

2.1 Documents to be submitted

2.1.1 In addition to those mentioned in Pt B, Ch 2, Sec 1, [2], the documents in Tab 1 are required for review.

Table 1 : Documents to be submitted

No.	Document
1	Means of communication diagram
2	Technical description of automatic engineer's alarm and connection of alarms to accommodation and wheelhouse, when applicable
3	System of protection against flooding
4	Fire detection system: diagram, location and cabling

3 Fire precautions

3.1 Fire prevention

3.1.1 For arrangements of remote stop, the requirements in Pt C, Ch 4, Sec 2, [2.1] are applicable.

3.2 Fire detection

3.2.1 An automatic fire detection system is to be fitted in machinery spaces intended to be unattended.

3.2.2 The fire detection system is to be designed with self-monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm.

3.2.3 The fire detection indicating panel is to be located in the wheelhouse, fire control station or other accessible place where a fire in the machinery space will not render it inoperative.

3.2.4 The fire detection indicating panel is to indicate the place of the detected fire in accordance with the arranged fire zones by means of a visual signal. Audible signals clearly distinguishable in character from any other signals are to be audible throughout the wheelhouse and the accommodation area of the personnel responsible for the operation of the machinery space.

3.2.5 Fire detectors are to be of such type and so located that they will rapidly detect the onset of fire in conditions normally present in the machinery space. The type and location of detectors are to be approved by the Society and a combination of detector types is recommended in order to enable the system to react to more than one type of fire symptom.

3.2.6 Except in spaces of restricted height and where their use is specially appropriate, detection systems using thermal detectors only are not permitted. Flame detectors may be installed, although they are to be considered as complementary and are not to replace the main installation.

3.2.7 Fire detector zones are to be arranged in a manner that will enable the operating staff to locate the seat of the fire. The arrangement and the number of loops and the location of detector heads are to be approved in each case. Air currents created by the machinery are not to render the detection system ineffective.

3.2.8 When fire detectors are provided with the means to adjust their sensitivity, necessary arrangements are to be allowed to fix and identify the set point.

3.2.9 When it is intended that a particular loop or detector is to be temporarily switched off, this state is to be clearly indicated. Reactivation of the loop or detector is to be performed automatically after a preset time.

3.2.10 The fire detection indicating panel is to be provided with facilities for functional testing.

3.2.11 The fire detection system is to be fed automatically from the emergency source of power by a separate feeder if the main source of power fails.

3.2.12 Facilities are to be provided in the fire detecting system to manually release the fire alarm from the following places:

- passageways having entrances to machinery spaces
- the wheelhouse
- the control station in the machinery space.

3.3 Fire fighting

3.3.1 Unless otherwise stated, pressurisation of the fire main at a suitable pressure by starting a main fire pump and carrying out the other necessary operations is to be possible from the wheelhouse. Alternatively, the fire main system may be permanently under pressure.

4 Flooding precautions

4.1 Protection against flooding

4.1.1 Bilge wells or machinery spaces bilge levels are to be monitored in such a way that the accumulation of liquid is detected in normal angles of trim and heel, and are to be large enough to accommodate easily the normal drainage during the unattended period.

4.1.2 Bilge level alarms are to be given at the main control station and the wheelhouse.

4.1.3 Alarm is to be given to the wheelhouse in case of flooding into the machinery space situated below the load line, in compliance with Tab 2.

5 Machinery

5.1 General

5.1.1 Under all sailing conditions, including manoeuvring, the speed, direction of thrust and, if applicable, the pitch of the propeller shall be fully controllable from the wheelhouse.

5.1.2 All manual operations or services expected to be carried out with a periodicity of less than 24 h are to be eliminated or automated, particularly for: lubrication, toping up of make up tanks and filling tanks, filter cleaning, cleaning of centrifugal purifiers, drainage, load sharing on main engines and various adjustments. Nevertheless, the transfer of operation mode may be effected manually.

5.1.3 A centralised control position shall be arranged with the necessary alarm panels and instrumentation indicating any alarm.

5.1.4 Parameters for essential services which need to be adjusted to a preset value are to be automatically controlled.

5.1.5 The control system shall be such that the services needed for the operation of the main propulsion machinery and its auxiliaries are ensured through the necessary automatic arrangements.

5.1.6 It shall be possible for all machinery essential for the safe operation of the vessel to be controlled from a local position, even in the case of failure in any part of the automatic arrangements.

5.1.7 The design of the remote automatic control system shall be such that, in the case of its failure, an alarm will be given. Unless impracticable, the preset speed and direction of thrust of the propeller shall be maintained until local control is in operation.

5.1.8 Critical speed ranges, if any, are to be rapidly passed over by means of an appropriate automatic device.

5.1.9 Propulsion machinery is to stop automatically only in exceptional circumstances which could cause quick critical damage, due to internal faults in the machinery. The design of automation systems whose failure could result in an unexpected propulsion stop is to be specially examined. An overriding device for canceling the automatic shutdown is to be considered.

5.1.10 Where the propulsive plant includes several main engines, a device is to be provided to prevent any abnormal overload on each of them.

5.1.11 Where standby machines are required for other auxiliary machinery essential to propulsion, automatic changeover devices shall be provided.

5.2 Control of machinery

5.2.1 Monitoring and control of machinery equipment is to be performed according to Tab 2.

Table 2 : Monitoring and control of machinery installations

Symbol convention H = High, HH = Very high, L = Low I = Individual alarm, G = Group alarm		Monitoring				
Identification of system parameter		Alarms	Indication local	Alarms wheelhouse **(4)**	Indication wheelhouse	Shut down
MAIN ENGINE						
Engine speed	All engines		x		x	
	Engine power > 220kW	HH	x	I		x
Shaft revolution indicator			x		x	
Lubricating oil pressure		L	x	G	x	
Lubricating oil temperature		H	x	G		
Fresh cooling water system inlet pressure **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Fuel oil temperature for engines running on HFO		L	x	G		
Exhaust gas temperature (single cylinder when the dimensions permit)			x			
Starting air pressure		L	x	I	x	
Charge air pressure			x			
Control air pressure			x		x	
Exhaust gas temperature at turbocharger inlet/outlet (where the dimensions permit)			x			
Manual emergency stop of propulsion		x	x		x	x **(3)**
Fault in the electronic governor		x	x	G		
REDUCTION GEAR						
Tank level			x		x	
Lubricating oil temperature			x			
Lubricating oil pressure			x		x	
AUXILIARY MACHINE (2)						
Engine speed	All engines		x		x	
	Engine power > 220 kW	HH	x	I	x	x
Low pressure cooling water system **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Lubricating oil pressure		L	x	G		
Fault in the electronic governor		x	x	G		
DIESEL BOW THRUSTER (2)						
Engine speed	All engines		x		x	
	Engine power > 220 kW	HH	x	G	x	x
Low pressure cooling water system **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Direction of propulsion			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature			x			
Fault in the electronic governor		x	x	G		
PROPULSION						
Propulsion remote control ready			x		x	
Pitch control			x		x	
ELECTRICITY						
Earth fault (when insulated network)		x	x	G		
Main supply power failure		x	x	G		

Symbol convention H = High, HH = Very high, L = Low I = Individual alarm, G = Group alarm	Monitoring				
Identification of system parameter	Alarms	Indication local	Alarms wheelhouse **(4)**	Indication wheelhouse	Shut down
FUEL OIL TANKS					
Fuel oil level in service tank or tanks supplying directly services essential for safety or navigation	L	x	G		
STEERING GEAR					
Rudder angle indicator		x		x	
Level of each hydraulic fluid	L	x	I	x	
Indication that electric motor of each power unit is running		x		x	
Failure of rate of turn control	x		I	x	
Overload failure	x	x	I	x	
Phase failure	x	x	I	x	
Loss of power supply	x	x	I	x	
Loss of control supply	x	x	I	x	
STEAM BOILER					
Water level	L+H	x			
	LL				x
Circulation stopped (when forced circulation boiler)	x				x
Flame failure	x				x
Temperature in boiler	H				
Steam pressure	HH	x			x
THERMAL OIL					
Thermal fluid temperature heater outlet	H	x			x **(5)**
Thermal fluid pressure pump discharge	H	x			x
Thermal fluid flow through heating element	L	x			
	LL				x **(5)**
Expansion tank level	L	x			
	LL				x **(6)**
Expansion tank temperature	H				
Forced draft fan stopped	x				x
Burner flame failure	x				x
Flue gas temperature heater outlet	H				
	HH				x **(6)**
FIRE					
Fire detection	x			x	
Fire manual call point	x			x	
Automatic fixed fire extinguishing system activation, if fitted	x			x	
FLOODING					
Level of machinery space bilges/drain wells	x			x	
ALARM SYSTEM					
Alarm system power supply failure	x	x		x	

(1) A combination of level indication/alarm in expansion tank and indication/alarm cooling water temperature can be considered as equivalent with consent of the Society.
(2) Exemptions can be given for diesel engines with a power of 50 kW and below.
(3) Openings of clutches can, with the consent of the Society, be considered as equivalent.
(4) Group of alarms are to be detailed in the machinery space or control room (if any).
(5) Shut-off of heat input only.
(6) Stop of fluid flow and shut-off of heat input.

6 Alarm system

6.1 General

6.1.1 A system of alarm displays and controls is to be provided which readily allows identification of faults in the machinery and satisfactory supervision of related equipment. This may be arranged at a main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

6.1.2 Unless otherwise justified, separation of monitoring and control systems is to be provided.

6.1.3 The alarm system is to be designed to function independently of control and safety systems, so that a failure or malfunction of these systems will not prevent the alarm system from operating. Common sensors for alarms and automatic slowdown functions may be accepted in specific cases.

6.1.4 The alarm system shall be continuously powered and shall have an automatic change-over to a standby power supply in the case of loss of normal power supply.

6.2 Alarm system design

6.2.1 The alarm system and associated sensors are to be capable of being tested during normal machinery operation.

6.2.2 Insulation faults on any circuit of the alarm system are to generate an alarm, when an insulated earth distribution system is used.

6.2.3 An engineer's alarm is to be activated when the machinery alarm has not been accepted in the machinery spaces or control room within 5 minutes.

6.3 Machinery alarm system

6.3.1 The local silencing of the alarms in the wheelhouse or in accommodation spaces is not to stop the audible machinery space alarm.

6.3.2 Machinery faults are to be indicated at the control locations for machinery.

6.4 Alarm system in wheelhouse

6.4.1 Alarms associated with faults requiring speed reduction or automatic shutdown are to be separately identified in the wheelhouse.

6.4.2 The alarm system is to activate an audible and visual alarm in the wheelhouse for any situation which requires action by or the attention of the officer on watch.

6.4.3 Individual alarms are to be provided in the wheelhouse indicating any power supply failures of the remote control of propulsion machinery.

7 Safety system

7.1 General

7.1.1 Safety systems of different units of the machinery plant are to be independent. Failure in the safety system of one part of the plant is not to interfere with the operation of the safety system in another part of the plant.

7.1.2 In order to avoid undesirable interruption in the operation of machinery, the system is to intervene sequentially after the operation of the alarm system by:

- starting of standby units
- load reduction or shutdown, such that the least drastic action is taken first.

7.1.3 The arrangement for overriding the shutdown of the main propelling machinery is to be such as to preclude inadvertent operation.

7.1.4 After stoppage of the propulsion engine by a safety shutdown device, the restart is only to be carried out, unless otherwise justified, after setting the propulsion wheelhouse control level on ″stop″.

8 Testing

8.1 General

8.1.1 The tests of automated installations are to be carried out according to Pt C, Ch 3, Sec 6 to determine their operating conditions. The details of these tests are defined, in each case, after having studied the concept of the automated installations and their construction. A complete test program is to be submitted for approval.

SECTION 9 ANNUAL SURVEY

1 General

1.1 Application

1.1.1 The additional class notation **Annual survey** is assigned in accordance with Pt A, Ch 1, Sec 3, [11.1] to vessels submitted to annual survey and intermediate survey complying with the requirements of this Section. This Section applies in addition to the applicable provisions of Pt A, Ch 3, Sec 3 to Pt A, Ch 3, Sec 9.

1.1.2 Annual survey

Vessels assigned with the additional class notation **Annual survey** are to be submitted to annual survey in compliance with [2], carried out within three months before or after each anniversary date.

1.1.3 Intermediate survey

In addition to all the inspections and checks required for annual surveys, the intermediate survey is to be carried out in compliance with [3], within the window from three months before the second to three months after the third anniversary date.

The intermediate survey is not applicable to vessels with character of class **II**.

1.1.4 Owners are reminded that, in compliance with the requirements in Pt A, Ch 2, Sec 2, [10.2], any modification to the vessel's hull and equipment affecting its classification is to be made known to the Society.

1.2 Links between anniversary dates and annual surveys, intermediate surveys and class renewal surveys

1.2.1 The link between the anniversary dates, the class renewal survey and the annual and intermediate surveys is given in Fig 1.

2 Annual survey

2.1 General

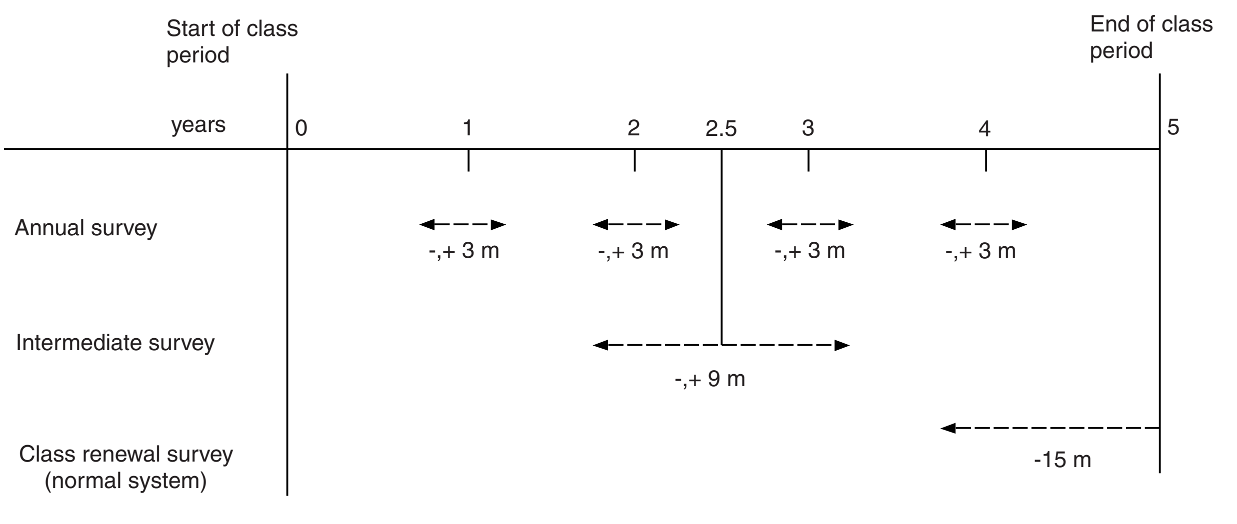
2.1.1 At the time of annual surveys, the vessel is to be generally examined. The survey is to include a visual inspection of the hull and hull equipment of the vessel and some tests thereof, so far as necessary and practicable in order to verify that the vessel is in a satisfactory and efficient general condition and is properly maintained.

2.2 Hull - General requirement

2.2.1 The main structural elements of the hull are to be subjected to a general visual inspection, as far as accessible. If applicable, ballast tank, storage and engine rooms are to be surveyed at random, depending on the vessel type, age and general condition. Where damages or excessive wastage affecting the class are suspected, the Surveyor is entitled to carry out further investigations as well as thickness measurements, if required.

2.2.2 The rudder and manoeuvring arrangement and the anchor equipment are to be checked for visible damages. For the related machinery and for operability, see Pt A, Ch 3, Sec 2, [4.1.1].

Figure 1 : Links between anniversary dates and annual, intermediate and class renewal surveys



2.2.3 The foundations and their substructure of special equipment, particularly on the upper deck, shall be inspected for damages.

2.2.4 Compartments and rooms normally not accessible, or accessible only after special preparations, may be required to be opened for inspection, depending on the vessel's age and available information about service conditions.

2.3 Ballast tanks

2.3.1 Depending on the vessel's age, the Surveyor may require opening of ballast tanks for visual inspection, particularly if deterioration of the coating or excessive wastage has already been observed at previous surveys.

If coating is to be partly or totally renewed, only approved coating is applicable in case of a repair. The whole working procedure including the surface preparation has to be documented.

2.4 Hatches and covers, bow, side and stern doors

2.4.1 Hatches and covers, bulkhead and hull doors, ramps and any openings in the outer shell shall be surveyed regarding structural integrity as well as tightness and operability of all closures.

2.4.2 Additionally to the overall survey the following structural members of bow, side and stern doors are to be thoroughly inspected:

- all hinges and the pertinent hydraulic cylinders in way of their securing points
- all securing elements of the locking devices and stoppers.

2.4.3 Where considered necessary by the Surveyor, additionally crack tests shall be carried out at structural members of bow, side and stern doors.

Essentially, the crack tests will cover:

- main joining welds and their interfacial areas both on the vessel's hull and on the doors
- highly stressed areas in way of the centres of rotation of the hinges
- highly stressed areas of the locking devices and their stoppers
- repair welding.

For crack detection the dye penetration method or the magnetic particle inspection method shall be employed, and a test protocol is to be prepared.

2.5 General machinery installations

2.5.1 The survey of general machinery installations is to cover the following items:

- general examination of machinery and boiler spaces with particular attention to the fire and explosion hazards; confirmation that emergency escape routes are practicable and not blocked
- general examination of the machinery, steam, hydraulic, pneumatic and other systems and their associated fittings, for confirmation of their proper maintenance
- testing of the means of communication and order transmission between the navigating bridge and the machinery control positions and other control stations
- confirmation that the rudder angle indicator on the bridge is in working order
- examination, as far as practicable, of the bilge pumping systems and bilge wells, including operation of the pumps, remote reach rods and level alarms, where fitted
- visual examination of the condition of any expansion joints in river water systems
- external examination of pressure vessels other than boilers and their appurtenances, including safety devices, foundations, controls, relieving gear, high pressure piping, insulation and gauges.

2.5.2 When the vessel is equipped with a refrigerating plant (whether or not covered by an additional class notation), the annual survey is to include the external examination of:

- pressure vessels of the installation to the same extent as indicated in [2.5.1]
- refrigerant piping, as far as practicable
- for refrigerating machinery spaces using ammonia as refrigerant:
  - ventilation system including functional test
  - water-spraying fire-extinguishing system; see [2.8.2] item d)
  - bilge system including functional test
  - electrical equipment, confirming its proper maintenance
  - gas detection system
  - breathing apparatus and protective clothing.

2.5.3 When the vessel is equipped with thruster installations, the annual survey is to include:

- an external examination of the machinery installation
- an operating test of the complete installation.

2.6 Boilers

2.6.1 For main and auxiliary boilers, the annual survey consists of an external examination of boilers and their appurtenances, including safety devices, foundations, controls, relieving, high pressure and steam escape piping, insulation and gauges.

2.6.2 For thermal oil heaters, a functional test while in operation is to be carried out, during which the following items are checked:

- the heater for detection of leakages
- the condition of the insulation
- the operation of indication, control and safety devices
- the condition of remote controls for shut-off and discharge valves.

A satisfactory analysis of the quality of oil is to be made available to the Surveyor.

2.6.3 For exhaust gas thermal oil heaters, in addition to the requirements of [2.6.2], a visual examination and a tightness testing to the working pressure of the heater tubes are to be carried out.

2.7 Electrical machinery and equipment

2.7.1 The survey of electrical machinery and equipment is to cover the following items:

- general examination, visually and in operation, as feasible, of the electrical installations for power and lighting, in particular main and emergency generators, electric motors, switchboards, switchgears, cables and circuit protective devices, indicators of electrical insulation and automatic starting, where provided, of emergency sources of power
- checking, as far as practicable, the operation of emergency sources of power and, where they are automatic, also including the automatic mode.

2.7.2 The survey is also to cover the bridge control of propulsion machinery, and related arrangements (alarms and safety devices), when fitted.

2.8 Fire protection, detection and extinction

2.8.1 The survey of fire prevention and other general arrangements is to cover the following items:

- examination and testing, as feasible, of the operation of manual and/or automatic fire doors, where fitted
- checking, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces and, where fitted, the remote controls for stopping fans in accommodation spaces and the means of cutting off power to the galley are in working order
- examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable
- examination, as far as practicable, and testing, as feasible and at random, of the fire and/or smoke detection systems.

2.8.2 The operational readiness and maintenance of fire fighting systems is to be checked. The survey requirements for all types of fire-fighting systems that are usually found on board vessels related either to machinery spaces or to cargo areas and/or spaces or to accommodation spaces, irrespective of the service notation assigned, are the following:

a) Water fire system
   - examination of the fire main system and confirmation that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants, at any part of the vessel whilst the required pressure is maintained in the fire main
   - checking that fire hoses, nozzles, applicators, spanners and international shore connection (where fitted) are in satisfactory working condition and situated at their respective locations

b) Fixed gas fire-extinguishing system
   - external examination of receivers of CO_2 (or other gas) fixed fire-extinguishing systems and their accessories, including the removal of insulation for insulated low pressure CO_2 containers
   - examination of fixed fire-fighting system controls, piping, instructions and marking; checking for evidence of proper maintenance and servicing, including date of last system tests
   - test of the alarm triggered before the CO_2 is released

c) Sprinkler system
   - examination of the system, including piping, valves, sprinklers and header tank
   - test of the automatic starting of the pump activated by a pressure drop
   - check of the alarm system while the above test is carried out

d) Water-spraying system
   - examination of the system, including piping, nozzles, distribution valves and header tank
   - test of the starting of the pump activated by a pressure drop (applicable only for machinery spaces)

e) Fixed foam systems (low or high expansion)
   - examination of the foam system
   - test to confirm that the minimum number of jets of water at the required pressure in the fire main is obtained when the system is in operation
   - checking the supplies of foam concentrate and receiving confirmation that it is periodically tested (not later than three years after manufacture and annually thereafter) by the manufacturer or an agent

f) Dry powder system
   - examination of the dry powder system, including the powder release control devices
   - checking the supplies of powder contained in the receivers and that it has maintained its original smoothness
   - checking that the pressure of propelling inert gas contained in the relevant bottles is satisfactory.

2.8.3 As far as other fire-fighting equipment is concerned, it is to be checked that:

- semi-portable and portable fire extinguishers and foam applicators are in their stowed positions, with evidence of proper maintenance and servicing, and detection of any discharged containers
- firemen's outfits are complete and in satisfactory condition.

3 Intermediate survey

3.1 General

3.1.1 The intermediate survey is to include examination and checks on a sufficiently extensive part of the structure to show that the structures of the vessel are in satisfactory condition so that the vessel is expected to operate until the end of the current period of class, provided that the vessel is properly maintained and other surveys for maintenance of class are duly carried out during this period.

3.2 Hull

3.2.1 The requirements given in Tab 1 for the survey and testing of water ballast spaces, cargo holds and cargo tanks are to be complied with.

Table 1 : Intermediate survey of hull

ITEM	Age of vessel (in years at time of intermediate survey)		
	5 < age ≤ 10	10 < age ≤ 15	age > 15
WATER BALLAST SPACES	Representative spaces internally examined Thickness measurements, if considered necessary by the Surveyor See **(1) (2) (3)**	All spaces internally examined Thickness measurements, if considered necessary by the Surveyor See **(1) (3)**	All spaces internally examined Thickness measurements, if considered necessary by the Surveyor Tightness of inner bottom plating of cargo holds in way of double bottom water ballast tanks checked, if considered necessary by the Surveyor See **(1) (3)**
CARGO HOLDS			Selected cargo holds internally examined
CARGO TANKS		Selected cargo tanks internally examined	Selected cargo tanks internally examined

(1) If such examinations reveal no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remains effective.
(2) If there is no hard protective coating, soft coating or poor coating condition, the examination is to be extended to other ballast spaces of the same type.
(3) For water ballast spaces, if there is no hard protective coating, soft coating or poor coating condition and it is not renewed, the spaces in question are to be internally examined at annual intervals.
Note 1: Due attention is also to be given to fuel oil piping passing through ballast tanks, which is to be pressure tested should doubts arise.

SECTION 10 GRABLOADING

1 General

1.1 Application

1.1.1 The additional class notation **Grabloading** is assigned, in accordance with Pt A, Ch 1, Sec 3, [11.10.1] to bulk cargo vessels with holds specially reinforced for loading/unloading cargoes by means of buckets or grabs and complying with the requirements of this Section.

2 Scantlings

2.1 General

2.1.1 The net scantlings of plating and structural members within the cargo hold obtained from Ch 1, Sec 2 are to be increased in compliance with [2.2] and [2.3].

2.2 Inner bottom

2.2.1 The net scantlings of inner bottom plating and longitudinals, where no continuous wooden ceiling is fitted, obtained from Ch 1, Sec 2 are to be reinforced as follows:

- inner bottom plating net thickness is to be increased by 2 mm
- inner bottom longitudinal net section modulus is to be increased 1,4 times.

2.3 Hold sides and bulkheads

2.3.1 The net thicknesses of:

- hold side plating up to 1,5 m from the inner bottom
- hold bulkhead plating up to 1,5 m from the inner bottom,

are to be increased by 1,5 mm.

2.3.2 The net section modulus of:

- hold side secondary stiffeners up to 1,5 m from the inner bottom
- hold bulkhead secondary stiffeners up to 1,5 m from the inner bottom,

is to be increased 1,4 times.

2.3.3 Above 1,5 m from the inner bottom, the net scantlings of plating and structural members may be tapered to those obtained from Ch 1, Sec 2.

SECTION 11 POLLUTION PREVENTION

1 Scope and application

1.1 General

1.1.1 This Section contains the requirements for the prevention of water and air pollution.

1.1.2 Additional class notations for the prevention of water and air pollution include:

- **Cleanvessel**
- other notations having a specific scope.

The relevant symbol, scope, reference to the Rules and assignment conditions are given in Tab 1.

Examples of notations:

- **Cleanvessel**
- **OWS-5 ppm**
- **AWT**, **NDO-2 days**

1.1.3 Requirements for onboard surveys are given in Article [4] and in Pt A, Ch 3, Sec 9, [3].

1.2 Applicable rules and regulations

1.2.1 Additional requirements may be imposed by the vessel flag Authorities and/or by the State or Port Administration in the jurisdiction of which the vessel is intended to operate, in particular with respect to:

- exhaust gas smoke (particulate emissions, smoke opacity)
- fuel oil sulphur content
- bilge water oil content
- on board waste incineration.

2 Definitions and abbreviations

2.1 Definitions related to water pollution

2.1.1 Hazardous wastes

Hazardous wastes are those wastes composed of substances which are identified as water pollutants in the European Agreement concerning the International Carriage of Dangerous Goods (ADN).

Hazardous wastes include in particular:

- photo processing chemicals
- dry cleaning waste
- used paints
- solvents
- heavy metals
- expired chemicals and pharmaceuticals
- waste from printers
- hydrocarbons and chlorinated hydrocarbons
- used fluorescent and mercury vapour light bulbs
- batteries.

Note 1: Empty packagings previously used for the carriage of hazardous substances are to be considered as hazardous substances.

2.1.2 Wastewater

Wastewater includes both sewage and grey water defined hereunder.

2.1.3 Sewage

Sewage means:

- drainage and other wastes from any form of toilets, urinals, and WC scuppers, here designated as black waters
- drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises
- drainage from spaces containing live animals, or
- other waste waters when mixed with the drainages defined above.

2.1.4 Sewage sludge

Sewage sludge means any solid, semi-solid, or liquid residue removed during the treatment of on-board sewage.

2.1.5 Grey water

Grey water includes drainage from dishwashers, showers, sinks, baths and washbasins, laundry and galleys.

2.1.6 Garbage

Garbage means all kinds of victual, domestic and operational waste excluding fresh fish and parts thereof, generated during the normal operation of the vessel.

Garbage includes all kinds of solid wastes like plastics, paper, oily rags, glass, metal, bottles, and incinerator ash. Food wastes are considered as garbage.

2.1.7 Oil residue (sludge)

Oil residue (sludge) means the residual waste oil products generated during the normal operation of a vessel such as those resulting from the purification of fuel or lubricating oil for main or auxiliary machinery, separated waste oil from oil filtering equipment, waste oil collected in drip trays, and waste hydraulic and lubricating oils.

Table 1 : Additional class notations for the prevention of pollution

Symbol	Scope	Reference in Part A	Applicable Rules	Assignment conditions
Cleanvessel	Prevention of sea and air pollution	Pt A, Ch 1, Sec 3, [11.15.2]	NR467, Pt F, Ch 9, Sec 2, [2]	
AWT	Fitting of an advanced wastewater treatment plant	Pt A, Ch 1, Sec 3, [11.15.3]	NR467, Pt F, Ch 9, Sec 3, [2]	
GREEN PASSPORT	Hazardous material inventory	Pt A, Ch 1, Sec 3, [11.15.4]	NR528	
GWT	Fitting of a treatment installation for Grey Waters	Pt A, Ch 1, Sec 3, [11.15.5]	NR467, Pt F, Ch 9, Sec 3, [5]	
NDO-x days	The ship is designed for No Discharge Operation during x days	Pt A, Ch 1, Sec 3, [11.15.6]	NR467, Pt F, Ch 9, Sec 3, [6]	
NOX-x%	Average NOx emissions of engines not exceeding x% of IMO Tier II limit	Pt A, Ch 1, Sec 3, [11.15.7]	NR467, Pt F, Ch 9, Sec 3, [7]	
OWS-x ppm	Fitting of an Oily Water Separator producing effluents having a hydrocarbon content not exceeding x ppm (parts per million)	Pt A, Ch 1, Sec 3, [11.15.8]	NR467, Pt F, Ch 9, Sec 3, [8]	
SOX-x%	Oil fuels used within and outside SECAs have a sulphur content not exceeding x% of the relevant IMO limit	Pt A, Ch 1, Sec 3, [11.15.9]	NR467, Pt F, Ch 9, Sec 3, [9]	As an alternative, equivalent arrangements (e.g. exhaust gas cleaning systems) may be accepted

2.1.8 Oil residue (sludge) tank

Oil residue (sludge) tank means a tank which holds oil residue (sludge) from which sludge may be disposed directly through the standard discharge connection or any other approved means of disposal.

2.1.9 Oily bilge water

Oily bilge water means water which may be contaminated by oil resulting from things such as leakage or maintenance work in machinery spaces. Any liquid entering the bilge system including bilge wells, bilge piping, tank top or bilge holding tanks is considered oily bilge water.

2.1.10 Oily bilge water holding tank

Oily bilge water holding tank means a tank collecting oily bilge water prior to its discharge, transfer.

2.1.11 Oily wastes

Oily wastes means oil residues (sludge) and oily bilge water.

2.1.12 Advanced Wastewater Treatment (AWT)

Advanced wastewater treatment means any treatment of wastewater that goes beyond the secondary or biological water treatment stage and includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids. AWT water effluent standard corresponds to the technology currently available for municipal wastewater treatment plants.

2.1.13 Accidental discharge

Accidental discharge is all discharge to water caused by unforeseen or accidental events, such as damage to the vessel or its equipment, and includes discharge necessary for the purpose of protection of the vessel or saving life.

2.1.14 No discharge condition

No discharge condition means the condition without discharge of hazardous wastes, treated and untreated wastewater, oily wastes or garbage into the water.

Note 1: In the scope of the “No discharge condition”, no effluents from exhaust gas cleaning systems may be discharged into the water.

2.2 Definitions related to air pollution

2.2.1 Emission

Emission means any release of substances from vessels into the atmosphere or water.

2.2.2 Ozone-depleting substances

Ozone-depleting substances means controlled substances defined in paragraph (4) of article 1 of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, listed in Annexes A, B, C or E to the said protocol in force at the time of application or interpretation of Annex VI of MARPOL 73/78.

Ozone-depleting substances that may be found on board vessel include, but are not limited to:

- Halon 1211 Bromochlorodifluoromethane
- Halon 1301 Bromotrifluoromethane
- Halon 2402 1,2-Dibromo-1,1,2,2-tetrafluoroethane (also known as Halon 114B2)
- CFC-11 Trichlorofluoromethane
- CFC-12 Dichlorodifluoromethane
- CFC-113 Trichloro-1,2,2-trifluoroethane
- CFC-114 1,2-Dichloro-1,1,2,2-tetrafluoroethane
- CFC-115 Chloropentafluoroethane.

2.2.3 NOx technical code

NOx Technical Code means the Revised Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines adopted at MEPC 58 on 10 October 2008 with Resolution MEPC.177(58).

2.2.4 Emission control area

Emission control area means an area where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce and control air pollution from NOx or SOx and particulate matter or all three types of emissions and their attendant adverse impacts on human health and the environment. Emission control areas include those listed in, or designated under, regulations 13 and 14 of Annex VI of MARPOL 73/78.

2.2.5 Onboard incineration

Onboard incineration means the incineration of wastes or other matter on board a vessel, if such wastes or other matter were generated during normal operation of that vessel.

2.2.6 Onboard incinerator

Onboard incinerator means an onboard facility designed for the primary purpose of incineration.

2.3 Abbreviations

2.3.1 AWT

AWT means advanced wastewater treatment.

2.3.2 ECA

ECA means emission control area

2.3.3 EGC

EGC means exhaust gas cleaning.

2.3.4 OWS

OWS means oily water separator.

3 Documents to be submitted and applicable standards

3.1 Documents to be submitted

3.1.1 Certificates

The certificates to be submitted prior to the assignment of the additional class notation **Cleanvessel** and other notations are listed in NR467, Pt F, Ch 9, Sec 1, Tab 2.

3.1.2 Operational procedures

The operational procedures to be submitted are listed in NR467, Pt F, Ch 9, Sec 1, Tab 3.

3.1.3 Plans and documents

The plans and documents to be submitted are listed in NR467, Pt F, Ch 9, Sec 1, Tab 4.

3.2 Modifications and additions

3.2.1 In case of modifications or additions to the approved installations, arrangements or procedures, the relevant details are to be submitted for review.

4 Onboard surveys

4.1 Application

4.1.1 Survey requirements for the additional class notations **Cleanvessel**, and other additional class notations listed in Tab 1 are given in Pt A, Ch 3, Sec 9.

This Article contains additional requirements applying to the additional class notations **Cleanvessel**.

4.2 Periodical tests and measurements done by the vessel Owner

4.2.1 Purpose

The following tests and measurements, done under the responsibility of the vessel Owner, are intended to demonstrate the effective implementation of the waste management procedures and the constant level over time kept by the quality of the effluents discharged at water.

4.2.2 Initial period - Initial tests

During the first year of commercial operation, the vessel Owner is to proceed with the following measurements and analyses:

- collection of actual on board data's concerning the volume of wastes generation, using the waste streams as defined in NR467, Pt F, Ch 9, Sec 2, Tab 1.
- analyses of the effluent and waste streams for pollutant concentration, according to the periodicity defined in Tab 2.

Table 2 : Frequency of analyses of waste streams during the first year of service

Waste stream	Frequency of analyses
Metals analyses in incinerator ash **(1)**	quarterly
Metals analyses in grey water	quarterly
Effluent analyses sewage treatment plan	yearly
Effluent analyses for Advanced Wastewater Treatment	quarterly
(1) If the vessel is equipped to dump incinerator ash overboard.	

Table 3 : Frequency of analyses of waste streams after the first year of service

Waste stream	Number of analyses in a 5-year period
Metals analyses in incinerator ash **(1)**	2
Metals analyses in grey water	2
Effluent analyses sewage treatment plan	2
Effluent analyses for Advanced Wastewater Treatment	20
Oil content analyses of machinery bilge water	2
(1) If the vessel is equipped to dump incinerator ash overboard.	

4.2.3 Periodical tests after first year of service

The effluents and wastes usually discharged to water are to be periodically sampled and analyzed by a qualified laboratory. The frequency of these tests in a five-year term period is specified in Tab 3.

Table 4 : Permissible number of analyses exceeding limit values

Number of analyses in a 5-year period	Maximum number of analyses above limit
2-5	0
20	2

Table 5 : Biological analyses standard for waters

Water to be tested	Pollutant	Limit concentration	Reject value
Effluent of oil filtering equipment	Oil	15 ppm	–
Effluent of sewage treatment plant	Thermotolerant coliforms (TC)	100 TC/100 ml	–
	Total suspended solids (TSS)	35 mg/l	–
	5-day biochemical oxygen demand (BOD_5) **(1)**	25 mg/l	–
	Chemical oxygen demand (COD)	125 mg/l	–
Effluent of AWT unit (for ships having the additional class notation **AWT**	5-day biochemical oxygen demand (BOD_5) **(1)**	25 mg/l	60 mg/l
	Chemical oxygen demand (COD)	125 mg/l	–
	Total nitrogen	20 mg/l	–
	Total phosphorus	1.0 mg/l	–

(1) BOD_5 is the amount, in milligrams per litre, of oxygen used in the biochemical oxidation of organic matter in five days at 20°C.

Tab 4 lists the number of occurrences where the pollutant maximum concentration may exceed the limit concentration specified in Tab 5 and Tab 6, without exceeding the reject value.

Test results of the measurements are to be recorded in the wastewater and garbage logbooks and made available to the surveyor during the periodical surveys.

4.2.4 Water effluent standard

The effluent standard for biological analyses of waters are given in Tab 5.

4.2.5 Metals analyses

The analyses given in Tab 6 are to qualify the incinerator ash and grey water as free from hazardous wastes. The metals listed in Tab 6 are considered as indicators of toxicity.

4.3 Periodical surveys

4.3.1 Initial survey Tests

After installation on board, the equipment and systems relevant to the requirements of the present Section are to be tested in the presence of the Surveyor under operating conditions. The control, monitoring and alarm systems are also to be tested in the presence of the Surveyor or their functioning is to be simulated according to a procedure agreed with the Society.

4.3.2 Periodical survey

The periodical surveys are to be carried out in accordance with the provisions of Pt A, Ch 3, Sec 9, [3].

Table 6 : Detection of heavy metalsin ashes and water

Metal	Limit concentration (ppm)
Arsenic	0,3
Barium	4,0
Cadmium	0,3
Chromium	5,0
Lead	1,5
Mercury	0,01
Selenium	0,3
Silver	0,2

SECTION 12 ESTUARY PLUS

Symbols

h_2 : Reference value, in m, of the relative motion in the inclined vessel condition in Pt B, Ch 3, Sec 3, [2.2.1]

γ_{W1} : Partial safety factor covering uncertainties regarding wave hull girder loads

$\gamma_{W1} = 1,15$

M_H : Design still water bending moment in hogging condition, in kN.m, defined in Pt B, Ch 3, Sec 2, [1]

M_S : Design still water vertical bending moment in sagging condition, in kN.m, defined in Pt B, Ch 3, Sec 2, [1]

M_{WV} : Vertical wave bending moment, in kN.m, defined in Pt B, Ch 3, Sec 2, [3.2]

M_{WH} : Horizontal wave bending moment, in kN.m, to be determined according to Pt B, Ch 3, Sec 2, [3.3]

I_Y : Net moment of inertia, in cm^4, of the hull transverse section defined in Pt B, Ch 4, Sec 1, [2.1] around the horizontal neutral axis

I_z : Net moment of inertia, in cm^4, of the hull transverse section defined in Pt B, Ch 4, Sec 1, [2.1] around the vertical neutral axis

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section

y : Y co-ordinate, in m, of the calculation point

z : Z co-ordinate, in m, of the calculation point

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the navigation notation **Estuary plus**, as defined in Pt A, Ch 1, Sec 3, [12.3].

1.1.2 Vessels dealt with in this Section are to comply with the requirements stipulated in Part A, Part B and Part C of the Rules, as applicable, and with the requirements of this Section, which are specific to **Estuary plus** vessels.

1.1.3 Sea-keeping characteristics will be specially considered by the Society in the case of vessels of unusual design e.g.:

- vessel without any bilge keel
- vessel with an unusual hull shape.

2 Vessel design

2.1 Bilge keel

2.1.1 If fitted, the bilge keel is to comply with the requirements as defined in [2.1.2], [2.1.3], [2.1.4] and [2.1.5].

2.1.2 Arrangement

Bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The ends of the bilge keel are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

2.1.3 Materials

The bilge keel and the intermediate flat are to be made of steel with the same yield stress and grade as that of the bilge strake.

2.1.4 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm.

2.1.5 Welding

Welding of bilge keel and intermediate plate connections is to be in accordance with Pt B, Ch 8, Sec 2, [3.2].

2.2 Fore part

2.2.1 The minimum draught at the most forward point of the keel, T_{min}, is not to be less than:

$$T_{min} = 1,1\ h_2$$

2.2.2 Vessels not complying with [2.2.1] will be specially considered by the Society.

2.3 Hull integrity

2.3.1 The safety clearance of the lowest non-weathertight opening is to be greater than $1,5\ h_2$.

2.3.2 The freeboard, in m, is not to be less than:

$$F_B = 1,5 h_2 - 0,95$$

2.3.3 The bow height defined as the vertical distance at the forward perpendicular between the waterline and the top of the exposed deck shall not be less than 1,5 h_2. The bow height may be obtained through:

- a sheer extending for at least 0,15L measured from the forward perpendicular, or
- a raised forecastle deck extending from the stem to a point at least 0,07L abaft the forward perpendicular.

2.3.4 A forecastle bulwark complying with [2.4] extending from the stem to a point at least 0,07L abaft the forward perpendicular may be taken into account in the assessment according to [2.3.3], at the Society's discretion.

2.3.5 The angle of roll θ_R is to be limited as follows:

$$\theta_R \leq 2\theta_f/3$$

θ_R : Angle of roll, in degree, defined in [5.2.1]

θ_f : Angle of heel, in degree, defined in [5.2.1]

In all cases, the angle of roll θ_R shall not exceed 15°.

2.4 Bulwarks and guard rails

2.4.1 General requirements of Pt B, Ch 7, Sec 2 are to be complied with.

2.4.2 The height of the bulwarks or guard rails is to be at least 1 m from the deck. However, where their height would interfere with the normal operation of the vessel, a lesser height may be accepted, if adequate protection is provided and subject to any applicable statutory requirement.

2.4.3 Where bulwarks on the weather deck form a well, provisions are to be made for rapidly freeing the deck from water. The minimum required freeing port areas in bulwarks on the freeboard deck, on each side, are to be obtained as follows:

$$A_{fp} = 0,029 n l_B h_B$$

A_{fp} : Area of freeing ports, in m²

l_B : Length, in m, of bulwark in a well at one side of the vessel

h_B : Mean height, in m, of bulwark in a well of length l_B.

n : Navigation coefficient defined in Pt B, Ch 3, Sec 1, [5.2]

The lower edges of the freeing ports shall be as near the deck as practicable. All the openings in the bulwark are to be protected by rails or bars spaced approximately 230 mm apart.

Where a sheer is provided, two thirds of the freeing port area required shall be provided in the half of the well nearest the lowest point of the sheer curve. Where the exposed freeboard deck or an exposed forecastle deck has little or no sheer, the freeing port area is to be spread along the length of the well.

3 Design loads

3.1 General

3.1.1 General requirements of Part B, Chapter 3 are to be complied with.

3.1.2 Wind pressure

Wind pressure, in N/m², is to be obtained by use of the wind force as provided by the relevant administration or the harbour master.

The Society reserves the rights to impose a reasonable wind force if necessary.

4 Hull scantlings

4.1 General

4.1.1 The scantling is to be carried out according to relevant Sections in Part B, Chapter 5 and Part B, Chapter 6 using the load model defined in Pt B, Ch 2, Sec 5, [3].

4.1.2 Depending on the hull structural configuration and loading conditions, the Society may require stresses resulting from torsion analysis to be taken into account.

4.2 Load model

4.2.1 General

The wave lateral pressures and hull girder loads are to be calculated in mutually exclusive load cases "a", "b", "c" and "d" defined in Pt B, Ch 3, Sec 1, [4].

4.2.2 Hull girder normal stresses

The hull girder normal stresses to be considered for the strength check of plating, ordinary stiffeners and primary supporting members are obtained, in N/mm², from the following formulae:

- in general

  $$\sigma_{X1} = \sigma_{S1} + \gamma_{W1}(C_{FV}\sigma_{WV1} + C_{FH}\sigma_{WH})$$

- for structural members not contributing to the hull girder longitudinal strength:

  $\sigma_{X1} = 0$

- In flooding conditions:

  $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV}, σ_{WH} : Hull girder normal stresses, in N/mm², defined in:

- Tab 2, for plating subjected to lateral loads
- Tab 3, for plating in-plane hull girder compression normal stresses
- Tab 4, for ordinary stiffeners and primary supporting members subjected to lateral pressure
- Tab 5, for ordinary stiffeners and primary supporting members subjected to wheeled loads

C_{FV}, C_{FH} : Combination factors defined in Tab 1

Table 1 : Combination factors C_{FV} and C_{FH}

Load case	C_{FV}	C_{FH}
"a"	0	0
"b"	1,0	0
"c"	0,4	1,0
"d"	0,4	1,0

Table 2 : Hull girder normal stresses - Plating subjected to lateral loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²	σ_{WH}, in N/mm²
$\frac{\lvert M_S + 0{,}625\gamma_{W1}C_{FV}M_{WV}\rvert}{M_H + 0{,}625\gamma_{W1}C_{FV}M_{WV}} \geq 1$	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WH}}{I_Z}y\right\rvert 10^{-3}$
$\frac{\lvert M_S + 0{,}625\gamma_{W1}C_{FV}M_{WV}\rvert}{M_H + 0{,}625\gamma_{W1}C_{FV}M_{WV}} < 1$	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.			

Table 3 : In-plane hull girder compression normal stresses - Plating

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²	σ_{WH}, in N/mm²
$z \geq N$	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WH}}{I_Z}y\right\rvert 10^{-3}$
$z < N$	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.			

Table 4 : Hull girder normal stresses - Ordinary stiffeners and primary supporting members subjected to lateral pressure

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²	σ_{WH}, in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:			$\left\lvert\frac{0{,}625 M_{WH}}{I_Z}y\right\rvert 10^{-3}$
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
Lateral pressure applied on the same side as the ordinary stiffener:			
• $z \geq N$ in general ; $z < N$ for stiffeners simply supported at both ends	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
• $z < N$ in general ; $z \geq N$ for stiffeners simply supported at both ends	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.			

Table 5 : Hull girder normal stresses - Ordinary stiffeners and primary supporting members subjected to wheeled loads

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²	σ_{WH}, in N/mm²
Hogging	$\left\lvert\frac{M_H}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WH}}{I_Z}y\right\rvert 10^{-3}$
Sagging	$\left\lvert\frac{M_S}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{0{,}625 M_{WV}}{I_Y}(z-N)\right\rvert 10^{-3}$	
(1) When the vessel in still water is always in hogging condition, M_S is to be taken equal to 0.			

5 Intact stability

5.1 Design criteria

5.1.1 GZ curve area

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

In case that the angle of down-flooding θ_f is less than 30°, the area under the righting lever curve (GZ curve) shall not be less than 0,09 m.rad up to θ_f.

5.1.2 Minimum righting lever

The righting lever GZ shall be at least 0,2 m at an angle of heel equal to or greater than min(30°, θ_f).

5.1.3 Angle of maximum righting lever

The maximum righting lever shall occur at an angle of heel not less than min(25°, θ_f).

5.1.4 Angle of down-flooding

The angle of down-flooding θ_f shall be not less than 17°.

5.1.5 Initial metacentric height

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

5.2 Severe wind and rolling criterion (weather criterion)

5.2.1 The ability of a vessel to withstand the combined effects of beam wind and rolling shall be demonstrated, with reference to Fig 1 as follows:

a) The vessel is subjected to a steady wind pressure acting perpendicular to the vessel's centerline which results in a steady wind heeling lever (ℓ_{w1});

b) From the resultant angle of equilibrium (θ_0), the vessel is assumed to roll owing to wave action to an angle of roll (θ_1) to windward. The angle of heel under action of steady wind (θ_0) should not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

c) The vessel is then subjected to a gust wind pressure which results in a gust wind heeling lever (ℓ_{w2}); and

d) Under these circumstances, area "b" shall be equal to or greater than area "a" as indicated in Fig 1

where the angles are defined as follows:

θ_0 : Angle of heel, in degree, under action of steady wind

θ_1 : Angle of roll, in degree, to windward due to wave action

$$\theta_1 = \theta_R + \theta_0$$

θ_R : Angle of roll, in degree

$$\theta_R = 1,5\frac{180}{\pi}A_R$$

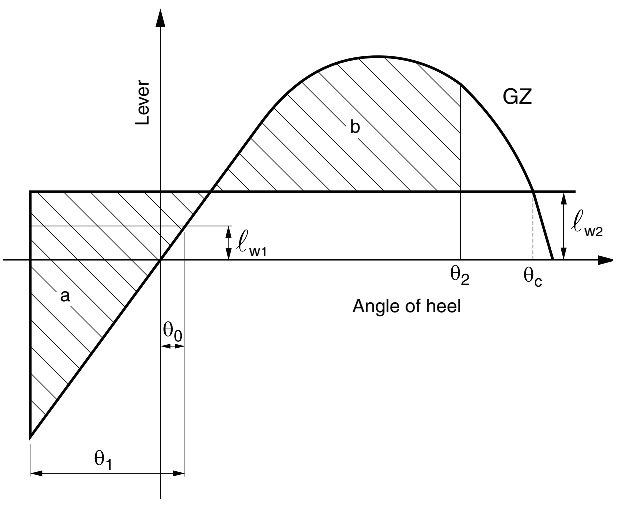
A_R : Roll amplitude, in radian, defined in Pt B, Ch 3, Sec 3, [2.1.4]

θ_2 : Angle of down-flooding (θ_f) or 50° or θ_c, whichever is less

θ_f : Angle of heel, in degree, at which the first unprotected opening is immersed

θ_c : Angle of second intercept between wind heeling lever ℓ_{w2} and GZ curves.

Figure 1 : Severe wind and rolling



5.2.2 The wind heeling levers ℓ_{w1} and ℓ_{w2} referred to in [5.2.1] a) and [5.2.1] c) are constant values at all angles of inclination and shall be calculated as follows:

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

$$\ell_{W2} = 2\ell_{W1}$$

where

P : Wind pressure, in N/m², as defined in [3.1.2]

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

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

Δ : Displacement in t

g : Gravitational acceleration of 9.81 m/s²

6 Machinery and systems

6.1 Propulsion

6.1.1 The vessel shall be equipped with two independent propulsion systems. The main propulsion system shall enable the vessel to reach a speed of at least 15 km/h. The auxiliary propulsion system shall enable the vessel to reach a speed of 7 km/h.

6.2 Main propulsion shafting

6.2.1 Shaft - Scantling

Scantlings of main propulsion shafting is to comply with applicable provisions of Pt C, Ch 1, Sec 7, [2.2] using the factor for type of propulsion installation as indicated below:

- F = 95 for intermediate and thrust shafts in turbine installations, diesel installations with hydraulic (slip type) couplings and electric propulsion installations
- F = 100 for all other diesel installation and all propeller shafts

6.3 Bilge system

6.3.1 A fixed bilge system with two independent pumps shall be provided. The capacity of each pump shall be as specified in Pt C, Ch 1, Sec 10, [6.7.4]. For each open cargo hold, a supplementary bilge pump shall be provided whose capacity shall be equal to the one of the two above-mentioned pumps. Each open cargo hold shall be fitted with a bilge level alarm.

7 Electrical installations

7.1 Power source

7.1.1 The power supply system shall comprise two generator sets. Each generator set shall be capable of supplying all essential consumers in case that the other generator set is defect. The two generator sets shall not be located in the same room.

8 Surveys

8.1 Survey requirements

8.1.1 In addition to applicable provisions of Pt A, Ch 3, Sec 3 to Pt A, Ch 3, Sec 9, vessels assigned with the notation **Estuary plus** shall be submitted to annual survey and intermediate survey complying with the requirements prescribed in Ch 2, Sec 9. The additional class notation **Annual survey** will be assigned in accordance with Pt A, Ch 1, Sec 3, [11.1].

Part D
Additional Requirements for Notations

Chapter 3
TRANSPORT OF DANGEROUS GOODS

SECTION 1	GENERAL
SECTION 2	DG-G
SECTION 3	DG-C
SECTION 4	DG-N
SECTION 5	OIL SEPARATOR VESSEL
SECTION 6	SUPPLY VESSEL
SECTION 7	TRANSPORT OF DRY DANGEROUS GOODS
SECTION 8	DGL
SECTION 9	DGD
APPENDIX 1	DEFINITIONS
APPENDIX 2	ADDITIONAL REQUIREMENTS CONCERNING CARRIAGE OF DRY CARGOES
APPENDIX 3	LIST OF DANGEROUS GOODS ACCEPTED FOR CARRIAGE IN TANK VESSELS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 The requirements of this Chapter apply to vessels intended for the carriage of dangerous goods.

1.1.2 Vessels dealt with in this Chapter are to comply with the requirements stated under Part A, Part B and Part C, as applicable.

1.1.3 Additional measures and Regulations containing the provisions dealing with:

- loading, carriage, unloading and handling of cargo
- vessel crews, equipment, operation and documentation
- vessel construction,

are also to be complied with.

1.1.4 Alternative arrangements and/or constructions, e.g. :

- arrangement for double hull construction
- design of electrical installations,

will be specially considered by the Society on a case-by-case basis, taking into account the level of encountered risks in handling and transporting dangerous substances intended to be carried together with anticipated counter-measures.

1.1.5 General or specific definitions used for the purposes of these Rules are given in Ch 3, App 1.

2 Classification

2.1 Classification of dangerous goods

2.1.1 In UN Model Regulations defined in Ch 3, App 1, [1.39], dangerous goods are assigned to different classes. Each class defines one type of dangerous goods. In some classes divisions are defined. The numerical order of the classes and divisions is not that of the degree of danger.

The classes defined in UN Model Regulations are given in Tab 1.

3 Carriage of dry cargoes

3.1 Mode of carriage of goods

3.1.1 Carriage of packages

Unless otherwise specified, the masses given for packages shall be the gross masses. When packages are carried in containers or vehicles, the mass of the container or vehicle shall not be included in the gross mass of such packages.

3.1.2 Carriage in containers, in intermediate bulk containers (IBCs) and in large packagings, in MEGCs, in portable tanks and in tank-containers

The carriage of containers, IBCs, large packagings, MEGCs, portable tanks and tank containers shall be in accordance with the provisions of the statutory Regulations or a recognized standard applicable to the carriage of packages.

Table 1 : Classification of dangerous goods

Class	Description
Class 1	Explosives
1.1	Substances and articles which have a mass explosion hazard
1.2	Substances and articles which have a projection hazard but not a mass explosion hazard
1.3	Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard
1.4	Substances and articles which present no significant hazard
1.5	Very intensive substances which have a mass explosion hazard
1.6	Extremely intensive articles which do not have a mass explosion hazard
Class 2	Gases
2.1	Flammable gases
2.2	Non-flammable, non-toxic gases
2.3	Toxic gases
Class 3	Flammable liquids
Class 4	Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases
4.1	Flammable solids, self-reactive substances and solid desensitized explosives
4.2	Substances liable to spontaneous combustion
4.3	Substances which in contact with water emit flammable gases
Class 5	Oxidizing substances and organic peroxides
5.1	Oxidizing substances
5.2	Organic peroxides
Class 6	Toxic and infectious substances
6.1	Toxic substances
6.2	Infectious substances
Class 7	Radioactive material
Class 8	Corrosive substances
Class 9	Miscellaneous dangerous substances and articles

3.1.3 Vehicles and wagons

The carriage of vehicles and wagons shall be in accordance with the provisions of the statutory Regulations or a recognized standard applicable to the carriage of packages.

3.1.4 Carriage in bulk

The dangerous goods may be carried in bulk only if permitted by the applicable provisions of the statutory Regulations or a recognized standard.

3.2 Permitted vessels

3.2.1 Dangerous goods may be carried in quantities not exceeding those indicated in Ch 3, App 2, [1.1.1], or, if applicable, in Ch 3, App 2, [1.1.3], in dry cargo vessels complying with Ch 3, Sec 7, [1] to Ch 3, Sec 7, [5].

3.2.2 Dangerous goods of classes 2, 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1, 7, 8 or 9 may be carried in quantities greater than those indicated in Ch 3, App 2, [1.1.1] and Ch 3, App 2, [1.1.3], in double hull dry cargo vessels complying with Ch 3, Sec 7.

3.3 Pushed convoys and side-by-side formations

3.3.1 Where a convoy or side-by-side formation comprises at least one vessel carrying dry dangerous goods, the requirements [3.3.2] to [3.3.3] apply.

3.3.2 The Vessels carrying dangerous goods shall comply with the requirements of Ch 3, Sec 7. See also [3.2.1] and [3.2.2].

3.3.3 The propulsion vessel and vessels not carrying dangerous goods shall comply with the requirements of Ch 3, Sec 9.

3.4 Materials of construction

3.4.1 The vessel's hull and the cargo holds must be constructed of hull structural steel conforming to the applicable requirements of NR216 Materials and Welding. See also Pt B, Ch 2, Sec 3.

4 Carriage of liquid cargoes

4.1 Carriage in cargo tanks

4.1.1 General

Substances, their assignment to the various types of tank vessels and the special conditions for their carriage in these tank vessels, are listed in Ch 3, App 3, Tab 2.

4.1.2 Substances which, according to column (6) of Ch 3, App 3, Tab 2, have to be carried in a tank vessel of N type open, may also be carried in a tank vessel of N type open with flame arresters, N type closed, C type or G type provided that all other conditions of carriage prescribed for tank vessels of N type open, as well as all other conditions of carriage required for these substances in Ch 3, App 3, Tab 2 are met.

4.1.3 Substances which, according to column (6) of Ch 3, App 3, Tab 2, have to be carried in a tank vessel of N type open with flame arresters, may also be carried in tank vessels of N type closed, C type or G type provided that all other conditions of carriage prescribed for tank vessels of N type open with flame arresters, as well as all other conditions of carriage required for these substances in Ch 3, App 3, Tab 2 are met.

4.1.4 Substances which, according to column (6) of Ch 3, App 3, Tab 2, have to be carried in a tank vessel of N type closed, may also be carried in tank vessels of C type or G type provided that all other conditions of carriage prescribed for tank vessels of N type closed, as well as all other conditions of carriage required for these substances in Ch 3, App 3, Tab 2 are met.

4.1.5 Substances which, according to column (6) of Ch 3, App 3, Tab 2, have to be carried in a tank vessel of C type may also be carried in tank vessels of G type provided that all other conditions of carriage prescribed for tank vessels of C type as well as all other conditions of carriage required for these substances in Ch 3, App 3, Tab 2 are met.

4.1.6 Oily and greasy wastes resulting from the operation of the vessel may only be carried in fire resistant receptacles, fitted with a lid, or in cargo tanks.

4.1.7 A substance which, according to column (8) of Ch 3, App 3, Tab 2, must be carried in cargo tank type 2 (integral cargo tank), may also be carried in a cargo tank type 1 (independent cargo tank) or cargo tank type 3 (cargo tank with walls distinct from the outer hull) of the vessel type prescribed in Ch 3, App 3, Tab 2 or a vessel type prescribed in [4.1.2] to [4.1.5], provided that all other conditions of carriage required for this substance by Ch 3, App 3, Tab 2 are met.

4.1.8 A substance which, according to column (8) of Ch 3, App 3, Tab 2, must be carried in cargo tank type 3 (cargo tank with walls distinct from the outer hull), may also be carried in a cargo tank type 1 (independent cargo tank) of the vessel type prescribed in Ch 3, App 3, Tab 2 or a vessel type prescribed in [4.1.2] to [4.1.5] or in a C type vessel with cargo tank type 2 (integral cargo tank), provided that at least the conditions of carriage concerning the prescribed N type are met and all other conditions of carriage required for this substance by Ch 3, App 3, Tab 2 or [4.1.2] to [4.1.5] are met.

4.2 Carriage of dangerous substances not listed in Ch 3, App 3, Tab 2

4.2.1 The requirements of this Chapter are also applicable to substances, which may be considered to come within the scope of these Rules, but are not at present listed in Ch 3, App 3, Tab 2.

Depending on the tank vessel design, construction and equipment, the Society may authorize the carriage of these substances, if their handling and transport conditions are found satisfactory.

4.3 Permitted vessels

4.3.1 Dangerous goods may be carried in tank vessels of N type, C type or G type in accordance with the applicable requirements of Ch 3, Sec 2 to Ch 3, Sec 6. The type of tank vessel to be used is specified in Ch 3, App 3, Tab 2 and in [4.1].

4.3.2 The substances accepted for carriage in the vessel will be indicated in a list issued by the Society.

The compatibility of the accepted dangerous goods with all the construction materials of the vessel, including installations and equipment, which come into contact with the cargo, is outside of the classification scope and remains the responsibility of the vessel Owner.

4.3.3 The relief pressure of the safety valves or of the high-velocity vent valves, the design pressure and the test pressure of cargo tanks will be indicated.

4.4 Pushed convoys and side-by-side formations

4.4.1 Where a convoy or side-by-side formation comprises at least one vessel carrying liquid dangerous goods, the requirements [4.4.2] to [4.4.4] apply.

4.4.2 The Vessels carrying dangerous goods shall comply with the requirements of [4.3].

4.4.3 The propulsion vessel shall comply with the requirements of Ch 3, Sec 8.

4.4.4 The vessels not carrying dangerous goods shall comply with the requirements of Ch 3, Sec 9.

4.5 Types of tank vessels

4.5.1 Tank vessel varieties

The tank vessel type, cargo tank design and cargo tank type are to be determined in compliance with Ch 3, App 3, Tab 2.

The basic tank types and their structural configuration are defined in Tab 2, where Txy is defined as follows:

T : Type of tank vessel, equal to (see Ch 3, App 3, Tab 2, column (6)):

- G for DG-G tank vessel
- C for DG-C tank vessel
- N for DG-N tank vessel

x : Cargo tank design, equal to (see Ch 3, App 3, Tab 2, column (7)):

- 1 for pressure tank
- 2 for closed cargo tank
- 3 for open cargo tank with flame arrester
- 4 for open cargo tank

y : Cargo tank type, equal to (see Ch 3, App 3, Tab 2, column (8)):

- 1 for independent cargo tank
- 2 for integral cargo tank
- 3 for cargo tank with walls distinct from the outer hull.
- 4 for membrane cargo tank.

4.6 Pressure cargo tanks

4.6.1 Scantling and arrangements of pressure cargo tanks are to be in compliance with Pt C, Ch 1, Sec 3.

Table 2 : Tank vessel varieties

Type of tank vessel	Description	Configuration Txy	Structural configuration	Remarks
DG-G	Carriage of gases	G11	Ch 1, Sec 3, Fig 3, Sketches b and c	double hull
		G21	Ch 1, Sec 3, Fig 3	
		G24	Ch 1, Sec 3, Fig 3 Ch 1, Sec 3, Fig 4	double hull
DG-C	Carriage of liquids • flush deck • double hull	C11	Ch 1, Sec 3, Fig 3, Sketch c	double hull
		C21	Ch 1, Sec 3, Fig 3, Sketches c and d	double hull
		C22	Ch 1, Sec 3, Fig 2, Sketch b	double hull
DG-N	Carriage of liquids	N11	Ch 1, Sec 3, Fig 3	
		N21		
		N31		
		N41		
		N22	Ch 1, Sec 3, Fig 1	single hull
		N23	Ch 1, Sec 3, Fig 2	double hull
		N32	Ch 1, Sec 3, Fig 1	single hull
		N33	Ch 1, Sec 3, Fig 2	double hull
		N42	Ch 1, Sec 3, Fig 1	single hull
		N43	Ch 1, Sec 3, Fig 2	double hull

4.7 Blanketing of the cargo and inerting

4.7.1 In cargo tanks and the corresponding piping, inerting in the gaseous phase or blanketing of the cargo may be necessary. Inerting and blanketing of the cargo are defined in [4.7.2] and [4.7.3].

4.7.2 Inerting

Cargo tanks and the corresponding piping and other spaces for which inerting is prescribed in column (20) of Ch 3, App 3, Tab 2 are filled with gases or vapours which prevent combustion, do not react with the cargo and maintain this state.

4.7.3 Blanketing

Spaces in the cargo tanks above the cargo and the corresponding piping are filled with a liquid, gas or vapour so that the cargo is separated from the air and this state is maintained.

4.8 Materials of construction

4.8.1 The vessel's hull and the cargo tanks must be constructed of hull structural steel conforming to the applicable requirements of NR216 Materials and Welding (see also Pt B, Ch 2, Sec 3) or other at least equivalent metal.

Table 3 : Permitted materials in the cargo area

	Wood	Aluminium alloys	Plastic materials	Rubber
Gangways	x	x	x	x
External ladders and passageways (gangways) **(1)**		x	x	x
Cleaning equipment, e.g. brooms	x		x	x
Movable equipment e.g. fire extinguishers, portable gas detectors, rescue winches		x	x	x
Fenders	x		x	x
Mooring cables, fender ropes			x	
Chocking of cargo tanks which are independent of the vessel's hull and chocking of installations and equipment	x		x	
Masts and similar round timber	x	x	x	
Engine parts		x	x	
Protective covers of engines and pumps			x	
Parts of the electrical installation		x	x	
Parts of the loading and unloading installation, e.g., gaskets		x	x	x
Boxes, cabinets or other receptacles placed on the deck for storage of disposal and recovery equipment for capstans, extinguishers, fire hoses, waste, etc.		x	x	
Supports and stops of any kind	x		x	
Ventilators, including hose assemblies for ventilation		x	x	
Parts of the water spray system, the shower and the eye and face bath		x	x	
Insulation of cargo tanks and of piping for loading and unloading, gas discharge pipes and heating pipes			x	x
Coating of cargo tanks and of piping for loading and unloading		x	x	x
All kinds of gaskets (e.g. for dome or hatch covers)			x	x
Cables for electrical equipment			x	x
Mat under hose assemblies for loading and unloading piping system			x	x
Fire hoses, air hoses, hoses for cleaning the deck, etc.			x	x
Sampling equipment and bottles			x	
Drip trays			x	

Note 1: Aluminium gauging rods are permitted, provided that they are fitted with brass feet or protected in another way to avoid sparking.

(1) The use of aluminium alloys or plastic material for passageways (gangways) in the cargo area is permitted only if the material does not readily ignite or conduct electricity.

4.8.2 The independent cargo tanks and membrane cargo tanks may also be constructed of other materials provided these have at least equivalent mechanical properties and resistance against the effects of temperature and fire.

For membrane tanks, the equivalence for resistance against the effect of temperature and fire is deemed to be proven where the materials of the membrane tanks fulfill the following requirements:

- they withstand the range between the maximum temperature in service and 5°C below the minimum design temperature, but not lower than - 196°C, and
- they are fire-resistant or protected by a suitable system such as a permanent inert gas environment or provided with a fire retardant barrier.

4.8.3 Every part of the vessel including any installation and equipment which may come into contact with the cargo shall consist of materials which can neither be dangerously affected by the cargo nor cause decomposition of the cargo or react with it so as to form harmful or hazardous products.

4.8.4 Venting pipes and gas discharge pipes shall be protected against corrosion.

4.8.5 The use of wood, aluminium alloys, plastic materials or rubber in the cargo area is permitted only for items indicated in Tab 3.

4.8.6 All permanently fitted materials in the accommodation or wheelhouse, with the exception of furniture, shall not readily ignite. They shall not evolve fumes or toxic gases in dangerous quantities, if involved in a fire.

4.8.7 The paint used in the cargo area shall not be liable to produce sparks in case of impact.

4.8.8 The use of plastic material for vessel's boats is permitted only if the material does not readily ignite.

5 Certification, inspection and testing of cargo system

5.1 Application

5.1.1 The provisions of this Article are related to cargo piping and other equipment fitted in the cargo area. They supplement those given in Pt C, Ch 1, Sec 10, [20] for piping systems.

5.2 Type approval

5.2.1 The following cargo system equipment and installations are subject to type approval:

- expansion joints and cargo hoses
- gas-tight penetration glands
- cargo tank P/V and high velocity valves: to be tested according to Standard ISO 16852 (2016) or equivalent standard
- gas detection system
- instrumentation
- fans for enclosed spaces
- insulation materials
- safety relief valves
- flame arresters: to be tested according to Standard ISO 16852 (2016) or equivalent standard.

Inspection and testing at works are to be carried out according to [5.3].

5.3 Workshop tests

5.3.1 Tests for materials

Materials used for pipes, valves and fittings are to be subjected to the tests specified in Pt C, Ch 1, Sec 10, [20.3].

5.3.2 Inspection of welded joints

Welded joints are to be subjected to the examinations specified in Pt C, Ch 1, Sec 10, [20.3] for class II pipes.

5.3.3 Hydrostatic testing

a) Cargo pipes, valves, fittings and pump casings are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [20.4].

b) Expansion joints and cargo hoses are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [20.4].

c) Where fitted, bellow pieces of gas-tight penetration glands are to be pressure tested.

5.3.4 Tightness tests

Tightness of the following devices is to be checked:

- gas-tight penetration glands
- cargo tank P/V and high velocity valves.

Note 1: These tests may be carried out in the workshops or on board.

5.3.5 Check of the safety valves setting

The setting pressure of the pressure/vacuum valves is to be checked with regard to applicable Society’s Rules.

5.3.6 Summarising table

Inspections and tests required for cargo piping and other equipment fitted in the cargo area are summarised in Tab 4.

5.4 On board tests

5.4.1 Pressure test

After installation on board, the cargo piping system is to be checked for leakage under operational conditions.

Table 4 : Inspection and testing at works

No.	Item	Tests for materials		Inspections and tests for the products			References to this Section
		Y/N **(1)**	Type of material certificate **(2)**	during manufacturing **(1)**	after completion **(1) (3)**	Type of product certificate **(2)**	
1	Pipes, valves and fittings (liquid cargo)	Y	C where ND > 100 mm W where ND ≤ 100 mm	Y **(4)**	Y	C	[5.3.1] [5.3.1] [5.3.2] [5.3.3] **(7)**
2	Pipes, valves and fittings (liquefied gas)	Y	C where ND > 100 mm W where ND ≤ 100 mm	Y **(4)**	Y	C	[5.3.1] [5.3.1] [5.3.2] [5.3.3]
3	Expansion joints and cargo hoses	Y **(5)**	W	N	Y	C	[5.3.1] [5.3.3]
4	Cargo pumps (liquid cargo)	Y	C for cast body W for welded construction	Y **(6)**	Y	W	**(6)** [5.3.3]
5	Cargo pumps (liquefied gas)	Y	C for cast body W for welded construction	Y **(6)**	Y	C	**(6)** [5.3.3] **(7)**
6	Compressors	Y	C for cast body W for welded construction	Y **(6)**	Y	C	**(6)** [5.3.3]
7	Gas-tight penetration glands	N		N	Y	C	[5.3.3], [5.3.4] **(7)**
8	Cargo tank P/V and high velocity valves	Y	W	Y	Y	C	[5.3.1] [5.3.2] [5.3.3], [5.3.4] **(7)**
9	Flame arresters	N		N	Y	C	**(3)** **(7)**

No.	Item	Tests for materials		Inspections and tests for the products			References to this Section
		Y/N **(1)**	Type of material certificate **(2)**	during manufacturing **(1)**	after completion **(1)** **(3)**	Type of product certificate **(2)**	
10	Gas detection system	N		N	Y	C	**(7)**
11	Instrumentation	N		N	Y	C	**(7)**
12	Fans for enclosed spaces	N		N	Y	W	

(1) Y = required, N = not required.
(2) C = class inspection certificate, W = works' certificate.
(3) Includes the checking of the rule characteristics according to the approved drawings.
(4) Only in the case of welded construction.
(5) If metallic.
(6) Inspection during manufacturing is to be carried out according to a program approved by the Society.
(7) Or alternative type of certificate, depending on the survey scheme.

SECTION 2 DG-G

Symbols

L_{OA} : Length overall, in m, defined in: Pt B, Ch 1, Sec 2, [2.5]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional service feature **DG-G**, as defined in Pt A, Ch 1, Sec 3, [3.2.13].

1.1.2 These Rules apply in addition to Ch 3, Sec 1 and Ch 1, Sec 3.

1.2 Applicable rule requirements

1.2.1 For scantling of the hull of vessels with inserted tanks, see Ch 1, Sec 3, [6.1.1].

1.2.2 The design and construction of pressure tanks is to conform to Pt C, Ch 1, Sec 3.

1.3 Documents to be submitted

1.3.1 Tab 1 lists the plans and information to be submitted in addition to those required in the other Parts of the Rules for the vessel parts not affected by the cargo, as applicable.

1.4 Definitions

1.4.1 Design pressure

The design pressure p_0 is defined in Ch 3, App 1, [1.14].

For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, p_0 is not to be less than the gauge vapour pressure of the cargo at a temperature of 40°C.

In all cases p_0 is not to be less than MARVS.

1.4.2 Design temperature

The design temperature for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks. Provisions to the satisfaction of the Society are to be made that the tank or cargo temperature cannot be lowered below the design temperature.

1.4.3 MARVS

MARVS is the maximum allowable relief valve setting of a cargo tank.

2 Vessel arrangement

2.1 Protection against the penetration of dangerous gases and the spreading of dangerous liquids

2.1.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.1.2 Liquid-tight protective coamings shall be fitted on deck at the height of the external bulkheads of the cargo tanks, at a maximum distance of 0,60 m from the outer cofferdam bulkheads or the hold end bulkheads. The protective coamings shall either extend over the entire width of the vessel or be fixed between the longitudinal spill coamings so as to prevent liquids from entering the forepeak and afterpeak. The height of the protective coamings and the spill coamings shall be at least 0,075 m. The protective coaming may correspond to the protection wall prescribed in [2.1.3] if the protection wall extends across the entire width of the vessel.

2.1.3 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the use of installations and equipment that are not of at least the “limited explosion risk” type is not permitted during loading and unloading operations in parts of the deck outside the cargo area, unless those parts are protected against the entry of gases and liquids by a gas- and liquid-tight protection wall. The wall must either extend from one side of the vessel to the other or surround the areas to protect in an U-shaped form. The wall must cover the whole width of the area to protect and at least 1.00 m in the direction opposite to the cargo area (see Ch 3, App 1, Fig 1). The height of the wall shall be at least 1.00 m above the adjacent cargo deck area in the cargo area. The outer wall and side walls of the accommodation can be considered as a protection wall if they do not include openings and if the dimensions are complied with.

A protection wall is not required where the distance between the areas to be protected and the safety valve, the shore connections of the piping for loading and unloading, and venting piping, the compressor on deck and the opening of the closest pressure tanks is at least 12.00 m.

Table 1 : Plans and documents to be submitted

No.	A/I **(1)**	Documents
1	I	List of substances intended to be carried with their UN number (see Ch 3, App 3, Tab 2), including all design characteristics of substances and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks
3	A	Hazardous areas plan and location of the electrical equipment installed in these areas
4	A	Location of void spaces and accesses to dangerous zones
5	A	Air locks between safe and dangerous zones
6	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
7	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.
8	A	Calculation of the hull temperature in all the design cargo conditions
9	A	Intact and damage stability calculations
10	A	Scantlings, material and arrangement of the cargo containment system
11	A	Details of insulation
12	A	Details of ladders, fittings and towers in tanks and relative stress analysis, if any
13	A	Details of tank domes and deck sealings
14	A	Plans and calculations of safety relief valves
15	A	Details of cargo handling and vapour system, including arrangements and details of piping and fitting
16	A	Details of cargo pumps and cargo compressors
17	A	Details of process pressure vessels and relative valving arrangement
18	A	Bilge and ballast system in cargo area
19	A	Gas freeing system in cargo tanks including inert gas system
20	A	Ventilation system in cargo area
21	A	Refrigeration plant system diagram, if any
22	A	Water spray system diagram
23	A	List of the electrical equipment installed in hazardous areas comparable to zone 0 and 1, including the following equipment particulars: location, type of protection, type of protection against explosion, testing body and approval number
24	A	Schematic electrical wiring diagram in cargo area
25	A	Gas detection system
26	A	Cargo tank instrumentation, including cargo and hull temperature monitoring system
27	A	Emergency shutdown system
28	A	Details of fire-extinguishing appliances and systems in cargo area
29	A	Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar
30	A	Loading and unloading operation description, including cargo tank filling limits
31	A	List of equipment installed in hazardous areas comparable to zone 2 which may be used during loading, unloading and gas-freeing and red equipment
(1) A = to be submitted for review I = to be submitted for information.		

2.1.4 On deck, the lower edges of door-openings in the sidewalls of superstructures and the sills of hatches and ventilation openings of premises located under the deck shall have a height of not less than 0,50 m above the deck.

This requirement does not apply to access openings to double-hull spaces and double bottoms.

2.1.5 The bulwarks, foot-rails, etc., shall be provided with sufficiently large openings which are located directly above the deck.

2.2 Engine rooms

2.2.1 Internal combustion engines for the vessel’s propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.2.2 The engine room shall be accessible from the deck; the entrances shall not face the cargo area. When the doors are not located in a recess whose depth is at least equal to the door width, the hinges shall face the cargo area.

2.3 Accommodation and service spaces

2.3.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area, see Ch 3, App 1, [1.7] for definition, forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1,00 m above the bottom of the wheelhouse may tilt forward.

2.3.2 Entrances to spaces and openings of superstructures shall not face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors shall have their hinges facing the cargo area.

2.3.3 Entrances from the deck and openings of spaces facing the weather shall be capable of being closed.

2.3.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. No wheelhouse doors and windows shall be located within 2,00 m from any hazardous area comparable to zone 0 or 1, except where there is no direct connection between the wheelhouse and the accommodation.

2.3.5

a) Driving shafts of the bilge or ballast pumps may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with [2.4.6].

b) The penetration of the shaft through the bulkhead shall be gastight and shall have been approved by the Society.

c) Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic lines and piping for measuring, control and alarm systems, provided that the penetrations have been approved by the Society. The penetrations shall be gastight. Penetrations through a bulkhead with a "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), shall have an equivalent fire protection.

d) Pipes may pass through the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

e) Notwithstanding [2.4.5], pipes from the engine room may pass through the service space in the cargo area or a cofferdam or a hold space or a double-hull space to the outside provided that within the service space or cofferdam or hold space or double hull space they are of the thick-walled type and have no flanges or openings.

f) Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration shall be gastight.

2.3.6 A service space located within the cargo area below deck shall not be used as a cargo pump room for the vessel's own gas discharging system, e.g. compressors or the compressor/heat exchanger/pump combination, except where:

- the cargo pump room is separated from the engine room or from service spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), or by a service space or a hold space
- the "A-60" bulkhead required above does not include penetrations referred to in [2.3.5], item a)
- ventilation exhaust outlets are located not less than 6,00 m from entrances and openings of the accommodation and service spaces
- the access hatches and ventilation inlets can be closed from the outside
- All piping for loading and unloading (at the suction side and the delivery side) are led through the deck above the pump-room. The necessary operation of the control devices in the pump-room, starting of pumps or compressors and control of the liquid flow rate shall be effected from the deck
- the system is fully integrated in the gas and liquid piping system
- the cargo pump room is provided with a permanent gas detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system shall be placed at suitable positions at the bottom and directly below the deck.

  Measurement shall be continuous.

  The audible and visual alarms are installed in the wheelhouse and in the cargo pump room and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system shall be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms.
- the ventilation system prescribed in [2.5] has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

2.4 Hold spaces

2.4.1 The hold spaces shall be separated from the accommodation, engine rooms and service spaces outside the cargo area below deck by bulkheads provided with a class A-60 fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]).

A space of not less than 0,20 m shall be provided between the cargo tanks and the end bulkheads of the hold spaces. Where the cargo tanks have plane end bulkheads this space shall be not less than 0,50 m.

2.4.2 The hold spaces and cargo tanks shall be capable of being inspected.

2.4.3 All spaces in the cargo area shall be capable of being ventilated. Means for checking their gas-free condition shall be provided.

2.4.4 Double hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with [2.7].

2.4.5 The bulkheads bounding the hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck. The bulkhead between the engine room and the service spaces within the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the requirements of [2.3.5].

2.4.6

a) A space in the cargo area below deck may be arranged as a service space, provided that the bulkhead bounding the service space extends vertically to the bottom and the bulkhead not facing the cargo area extends from one side of the vessel to the other in one frame plane. This service space shall only be accessible from the deck.

b) The service space shall be watertight with the exception of its access hatches and ventilation inlets.

c) No piping for loading or unloading shall be fitted within the service space referred to in item a) above.

   Piping for loading and unloading may be fitted in the cargo pump-rooms below deck only when they conform to the provisions of [2.3.6].

2.4.7 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious persons to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

2.4.8 Hold spaces and other accessible spaces within the cargo area shall be arranged so as to ensure that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings, except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks, shall be in compliance with Pt B, Ch 2, Sec 1, [3.2.2].

2.4.9 In case the vessel has insulated cargo tanks, the hold spaces shall only contain dry air to protect the insulation of the cargo tanks against moisture.

2.5 Ventilation

2.5.1 Each hold space shall have two openings the dimensions and location of which shall be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it shall be possible to fill the hold spaces with inert gas or dry air.

2.5.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water and cofferdams between engine rooms and pump-rooms, if they exist, shall be provided with ventilation systems.

2.5.3 A service space located within the cargo area below deck shall be provided with a ventilation system. The capacity of the fans shall be sufficient to ensure 20 complete changes of air per hour based on the volume of the service space.

The ventilation exhaust ducts shall extend down to 50 mm above the bottom of the service space. The air shall be supplied through a duct at the top of the service space.

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the air inlets shall be located not less than 2.00 m above the deck, at a distance of not less than 2.00 m from tank openings and 6.00 m from the outlets of safety valves.

The extension pipes which may be necessary may be of the hinged type.

2.5.4 Ventilation of accommodation and service spaces shall be possible.

2.5.5 All ventilation inlets of accommodation, wheelhouse and service spaces leading to the open air outside the cargo area shall be fitted with devices permanently fixed according to Pt C, Ch 4, Sec 4, [4.2], enabling them to be closed rapidly. It shall be clear whether they are open or closed.

Such ventilation inlets shall be located not less than 2.00 m from the cargo area.

Ventilation inlets of service spaces in the cargo area may be located within that area.

2.6 Engines

2.6.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features Dualfuel or Gasfuel according to Pt A, Ch 1, Sec 3, [1.3.5].

2.6.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, the air intakes of the engines shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.7 Oil fuel tanks

2.7.1 When the vessel is fitted with hold spaces and double bottoms, double bottoms within the cargo area may be arranged as a liquid oil fuel tanks, provided their depth is not less than 0,60 m.

Oil fuel pipes and openings of such tanks are not permitted in the hold space.

2.7.2 The open ends of the air pipes of each oil fuel tanks shall extend to not less than 0,5 m above the open deck. These open ends and the open ends of overflow pipes leading to the deck shall be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

2.8 Exhaust pipes

2.8.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.8.2 Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

2.9 Bilge pumping and ballasting arrangements

2.9.1 Bilge and ballast pumps for spaces within the cargo area shall be installed within such area.

This provision does not apply to:

- double-hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks;
- cofferdams and hold spaces where ballasting is carried out using the piping of the fire fighting system in the cargo area and bilge-pumping is performed using eductors which are installed in the cargo area.

2.9.2 Where the double bottom is used as a liquid oil fuel tank, it shall not be connected to the bilge piping system.

2.9.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water shall be located within the cargo area.

2.9.4 It shall be possible for an under-deck pump room to be stripped in an emergency using a system located in the cargo area and independent of any other system. This stripping system shall be located outside the pump-room.

2.10 Ventilation of cargo pump rooms and gas compressor rooms

2.10.1 Cargo pump and compressor rooms must be provided with extraction type ventilation systems, independent of other vessel's spaces, providing at least 30 cycles of air change per hour. Warning notices shall be placed requiring that the ventilation is in operation for at least 15 minutes prior to entering these spaces.

2.10.2 Portable means must be provided for gas-freeing of cargo tanks and other spaces not equipped with fixed ventilation.

3 Cargo containment

3.1 Cargo area hull design

3.1.1 General

In the cargo area, the vessel shall be designed either as a double hull and double bottom vessel, or as a single hull vessel, according to [3.1.2] to [3.1.4].

Alternative constructions will be specially considered by the Society on a case-by-case basis.

3.1.2 Double hull vessel

Vessels with double hull and double bottom shall comply with the following:

- the internal distance between the side platings of the vessel and the longitudinal bulkheads shall not be less than 0,80 m
- the height of the double bottom shall not be less than 0,60 m
- the cargo tanks shall be supported by saddles extending between the tanks to not less than 20° below the horizontal centreline of the cargo tanks.

3.1.3 Single hull vessel

Single hull vessel shall comply with the following:

- it shall be fitted with side platings between gangboard and top of floor plates provided with side stringers at intervals of not more than 0,60 m which are supported by web frames spaced at intervals of not more than 2,00 m
- the side stringers and the web frames shall have a height of not less than 10% of the vessel depth, however, not less than 0,30 m
- the side stringers and web frames shall be fitted with a face plate made of a flat steel and having a cross section of not less than 7,5 cm^2 and 15 cm^2 respectively
- the distance between the side plating of the vessel and the cargo tanks shall be not less than 0,80 m and between the bottom and the cargo tanks not less than 0,60 m. the depth below the suction wells may be reduced to 0,50 m
- the lateral distance between the suction well of the cargo tanks and the bottom structure shall be not less than 0,10 m
- The cargo tank supports and fastenings should extend to not less than 10° below the horizontal centreline of the cargo tanks.

3.1.4 Side-struts linking or supporting the load-bearing components of the sides of the vessel with the load bearing components of the longitudinal walls of cargo tanks and side struts linking the load-bearing components of the vessel’s bottom with the tank bottom are prohibited.

3.2 Carriage of liquefied gases under pressure

3.2.1 Cargo tank design

a) Pressure vessels shall, in general, be designed as the domed type. Fittings must be mounted on the domes or elsewhere on the upper part of the tanks above the open deck in the cargo area. They shall be protected against damage and must be secured in such a way that undue stresses caused by vibration or expansion cannot occur. At least one manhole shall be arranged in the tank dome or as a separate dome with the access opening located on the open deck.

b) Pressure independent built-in cylindrical tanks shall have a length to diameter ratio ≤ 7.

c) The pressure tanks shall be designed for a cargo temperature of +40°C.

3.2.2 Insulation

The insulation of pressure vessels is to be made of approved material covered with a vapour barrier of low flame spread type.

3.2.3 Coating

Pressure vessels shall be painted externally for protection against corrosion. Uninsulated or unprotected portions on the open deck shall be coated with reflecting paints.

3.2.4 Maximum filling

With the cargo at the reference temperature specified in [1.4], pressure vessels may not be filled to more than 91% for un-cooled and 95% for cooled carriage.

3.2.5 Name plates

Each pressure vessel must bear a name plate showing the following data:

- name of manufacturer, serial number, year of manufacture
- cubic capacity, in m^3
- design pressure and test pressure, in bar
- certificate No., month and year of test
- stamp of certifying firm
- lowest operation temperature, in °C
- vapour pressure, in bar at reference temperature, in °C.

The name plates must be legible from the deck.

3.3 Carriage of refrigerated liquefied gases

3.3.1 Requirements as set out in the applicable statutory Regulations or a recognized standard are to be observed.

Further individual requirements are to be decided in consultation with the Society on a case by case basis in accordance with the provisions for liquefied gas tankers laid down in the Society's Rules.

3.3.2 Refrigerated cargo tanks and cargo tanks used for the transport of refrigerated liquefied gases shall be installed only in hold spaces bounded by double hull spaces and double bottom.

3.3.3 Cargo tanks intended to contain products at a temperature below −10°C shall be suitably insulated to ensure that the temperature of the vessel's structure does not fall below the minimum allowable material design temperature. The insulation material shall be resistant to flame spread.

3.4 Cargo tank openings

3.4.1

a) Cargo tank openings shall be located on deck in the cargo area.

b) Cargo tank openings with a cross-section greater than 0,10 m^2 shall be located not less than 0,50 m above the deck.

3.4.2 The exhaust outlets of the pressure relief valves shall be located not less than 2,00 m above the deck at a distance of not less than 6,00 m from the accommodation and from the service spaces located outside any hazardous area comparable to zone 0 or 1. This height may be reduced when within a radius of 1,00 m round the pressure relief valve outlet there is no equipment, no work is being carried out and signs indicate the area.

3.4.3 Where the list of substances accepted for carriage in the tanker includes those for which anti-explosion protection is prescribed in column (17) of Ch 3, App 3, Tab 2, the closing devices normally used in loading and unloading operations shall not be capable of producing sparks when operated.

3.4.4 Each tank in which refrigerated substances are carried shall be equipped with a safety system to prevent unauthorized vacuum or overpressure.

3.5 Membrane tanks

3.5.1 Definition

Membrane tanks are non-self supporting tanks that consists of a thin liquid and gastight layer (membrane) supported through insulation by the adjacent hull structure.

3.5.2 Structural design and arrangement

The structural design and arrangement of membrane tanks, where fitted, are to comply with NR467, Pt D, Ch 9, Sec 4, [12].

3.5.3 Testing

a) In vessels fitted with membrane cargo containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically tested.

b) All hold structures supporting the membrane shall be tested for tightness before installation of the cargo containment system.

c) Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.

d) The testing of membrane is to comply with the requirements in Pt B, Ch 8, Sec 4.

4 Cargo piping system

4.1 General

4.1.1 Pumps, compressors and accessory loading and unloading piping shall be placed in an area between the fore vertical plane and the aft vertical plane bounding the part of the cargo area below deck. Cargo pumps and compressors shall be capable of being shut down from this area and, in addition, from a position outside this area. Cargo pumps and compressors situated on deck shall be located not less than 6,00 m from entrances to, or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2 Arrangement of cargo piping

4.2.1 Piping for loading and unloading shall be independent of any other piping of the vessel. No cargo piping shall be located below deck, except those inside the cargo tanks and in the service spaces intended for the installation of the vessel's own gas discharging system.

4.2.2 Piping for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

4.2.3 The piping for loading and unloading on deck, the venting pipes with the exception of the shore connections but including the safety valves, and the valves shall be located within the longitudinal line formed by the outer boundaries of the domes and not less than B/4 from the outer shell. This requirement does not apply to the relief pipes situated behind the safety valves. If there is, however, only one dome athwartships, these pipes and their valves shall be located at a distance not less than 2,70 m.

4.2.4 Where cargo tanks are placed side by side, all the connections to the domes shall be located on the inner side of the domes. The external connections may be located on the fore and aft centre line of the dome. The shut-off devices of the loading and unloading piping shall be duplicated, one of the devices being constituted by a remote-controlled quick closing valve. When the inside diameter of a shut-off device is less than 50 mm this device may be regarded as a safety against bursts in the piping.

4.2.5 The shore connections shall be located not less than 6 m from the entrances to or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2.6 Each shore connection of the venting pipe and shore connections of the piping for loading and unloading, through which the loading or unloading operation is carried out, shall be fitted with a shut-off device and a quick closing valve. However, each shore connection shall be fitted with a blind flange when it is not in operation.

4.2.7 Piping for loading and unloading, and venting pipes, shall not have flexible connections fitted with sliding seals.

4.2.8 Use of the cargo piping for ballasting purposes shall not be possible.

4.2.9 For transport of refrigerated liquefied gases:

a) The piping for loading and unloading and cargo tanks shall be protected from excessive stresses due to thermal movement and from movements of the tank and hull structure.

b) Where necessary, piping for loading and unloading shall be thermally insulated from the adjacent hull structure to prevent the temperature of the hull falling below the design temperature of the hull material.

c) All piping for loading and unloading, which may be closed off at each end when containing liquid (residue), shall be provided with safety valves. These safety valves shall discharge into the cargo tanks and shall be protected against inadvertent closing.

4.3 Accessories

4.3.1 Cargo tank connections for gauging or measuring devices need not to be equipped with excess flow or emergency shut-off valves, provided that the devices are so constructed that the outward flow of tank contents cannot exceed that passed by a 1,5 mm diameter circular hole.

The stop valves or other shut-off devices of the pipes for loading and unloading shall indicate whether they are open or shut.

4.3.2 The piping for loading and unloading shall be fitted with pressure gauges at the inlet and outlet of the pump.

Reading of the pressure gauges shall be possible from the control position of the vessel's own gas discharging system. The maximum permissible overpressure or vacuum shall be indicated by a measuring device.

4.4 Bonding

4.4.1 Every component of the pipes for loading and unloading shall be electrically connected to the hull.

5 Cargo pressure and temperature control

5.1 Regulation of cargo pressure and temperature

5.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks shall be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

- a system for the regulation of cargo tank pressure using mechanical refrigeration
- a system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, shall be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system shall be deemed acceptable by the Society and shall ensure safety for a minimum time of three times the operation period

- for UN No. 1972 only, a system for the regulation of cargo tank pressure whereby the boil-off vapours are utilized as fuel
- other systems deemed acceptable by the Society.

5.1.2 The systems prescribed in [5.1.1] shall be constructed, installed and tested to the satisfaction of the Society. The materials used in their construction shall be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits shall be:

- air: +30°C
- water: +20°C.

5.2 Refrigeration system

5.2.1 The refrigeration system referred to in [5.1.1] shall be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by the Society is provided, provision shall be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. Provision shall be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity.

For all cargo systems, the heat transmission coefficient as used for the determination of the holding time shall be determined by calculation. Upon completion of the vessel, the correctness of the calculation shall be checked by means of a heat balance test. The calculation and test shall be performed under supervision by the Society. The heat transmission coefficient shall be documented and kept on board. The heat transmission coefficient shall be verified at every renewal of the certificate of approval.

Cargo tanks, piping and accessories shall be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

5.2.2 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care shall be given to the refrigeration systems so as to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in [5.2.1], shall be provided for each cargo.

5.2.3 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care shall be given to the refrigeration systems to prevent any mixing of the cargoes.

5.2.4 All primary and secondary coolant fluids shall be compatible with each other and with the cargo with which they may come into contact.

5.2.5 When the refrigeration system is installed in a separate service space, this service space shall meet the requirements of [2.3.6].

5.3 Water spray system

5.3.1 When water spraying is required in column (9) of Ch 3, App 3, Tab 2, a water spray system shall be installed in the cargo area on deck for the purpose of reducing gases given off by the cargo by spraying water.

5.3.2 The system shall be fitted with a connection device for supply from the shore. The spray nozzles shall be so installed that released gases are precipitated safely. The system shall be capable of being put into operation from the wheelhouse and from the deck. The capacity of the water-spray system shall be such that when all the spray nozzles are in operation, the outflow is not less than 50 liters per square meter of cargo deck area and per hour.

6 Pressure cargo tank venting system

6.1 Safety valves

6.1.1 The highest part of the vapour space (tank dome) of pressure vessels with a capacity of less than 20 m³ is to be fitted with at least one, and pressure vessels with a capacity of more than 20 m³ two independent, spring loaded safety valves. Means must be provided to prevent the accumulation of liquid cargo in the pipe upstream to the safety valves taking into account the vessel's trim and list.

6.2 Discharge capacity of safety valves

6.2.1 The total discharge capacity of the safety valves shall be according to the formula hereafter. During blowing down the pressure in the tank shall not rise more than 20% above the maximum allowable relief valve setting (MARVS).

$Q = F\ G\ A^{0,82}$

where:

Q : Minimum required equivalent discharge rate of air, in m³/s, at standard conditions of 273°K and 1,013 bar

F : Fire exposure factor for different cargo tank types:

- F = 1,0 for uninsulated tanks located on deck
- F = 0,5 for tanks above the deck when insulation is approved by the Society (approval will be based on the use of an approved fire proofing material, the thermal conductance of insulation, and its stability under fire exposure)
- F = 0,5 for uninsulated independent tanks installed in holds
- F = 0,2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds)
- F = 0,1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds).

For independent tanks partly protruding through the open deck, the fire exposure factor is to be determined on the basis of the surface areas above and below deck

G : Gas factor defined as:

$$G = \frac{12,4}{rD}\sqrt{\frac{ZT}{M}}$$

with:

T : Temperature in K (= 273 + °C) at the relieving conditions, i.e. 120% of the setting pressure

r : Latent heat of the material being vaporized at relieving conditions, in kJ/kg

D : Constant based on relation of specific heats k, shown in Tab 2; if k is not known, D = 0,606 shall be used.

The constant D may also be calculated by the following formula:

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

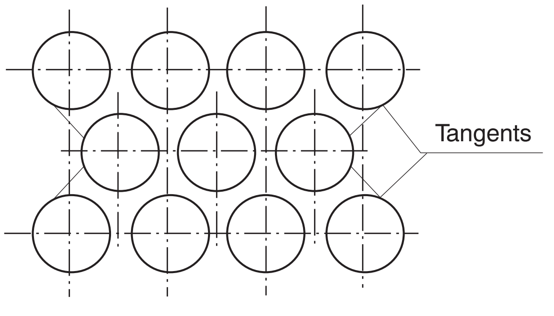
Z : Compressibility factor of the gas at relieving conditions; if not known, Z = 1,0 shall be used

M : Molecular weight of the product

A : External surface area of the tank in, m², for different tank types:

- for body of revolution type tanks, A is the external surface area
- for other than bodies of revolution type tanks, A is the external surface area less the projected bottom surface area
- for tanks consisting of an array of pressure vessels tanks, A is the external surface area of the hold less its projected bottom area
- insulation on the tank structure, A is the external surface area of the array of pressure vessels excluding insulation, less the projected bottom area as shown in Fig 1.

Figure 1 : Array of pressure vessels



6.2.2 The setting of the pressure relief valves is not to be higher than the maximum pressure for which the cargo tank is designed.

6.2.3 It is recommended that a device may be fitted enabling one safety valve at a time to be isolated for a short period for repair/maintenance. In this case, however, at least half the required safety valve cross-section must remain operative.

Table 2 : Constant D

k	D	k	D
1,00	0,606	1,52	0,704
1,02	0,611	1,54	0,707
1,04	0,615	1,56	0,710
1,06	0,620	1,58	0,713
1,08	0,624	1,60	0,716
1,10	0,628	1,62	0,719
1,12	0,633	1,64	0,722
1,14	0,637	1,66	0,725
1,16	0,641	1,68	0,728
1,18	0,645	1,70	0,731
1,20	0,649	1,72	0,734
1,22	0,652	1,74	0,736
1,24	0,656	1,76	0,739
1,26	0,660	1,78	0,742
1,28	0,664	1,80	0,745
1,30	0,667	1,82	0,747
1,32	0,671	1,84	0,750
1,34	0,674	1,86	0,752
1,36	0,677	1,88	0,755
1,38	0,681	1,90	0,758
1,40	0,685	1,92	0,760
1,42	0,688	1,94	0,763
1,44	0,691	1,96	0,765
1,46	0,695	1,98	0,767
1,48	0,698	2,00	0,770
1,50	0,701	2,02	0,772
		2,20	0,792

6.3 Safety valves blow-off lines

6.3.1 The blow-off lines of pressure vessel safety valves may be arranged individual or with common headers. The outlets are to be arranged at least 2,00 m above deck at a horizontal distance of 6 m from accommodation or other safe spaces. The height may be reduced to less than 2,00 m in case the area of 1,00 m around the high velocity valve is designed as non-accessible.

6.3.2 The total cross-section of the blow-off piping must be sufficient to discharge safely the quantity of gas calculated in [6.2].

7 Environmental control

7.1 Inerting facilities

7.1.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel shall be equipped with an inerting system.

7.1.2 This system shall be capable of maintaining a permanent minimum pressure of 7 kPa (0,07 bar) in the spaces to be inerted. In addition, the inerting system shall not increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve shall be 3,5 kPa (0,035 bar).

7.1.3 The premises to be inerted shall be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

7.1.4 Vessels equipped with membrane tanks shall have an inerting system capable of inerting all insulation spaces of the tanks.

The system shall be capable of keeping permanently a minimum pressure above atmospheric pressure in the spaces to be inerted.

8 Electrical installations

8.1 Type and location of electrical installations and equipment

8.1.1 Electrical installations and equipment shall be of at least the "limited explosion risk" type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.5]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2.00 m of the cargo area.

8.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

8.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [8.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

8.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

8.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [8.1.4].

8.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [8.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

8.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

8.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

8.1.9 Sockets for the connection of signal lights and gangway lighting shall be solidly fitted to the vessel close to the signal mast or the gangway. The sockets used in this area shall be designed so as to prevent connection or disconnection except when they are not live.

8.2 Type and location of electrical and non-electrical installations and equipment intended to be used in explosion hazardous areas

8.2.1 On board vessels covered by the classification of zones as defined in Ch 3, App 1, Tab 1, electrical and non-electrical installations and equipment used in explosion hazardous areas shall meet at least the requirements for use in the area concerned.

They shall be selected on the basis of the explosion groups/subgroups and temperature classes to which the substances to be carried belong (see columns (15) and (16) of Ch 3, App 3, Tab 2).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T4, T5 or T6 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 135°C (T4), 100° (T5) or 85°C (T6).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T1 or T2 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 200°C.

8.2.2 Except in the case of optical fibres, electrical cables shall be armoured or placed in a metallic sheath or in protective tubes.

Electrical cables for the active cathodic protection of the shell plating shall be led through thick-walled steel tubes with gastight connections up to the main deck.

8.2.3 Movable electric cables are prohibited in the explosion danger area, except for electric cables for intrinsically safe electric circuits or for connecting:

- Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway
- The power network on a vessel to a land-based power network; provided
  - The electric cables and the power supply unit conform with a valid standard
  - The power supply unit and connectors are located outside of the explosion danger area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

8.2.4 Electrical cables of intrinsically safe circuits shall be separated from other cables not intended for use in such circuits and shall be marked (they shall not be installed together in the same string of cables and they shall not be fixed by the same cable clamps).

8.2.5 For movable electrical cables permitted under, only sheathed cables of type H07RN-F in accordance with standard IEC 60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.50 mm^2 shall be used.

8.3 Earthing

8.3.1 The metal parts of electrical installations and equipment in the cargo area which are not live, as well as the protective metal tubes or metal sheaths of cables, in normal service shall be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

8.3.2 The provisions of [8.3.1] also apply to installations with a voltage of less than 50 V.

8.3.3 Independent cargo tanks, metal intermediate bulk containers and tank-containers shall be earthed.

8.3.4 Receptacles for residual products shall be capable of being earthed.

8.4 Storage batteries

8.4.1 Storage batteries shall be located outside any hazardous area comparable to zone 0 or 1.

9 Fire protection and fire extinction

9.1 Fire and naked light

9.1.1 The outlets of funnels shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

9.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

9.1.3 Only electrical lamps are permitted.

9.2 Fire extinguishing arrangements

9.2.1 In addition to the requirements of Part C, Chapter 4, the fire extinguishing arrangements in [9.3] to [9.5] are to be complied with.

9.3 Portable fire extinguishers

9.3.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], each vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in the cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

9.4 Fire extinguishing system

9.4.1 A fire-extinguishing system complying with the following requirements shall be installed on the vessel:

- It shall be supplied by two independent fire or ballast pumps, one of which shall be ready for use at any time. These pumps and their means of propulsion and electrical equipment shall not be installed in the same space.
- It shall be provided with a water main fitted with at least three hydrants in the cargo area above deck. Three suitable and sufficiently long hoses with spray nozzles having a diameter of not less than 12 mm shall be provided It shall be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water not supplied from the same hydrant.

  A spring-loaded non-return valve shall be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the cargo area.
- The capacity of the system shall be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.

9.5 Fixed fire extinguishing system

9.5.1 In addition the machinery spaces, the cargo pump room and the cargo compressor room shall be provided with a permanently fixed fire-extinguishing system, in compliance with Pt C, Ch 4, Sec 4, [4].

10 Safety and control installations

10.1 General

10.1.1 Cargo tanks shall be provided with the following equipment:

a) a level gauge

b) a level alarm device which is activated at the latest when a degree of filling of 86% is reached

c) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached

d) an instrument for measuring the pressure of the gas phase in the cargo tank

e) an instrument for measuring the temperature of the cargo

f) a connection for a closed-type sampling device. The connection shall be fitted with a shut-off device resistant to the internal pressure at the connection.

10.2 Cargo tank level indicators

10.2.1 Each cargo tank is to be equipped with a closed gauging device approved by the Society. If only one device is installed per tank, it shall be so arranged/designed that any failure can be rectified and its function can be restored when tank under pressure.

The level gauge shall allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling levels of 91%, 95% and 97%, as given in the list of substances, shall be marked on each level gauge.

10.3 Level alarm device

10.3.1 Cargo tank shall be provided with a level alarm device which is activated at the latest when a degree of filling of 86% is reached.

The level alarm device shall give a visual and audible warning on board when actuated. The level alarm device shall be independent of the level gauge.

10.4 High level sensor

10.4.1 Cargo tank shall be provided with a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached.

10.5 Cargo tank pressure monitoring

10.5.1 Each cargo tank shall be equipped with a pressure indicator for the vapour space activating a high pressure alarm when the working pressure is exceeded.

Pressure indicators shall be fitted on loading and discharge lines, pumps, compressors and manifold connections marked with the maximum permissible working pressure.

10.6 Cargo temperature monitoring

10.6.1 Temperature indicating devices in each cargo tank shall be provided for the mean temperature of the cargo.

10.7 Cargo tank sampling equipment

10.7.1 Each cargo tank shall be equipped with a connection for a closed-type sampling device.

10.8 Safety valves

10.8.1 Cargo pumps and compressors must be fitted with safety valves discharging to their suction side, in compliance with [6.2].

Pipeline sections of more than 50 litres volume which may be isolated in liquid full condition are to be provided with safety relief valves. The blow-off lines are to be returned to the cargo tanks or a blow down header.

10.9 Gas detection and alarm system

10.9.1 For the hold spaces of pressure vessel cargo tanks, portable gas detectors are to be approved by the Society.

10.10 Other protective measures

10.10.1 On vessels certified to carry refrigerated liquefied gases the following protective measures shall be provided in the cargo area:

a) Drips trays shall be installed under the shore connections of the piping for loading and unloading through which the loading and unloading operation is carried out. They must be made of materials which are able to resist the temperature of the cargo and be insulated from the deck. The drip trays shall have a sufficient volume and an overboard drain.

b) A water spray system to cover:

- exposed cargo tank domes and exposed parts of cargo tanks
- exposed on-deck storage vessels for flammable or toxic products
- parts of the cargo deck area where a leakage may occur.

c) A water film around the shore connection of the piping for loading and unloading in use to protect the deck and the vessel side in the way of the shore connection of the piping for loading and unloading in use during connecting and disconnecting the loading arm or hose. The water film shall have sufficient capacity.

11 Buoyancy and stability

11.1 General

11.1.1 General requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

11.1.2 Proof of sufficient stability shall be furnished including for stability in damaged condition.

11.1.3 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined in compliance with Pt B, Ch 2, Sec 2, [2.2].

11.1.4 Proof of sufficient intact stability shall be furnished for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the vessel substance list according to Ch 3, Sec 1, [4.3.2].

11.1.5 For every loading case, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel shall comply with the intact and damage stability requirements.

Intermediate stages during operations shall also be taken into consideration.

11.2 Intact stability

11.2.1 The requirements for intact stability resulting from the damaged stability calculation shall be fully complied with.

11.3 Damage stability

11.3.1 The following assumptions shall be taken into consideration for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: B_2 – 0,01 m, inboard from the vessel's side at right angles to the centreline at the level corresponding to the maximum draught
   - vertical extent: from base line upwards without limit.

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to D_2 – 0,01 m upwards, except for pump well.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen so as to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

11.3.2 In general, permeability shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the minimum values of permeability μ given in Tab 3 are to be used.

For the main engine room only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Table 3 : Permeability μ

Spaces	μ, in %
Engine rooms	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

11.3.3 The damage stability is generally regarded sufficient if (see Fig 2):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

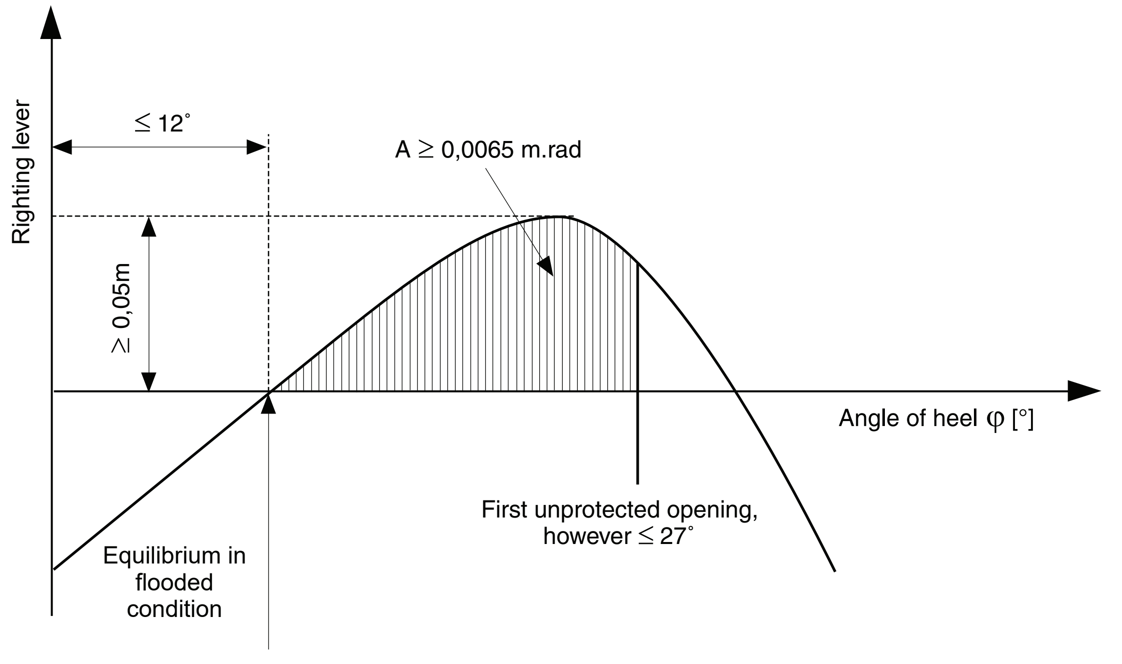
  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m·rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

11.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

11.3.5 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Figure 2 : Proof of damage stability



SECTION 3 DG-C

Symbols

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional service feature **DG-C**, as defined in Pt A, Ch 1, Sec 3, [3.2.14].

1.1.2 These Rule requirements apply in addition to Ch 1, Sec 3 and Ch 3, Sec 1.

1.2 Documents to be submitted

1.2.1 Tab 1 lists the plans and documents to be submitted in addition to the documents required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

2 Vessel arrangement

2.1 Protection against the penetration of dangerous gases and the spreading of dangerous liquids

2.1.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.1.2 Liquid-tight protective coamings shall be fitted on deck at the height of the external bulkheads of the cargo tanks, at a maximum distance of 0,60 m from the outer cofferdam bulkheads or the hold end bulkheads. The protective coamings shall either extend over the entire width of the vessel or be fixed between the longitudinal spill coamings so as to prevent liquids from entering the forepeak and afterpeak. The height of the protective coamings and the spill coamings shall be at least 0,075 m. The protective coaming may correspond to the protection wall prescribed in [2.1.3] if the protection wall extends across the entire width of the vessel.

2.1.3 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the use of installations and equipment that are not of at least the "limited explosion risk" type is not permitted during loading and unloading operations in parts of the deck outside the cargo area, unless those parts are protected against the penetration of gases and liquids by a gas- and liquid-tight protection wall. The wall must either extend over the full width of the vessel or surround the areas to be protected in a U-shaped form. The wall must cover the whole width of the area to be protected and at least 1.00 m in the direction opposite to the cargo area (see Ch 3, App 1, Fig 1). The height of the wall shall be at least 1.00 m above the adjacent cargo deck area in the cargo area. The outer wall and side walls of the accommodation can be considered as a protection wall if they do not include openings and if the dimensions are complied with.

A protection wall is not required where the distance between the areas to be protected and the high velocity vent valve, the shore connections of the piping for loading and unloading, the compressor on deck and the opening of the closest pressure tanks is at least 12.00 m.

2.1.4 On deck, the lower edges of door-openings in the sidewalls of superstructures and the sills of hatches and ventilation openings of premises located under the deck shall have a height of not less than 0,50 m above the deck.

This requirement does not apply to access openings to double-hull spaces and double bottoms.

2.1.5 The bulwarks, foot-rails, etc., shall be provided with sufficiently large openings which are located directly above the deck.

2.2 Engine rooms

2.2.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.2.2 The engine rooms shall be accessible from the deck; the entrances shall not face the cargo area. When the doors are not located in a recess whose depth is at least equal to the door width, the hinges shall face the cargo area.

Table 1 : Plans and documents to be submitted

No.	A/I	Documents
1	I	List of substances intended to be carried with their UN number (see Ch 3, App 3, Tab 2), including all design characteristics of substances and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks, void spaces
3	A	Hazardous areas plan and location of the electrical equipment installed in these areas
4	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
5	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, independent cargo tanks, etc.
6	A	Intact and damage stability calculations
7	A	Scantlings, material and arrangement of the cargo containment system
8	A	Details of cargo handling system, including arrangements and details of piping and fittings
9	A	Details of cargo pumps
10	A	Details of temperature and pressure control systems
11	A	Bilge and ballast system in cargo area
12	A	Gas freeing system in cargo tanks including inert gas system
13	A	Ventilation system in cargo area
14	A	List of the electrical equipment installed in hazardous areas comparable to zone 0 and 1, including the following equipment particulars: location, type of protection, type of protection against explosion, testing body and approval number
15	A	Schematic electrical wiring diagram
16	A	Pressure drop calculation note
17	A	Gas detection system
18	A	Cargo tank instrumentation
19	A	Details of fire-extinguishing appliances and systems in cargo area
20	A	Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar
21	I	Loading and unloading operation description, including cargo tank filling limits, where applicable
22	A	Gas return system
23	A	List of equipment installed in hazardous areas comparable to zone 2 which may be used during loading, unloading and gas-freeing and red equipment

Note 1:
A = to be submitted for review
I = to be submitted for information

2.3 Accommodation and service spaces

2.3.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area, see Ch 3, App 1, [1.7] for definition, forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1,00 m above the bottom of the wheelhouse may tilt forward.

2.3.2 Entrances to spaces and openings of superstructures shall not face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors shall have their hinges facing the cargo area.

2.3.3 Entrances from the deck and openings of spaces facing the weather shall be capable of being closed.

2.3.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. No wheelhouse doors and windows shall be located within 2,00 m from any hazardous area comparable to zone 0 or 1, except where there is no direct connection between the wheelhouse and the accommodation.

2.3.5

a) Driving shafts of the bilge or ballast pumps in the cargo area may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with [2.4.6].

b) The penetration of the shaft through the bulkhead shall be gastight and shall have been approved by the Society.

c) Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations have been approved by the Society. The penetrations shall be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), shall have an equivalent fire protection.

d) Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

e) Notwithstanding [2.4.4], pipes from the engine room may penetrate the service space in the cargo area or a cofferdam or a hold space or a double-hull space to the outside provided that within the service space or cofferdam or hold space or doublehull space they are of the thick-walled type and have no flanges or openings.

f) Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration shall be gastight.

2.3.6 A service space located within the cargo area below deck shall not be used as a cargo pump room for the loading and unloading system, except where:

- the cargo pump room is separated from the engine room or from service spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), or by a service space or a hold space
- the "A-60" bulkhead required above does not include penetrations referred to in [2.3.5], item a)
- ventilation exhaust outlets are located not less than 6.00 m from entrances and openings of the accommodation and service spaces outside the cargo area
- the access hatches and ventilation inlets can be closed from the outside
- all piping for loading and unloading as well as those of stripping systems are provided with shut-off devices at the pump suction side in the cargo pump room immediately at the bulkhead. The necessary operation of the control devices in the pump room, starting of pumps and necessary control of the liquid flow rate shall be effected from the deck
- the bilge of the cargo pump room is equipped with a gauging device for measuring the filling level which activates a visual and audible alarm in the wheelhouse when a liquid is accumulating in the cargo pump room bilge
- the cargo pump room is provided with a permanent gas detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system shall be placed at suitable positions at the bottom and directly below the deck.

  Measurement shall be continuous.

  The audible and visual alarms are installed in the wheelhouse and in the cargo pump room and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system shall be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms.
- the ventilation system prescribed in [2.5] has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

2.4 Hold spaces

2.4.1 The cargo tanks shall be separated by cofferdams of at least 0,60 m in width from the accommodation, engine room and service spaces outside the cargo area below deck or, if there are no such accommodation, engine room and service spaces, from the vessel's ends. Where the cargo tanks are installed in a hold space, a space of not less than 0,50 m shall be provided between such tanks and the end bulkheads of the hold space. In this case an end bulkhead meeting at least the definition for Class "A-60" (see Pt C, Ch 4, Sec 1, [2.2]), shall be deemed equivalent to a cofferdam. For pressure cargo tanks, the 0,50 m distance may be reduced to 0,20 m.

2.4.2 Hold spaces, cofferdams and cargo tanks shall be capable of being inspected.

2.4.3 All spaces in the cargo area shall be capable of being ventilated. Means for checking their gas-free condition shall be provided.

2.4.4 The bulkheads bounding the cargo tanks, cofferdams and hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck.

The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of [2.3.5].

The bulkhead between the cargo tank and the cargo pump-room below deck may be fitted with penetrations provided that they conform to the provisions of [2.3.6]. The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading or unloading pipes are fitted with shut-off devices in the cargo tank from which they come. The shut-off devices shall be operable from the deck.

2.4.5 Double hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with [2.7].

2.4.6

a) A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space shall only be accessible from the deck.

b) The service space shall be watertight with the exception of its access hatches and ventilation inlets.

c) No piping for loading and unloading shall be fitted within the service space referred to under (a) above.

   Piping for loading and unloading may be fitted in the cargo pump-rooms below deck only when they conform to the provisions of [2.3.6].

2.4.7 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

2.4.8 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area shall be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings, except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks, shall be in compliance with Pt B, Ch 2, Sec 1, [3.2.2].

2.5 Ventilation

2.5.1 Each hold space shall have two openings the dimensions and location of which shall be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it shall be possible to fill the hold spaces with inert gas or dry air.

2.5.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams shall be provided with ventilation systems.

2.5.3 A service space located within the cargo area below deck shall be provided with a ventilation system. The capacity of the fans shall be sufficient to ensure 20 complete changes of air per hour based on the volume of the service space.

The ventilation exhaust ducts shall extend down to 50 mm above the bottom of the service space. The air shall be supplied through a duct at the top of the service space.

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the air inlets shall be located not less than 2.00 m above the deck, at a distance of not less than 2.00 m from tank openings and 6.00 m from the outlets of safety valves.

The extension pipes which may be necessary may be of the hinged type.

2.5.4 Ventilation of accommodation and service spaces shall be possible.

2.5.5 All ventilation inlets of accommodation, wheelhouse and service spaces leading to the open air outside the cargo area shall be fitted with devices permanently fixed according to Pt C, Ch 4, Sec 4, [4.2], enabling them to be closed rapidly. It shall be clear whether they are open or closed.

Such ventilation inlets shall be located not less than 2.00 m from the cargo area.

Ventilation inlets of service spaces in the cargo area may be located within that area.

2.5.6 The flame-arresters prescribed in [3.6.4] and [3.6.5] shall be of a type approved for this purpose by the Society.

2.6 Engines

2.6.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.6.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, the air intakes of the engines shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.7 Oil fuel tanks

2.7.1 When the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0,60 m.

Oil fuel pipes and openings of such tanks are not permitted in the hold space.

2.7.2 The open ends of the air pipes of all oil fuel tanks shall extend to not less than 0,50 m above the open deck. Their open ends and the open ends of overflow pipes leading on the deck shall be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

2.8 Exhaust pipes

2.8.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.8.2 Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

2.9 Bilge pumping and ballasting arrangements

2.9.1 Bilge and ballast pumps for spaces within the cargo area shall be installed within such area.

This provision does not apply to:

- double hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks
- cofferdams, double hull spaces, hold spaces and double bottoms where ballasting is carried out using the piping of the fire fighting system in the cargo area and bilge-pumping is performed using eductors which are installed in the cargo area.

2.9.2 Where the double bottom is used as oil fuel tank, it shall not be connected to the bilge piping system.

2.9.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water shall be located within the cargo area but outside the cargo tanks.

2.9.4 A cargo pump room below deck shall be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation shall be provided outside the cargo pump-room.

2.10 Ventilation of cargo pump rooms

2.10.1 Cargo pump rooms must be provided with extraction type ventilation systems, independent of other vessel's spaces, providing at least 30 cycles of air change per hour. Warning notices shall be placed requiring that the ventilation is in operation for at least 15 minutes prior to entering these spaces.

2.10.2 Portable means must be provided for gas-freeing of cargo tanks and other spaces not equipped with fixed ventilation.

2.11 Arrangements of cofferdams

2.11.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with [2.4.6] shall be accessible through an access hatch.

2.11.2 No fixed pipe shall permit connection between a cofferdam and other piping of the vessel outside the cargo area.

3 Cargo containment

3.1 General

3.1.1 The scantlings and structural arrangements are to be in compliance with applicable requirements of Ch 1, Sec 3, [6] to Ch 1, Sec 3, [11].

3.2 Cargo area hull design

3.2.1 General

In the cargo area, the vessel shall be designed according to [3.2.2] to [3.2.10].

Alternative constructions will be specially considered by the Society on a case-by-case basis.

3.2.2 In the cargo area with the exception of the cofferdams, the vessel shall be designed as a flush-deck double-hull tanker, i.e. with double hull spaces and double bottoms but without trunk.

3.2.3 Cargo tanks independent of the vessel's hull and refrigerated cargo tanks may only be installed in a hold space which is bounded by double hull spaces and double bottoms in accordance with [3.2.7]. The cargo tanks shall not extend above the deck.

3.2.4 Side-struts linking or supporting the load-bearing components of the sides of the vessel with the load-bearing components of the longitudinal walls of cargo tanks and side-struts linking the load-bearing components of the vessel's bottom with the tank-bottom are prohibited.

3.2.5 A local recess in the cargo deck, contained on all sides, with a depth greater than 0,10 m, designed to house the loading and unloading pump, is permitted if it fulfils the following conditions:

- The recess shall not be greater than 1,00 m in depth.
- The recess shall be located not less than 6,00 m from entrances to and openings of accommodation and service spaces outside the cargo area.
- The recess shall be located at a minimum distance from the side plating equal to one quarter of the vessel's breadth.
- All pipes linking the recess to the cargo tanks shall be fitted with shut-off devices fitted directly on the bulkhead.
- All the controls required for the equipment located in the recess shall be activated from the deck.
- It shall be possible to drain the recess using a system installed on deck in the cargo area and independent of any other system.
- The recess shall be provided with a level alarm device which activates the draining system and triggers a visual and audible alarm in the wheelhouse when liquid accumulates at the bottom.
- When the recess is located above the cofferdam, the engine room bulkhead shall have an 'A-60' fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]).
- When the cargo area is fitted with a water-spray system, electrical equipment located in the recess shall be protected against infiltration of water.
- Pipes connecting the recess to the hull shall not pass through the cargo tanks.

3.2.6 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, and the recess is deeper than 0,50 m, then it shall be provided with a permanent gas detection system which automatically indicates the presence of flammable gases by means of direct-measuring sensors and actuates a visual and audible alarm when the gas concentration has reached 20 % of the lower explosive limit (LEL) of the cargo or 20 % of the lower explosive limit (LEL) of n-Hexane, whichever is the more critical value. The sensors of this system shall be placed at suitable positions at the bottom of the recess. Measurement shall be continuous and displayed near to the entrance.

Visual and audible alarms shall be installed in the wheelhouse and on deck and, when the alarm is actuated, the vessel loading and unloading system shall be shut down. Failure of the gas detection system shall be immediately signalled in the wheelhouse and on deck by means of visual and audible alarms.

The alarm shall be automatically relayed to the accommodation if it has not been switched off.

3.2.7 For double hull construction with the cargo tanks integrated in the vessel's structure, the distance between the side wall and the inner side wall of the vessel shall be not less than 1,00 m.

3.2.8 The mean depth of the double bottoms shall be not less than 0,70 m. It shall, however, never be less than 0,60 m.

3.2.9 The depth of the double bottom below the suction wells may be reduced to 0,50 m.

3.2.10 When a vessel is built with cargo tanks located in the hold space or refrigerated cargo tanks, the distance between the double walls of the hold space shall not be less than 0,80 m and the depth of the double bottom shall not be less than 0,60 m.

3.3 Cargo tank arrangements

3.3.1 The cargo tank is to comply with the following:

- for vessels with a length not more than 50,00 m, the length of a cargo tank shall not exceed 10,00 m
- for vessels with a length of more than 50,00 m, the length of a cargo tank shall not exceed 0,20 L, where L is the vessel rule length. This provision does not apply to vessels with independent built-in cylindrical tanks having a length to diameter ratio ≤ 7.

3.3.2 The capacity of a suction well shall be limited to not more than 0,10 m^3.

3.4 Integrated tank scantlings

3.4.1 The scantlings of the integrated tank structure are to be determined in compliance with Ch 1, Sec 3, [6].

3.5 Independent cargo tank scantlings

3.5.1 Tank scantlings

The scantlings of the independent tank structure are to be determined in compliance with Ch 1, Sec 3, [6.1.2].

When the vessel is provided with pressure cargo tanks, these tanks shall be designed in compliance with Pt C, Ch 1, Sec 3, for a working pressure of 400 kPa.

3.5.2 Supports and fastenings

The cargo tanks independent of the vessel's hull shall be fixed so that they cannot float.

The scantlings of the tank supports and fastenings are to be in compliance with Ch 1, Sec 3, [9].

3.6 Cargo tank openings

3.6.1

a) Cargo tank openings shall be located on deck in the cargo area.

b) Cargo tank openings with a cross-section of more than 0,10 m^2 and openings of safety devices for preventing overpressures shall be located not less than 0,50 m above deck.

3.6.2 Cargo tank openings shall be fitted with gastight closures capable of withstanding the test pressure in accordance with Pt B, Ch 3, Sec 4, [5].

3.6.3 Closures which are normally used during loading or unloading operations shall not cause sparking when operated.

3.6.4 Safety devices

a) Each cargo tank or group of cargo tanks connected to a common venting pipe shall be fitted with:
   - a connection for the safe return ashore of gases expelled during loading
   - a safe depressurization device for the cargo tanks, on which the position of the shut-off valve indicates clearly whether it is open or shut
   - safety devices for preventing unacceptable overpressures or vacuums.

     The opening pressure of the safety valves shall be permanently marked on the valves.

     The setting of the pressure relief valves shall be such that during the transport operation they do not blow off until the maximum permissible working pressure of the cargo tanks is reached.

     The gases shall be discharged upwards.

     The outlets of the pressure relief valves shall be located not less than 1.00 m above the deck and at a distance of not less than 6.00 m from the openings of accommodation, the wheelhouse and the service spaces outside the cargo area. No equipment shall be present in a circle of 1.00 m radius around the outlet of the pressure relief valve outlets. This area shall be marked as a danger zone.

b) If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2:
   - At the connection to each cargo tank, the venting piping and the vacuum valve shall be equipped with a flame arrester capable of withstanding a detonation, and
   - the device for the self depressurisation of cargo tanks shall be deflagration safe and capable of withstanding steady burning;

c) If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, or for which there is a T in column (3b) of Ch 3, App 3, Tab 2, then the pressure relief valve shall be designed as a high velocity vent valve;

d) If a shut-off device is to be mounted between the venting piping and the cargo tank, it shall be placed between the cargo tank and the flame arrester, and each cargo tank shall be equipped with pressure relief valves;

e) The autonomous protection systems mentioned in (b) and (c) shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2). The outlets of the high-velocity vent valves shall be located not less than 2.00 m above the deck and at a distance of not less than 6.00 m from the openings of the accommodations, the wheelhouse and the service spaces outside the cargo area. This height may be reduced to 1.00 m when there is no drive unit within a radius of 1.00 m around the pressure relief valve outlet. This area shall be marked as a danger zone;

   If the high velocity vent valve, the vacuum valve, the flame arresters and the venting piping are required to be heatable, the devices concerned shall be suitable for the relevant temperature.

3.6.5 Venting piping

a) When two or more cargo tanks are connected to common venting piping, it is sufficient that the equipment according to [3.6.4] (safety valves to prevent unacceptable overpressures and vacuums, high velocity vent valve, vacuum valve protected against deflagrations, safe pressure relief device for cargo tanks protected against deflagrations) is installed on the joint venting piping.

b) When each cargo tank is connected to its own venting piping, each cargo tank or the associated venting piping shall be equipped according to [3.6.4].

4 Cargo piping system

4.1 General

4.1.1 Pumps, compressors and accessory loading and unloading piping shall be placed in an area between the fore vertical plane and the aft vertical plane bounding the part of the cargo area below deck. Cargo pumps and compressors shall be capable of being shut down from this area and, in addition, from a position outside this area. Cargo pumps and compressors situated on deck shall be located not less than 6,00 m from entrances to, or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2 Arrangement of cargo piping

4.2.1 Piping for loading and unloading shall be independent of any other piping of the vessel. No cargo piping shall be located below deck, except for those inside the cargo tanks and inside the cargo pump room.

4.2.2 The piping for loading and unloading shall be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's tanks or the tanks ashore.

4.2.3 Piping for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

4.2.4 The piping for loading and unloading located on deck, with the exception of the shore connections shall be located not less than B/4 from the outer shell.

4.2.5 The shore connections shall be located not less than 6,00 m from the entrances to or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2.6 Each shore connection of the venting pipe and shore connections of the piping for loading and unloading, through which the loading or unloading operation is carried out, shall be fitted with a shut-off device. However, each shore connection shall be fitted with a blind flange when it is not in operation.

4.2.7 The flanges and stuffing boxes shall be provided with a spray protection device.

4.2.8 Piping for loading and unloading, and venting pipes, shall not have flexible connections fitted with sliding seals.

4.2.9 The piping for loading shall extend down to the bottom of the tank.

4.2.10 If the vessel is carrying several dangerous substances liable to react dangerously with each other, a separate pump with its own piping for loading and unloading shall be installed for each substance. The piping shall not pass through a cargo tank containing dangerous substances with which the substance in question is liable to react.

4.3 Control, monitoring and alarm devices

4.3.1 Stop valves

The stop valves or other shut-off devices of the pipes for loading and unloading shall indicate whether they are open or shut.

4.3.2 Pressure gauges

The piping for loading and unloading shall be fitted with pressure gauges at the outlet of the pumps.

The permissible maximum overpressure or vacuum value shall be indicated on each measuring device.

4.4 Bonding

4.4.1 Every component of the pipes for loading and unloading shall be electrically connected to the hull.

4.5 Supply of cargo tanks with washing or ballast water

4.5.1 When pipes for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes shall be located within the cargo area but outside the cargo tanks.

Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that suction is not possible through that part.

A spring-loaded non-return valve shall be provided to prevent any gases from being expelled from the cargo area through the tank washing system.

4.5.2 A non-return valve shall be fitted at the junction between the water suction pipe and the cargo loading pipe.

4.6 Permissible loading and unloading flows

4.6.1 The permissible loading and unloading flows shall be calculated.

4.6.2 Calculations concern the permissible maximum loading and unloading flow for each cargo tank or each group of cargo tanks, taking into account the design of the ventilation system. These calculations shall take into consideration the fact that in the event of an unforeseen cut-off of the gas return piping or the compensation piping of the shore facility, the safety devices of the cargo tanks will prevent pressure in the cargo tanks from exceeding the following values:

- over-pressure: 1.15 times the opening pressure of the pressure relief valve/high velocity vent valve;
- vacuum pressure: not more than the design pressure, but not exceeding a vacuum of 5 kPa (0,05 bar).

5 Cargo pressure and temperature control

5.1 Regulation of cargo pressure and temperature

5.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks shall be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

- a system for the regulation of cargo tank pressure using mechanical refrigeration
- a system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, shall be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system shall be deemed acceptable by the Society and shall ensure safety for a minimum time of three times the operation period
- other systems deemed acceptable by the Society.

5.1.2 The systems prescribed in [5.1.1] shall be constructed, installed and tested to the satisfaction of the Society. The materials used in their construction shall be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits shall be:

- air: +30°C
- water: +20°C

5.2 Refrigeration system

5.2.1 The refrigeration system referred to in [5.1.1] shall be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by the Society is provided, provision shall be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. Provision shall be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity.

Cargo tanks, piping and accessories shall be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

5.2.2 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care shall be given to the refrigeration systems so as to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in [5.2.1], shall be provided for each cargo.

5.2.3 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care shall be given to the refrigeration systems to prevent any mixing of the cargoes.

5.2.4 All primary and secondary coolant fluids shall be compatible with each other and with the cargo with which they may come into contact.

5.2.5 When the refrigeration system is installed in a separate service space, this service space shall meet the requirements of [2.3.6].

5.3 Cargo tank heating

5.3.1 Cargo tank heating system is to be installed as a separate system, equipped with a heat exchanger located in the cargo area. Where special heat transfer media are used this requirement may be dispensed with upon approval by the Society.

5.3.2 Boilers which are used for heating the cargo shall be fuelled with a liquid fuel having a flashpoint of more than 55°C. They shall be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.3.3 The cargo heating system shall be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught shall be ignited electrically.

5.3.4 The ventilation system of the engine room shall be designed taking into account the air required for the boiler.

5.3.5 Where the cargo heating system is used during loading, unloading or gas-freeing, the service space which contains this system shall fully comply with [8.1.1]. This requirement does not apply to the inlets of the ventilation system. These inlets shall be located at a minimum distance of 2,00 m from any hazardous area comparable to zone 0 or 1 and 6,00 m from the openings of cargo tanks or residual cargo tanks, loading pumps situated on deck, openings of high velocity vent valves, pressure relief devices and shore connections of loading and unloading pipes and must be located not less than 2,00 m above the deck.

The requirements of [8.1.1] are not applicable to the unloading of substances having a flash point of 60 °C or more when the temperature of the product is at least 15 K lower at the flash point.

5.4 Water spray system

5.4.1 When water spraying is required in column (9) of Ch 3, App 3, Tab 2, a water spray system shall be installed in the cargo area on deck to enable gas emissions from loading to be precipitated or to cool the tops of cargo tanks by spraying water over the whole surface so as to avoid safely the activation f the pressure relief valves/high velocity vent valves at 50 kPa.

5.4.2 The gas precipitation system shall be fitted with a connection device for supply from a shore installation.

5.4.3 The spray nozzles shall be so installed that the entire cargo deck area is covered and the gases released are precipitated safely.

5.4.4 The system shall be capable of being put into operation from the wheelhouse and from the deck. Its capacity shall be such that when all the spray nozzles are in operation, the outflow is not less than 50 litres per square metre of deck area and per hour.

6 Residual cargo tanks and receptacles for residual products

6.1 General

6.1.1 When vessels are provided with tanks for residual products or receptacles for residual products, they shall be located in the cargo area and comply with the provisions of [6.1.2] and [6.1.3]. Receptacles for residual products shall be located only in the cargo area on deck and not less than a quarter of the vessel's breadth from the outer shell.

6.1.2 Tanks for residual products shall be equipped with:

- a level gauge
- connections, with stop valves, for pipes and hose assemblies;
- a pressure relief/vacuum valve;

  The pressure relief valve shall be sized so that, during the transport operation, it does not open when in normal operation. This condition is met when the opening pressure of the valve meets the conditions required in column (10) of Ch 3, App 3, Tab 2 for the substances to be carried.

  If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the vacuum valve shall be designed so as to be capable of withstanding a deflagration. The deflagration safety may also be ensured by a flame arrester.

  If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2]is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, or for which there is a T in column (3b) of Ch 3, App 3, Tab 2, then the pressure relief valve shall be designed as a high velocity vent valve.

  The high velocity vent valve and the deflagration safe vacuum valve shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

The maximum permissible capacity is 30 m^3.

6.1.3 The receptacles for residual products shall be equipped with:

- a possibility of indicating the degree of filling
- connections, with stop valves, for pipes and hose assemblies;
- A connection enabling gases released during filling to be evacuated safely.

7 Environmental control

7.1 Inerting facility

7.1.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel shall be equipped with an inerting system.

7.1.2 This system shall be capable of maintaining a permanent minimum pressure of 7 kPa (0,070 bar) in the spaces to be inerted. In addition, the inerting system shall not increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve shall be 3,5 kPa (0,035 bar).

7.1.3 The premises to be inerted shall be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

8 Electrical installations

8.1 Type and location of electrical installations and equipment

8.1.1 Electrical installations and equipment shall be of at least the "limited explosion risk" type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.5]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2.00 m of the cargo area.

8.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

8.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [8.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

8.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

8.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [8.1.4].

8.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [8.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

8.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

8.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

8.1.9 Sockets for the connection of signal lights and gangway lighting shall be solidly fitted to the vessel close to the signal mast or the gangway. The sockets used in this area shall be designed so as to prevent connection or disconnection except when they are not live.

8.2 Type and location of electrical and non-electrical installations and equipment intended to be used in explosion hazardous areas

8.2.1 On board vessels covered by the classification of zones as defined in Ch 3, App 1, Tab 1, electrical and non-electrical installations and equipment used in explosion hazardous areas shall meet at least the requirements for use in the area concerned.

They shall be selected on the basis of the explosion groups/subgroups and temperature classes to which the substances to be carried belong (see columns (15) and (16) of Ch 3, App 3, Tab 2).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T4, T5 or T6 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 135°C (T4), 100° (T5) or 85°C (T6).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T1 or T2 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 200°C.

8.2.2 Except in the case of optical fibres, electrical cables shall be armoured or placed in a metallic sheath or in protective tubes.

Electrical cables for the active cathodic protection of the shell plating shall be led through thick-walled steel tubes with gastight connections up to the main deck.

8.2.3 Movable electric cables are prohibited in the explosion danger area, except for electric cables for intrinsically safe electric circuits or for connecting:

- Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway
- The power network on a vessel to a land-based power network; provided
  - The electric cables and the power supply unit conform with a valid standard
  - The power supply unit and connectors are located outside of the explosion danger area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

8.2.4 Electrical cables of intrinsically safe circuits shall be separated from other cables not intended for use in such circuits and shall be marked (they shall not be installed together in the same string of cables and they shall not be fixed by the same cable clamps).

8.2.5 For movable electrical cables permitted under, only sheathed cables of type H07RN-F in accordance with standard IEC 60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.50 mm^2 shall be used.

8.3 Earthing

8.3.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service shall be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

8.3.2 The provisions of [8.3.1] apply also to equipment having service voltages of less than 50 V.

8.3.3 Independent cargo tanks, metal intermediate bulk containers and tank-containers shall be earthed.

8.3.4 Receptacles for residual products shall be capable of being earthed.

8.4 Storage batteries

8.4.1 Storage batteries shall be located outside any hazardous area comparable to zone 0 or 1.

9 Fire protection and fire extinction

9.1 Fire and naked light

9.1.1 The outlets of funnels shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

9.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55 °C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

9.1.3 Only electrical lamps are permitted.

9.2 Fire extinguishing arrangements

9.2.1 In addition to the requirements of Part C, Chapter 4, the fire extinguishing arrangements in [9.3] to [9.5] are to be complied with.

9.3 Portable fire extinguishers

9.3.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2] each vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

9.4 Fire extinguishing system

9.4.1 A fire extinguishing system complying with the following requirements shall be installed on the vessel:

- It shall be supplied by two independent fire or ballast pumps, one of which shall be ready for use at any time. These pumps and their means of propulsion and electrical equipment shall not be installed in the same space.
- It shall be provided with a water main fitted with at least three hydrants in the cargo area above deck. Three suitable and sufficiently long hoses with spray nozzles having a diameter of not less than 12 mm shall be provided.
- It shall be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water not supplied from the same hydrant.

  A spring-loaded non-return valve shall be fitted to ensure that no gases can escape through the fire extinguishing system into the accommodation or service spaces outside the cargo area.
- The capacity of the system shall be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.

9.5 Fixed fire extinguishing system

9.5.1 In addition the machinery spaces and the cargo pump room shall be provided with a permanently fixed fire extinguishing system, in compliance with Pt C, Ch 4, Sec 4, [4].

10 Safety and control installations

10.1 General

10.1.1 Cargo tanks shall be provided with the following equipment:

a) a level gauge

b) a level alarm device which is activated at the latest when a degree of filling of 90% is reached

c) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached

d) an instrument for measuring the pressure of the vapour phase inside the cargo tank

e) an instrument for measuring the temperature of the cargo, if in column (9) of Ch 3, App 3, Tab 2, a cargo heating installation or a possibility of heating the cargo is required on board, or if a maximum temperature is indicated in column (20) of Ch 3, App 3, Tab 2

f) A connection for a closed-type or partly closed-type sampling device, and/or at least one sampling opening as required in column (13) of Ch 3, App 3, Tab 2. The connection shall be fitted with a shut-off device resistant to the internal pressure at the connection.

   If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the flame arrester plate stack capable of withstanding steady burning of the sampling opening shall be selected according to the explosion groups/subgroups of the substances foreseen for inclusion in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

10.2 Cargo tank level indicators

10.2.1 Each cargo tank is to be equipped with a closed gauging device approved by the Society.

The level gauge shall allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling level of the cargo tank shall be marked on each level gauge.

10.3 Level alarm device

10.3.1 Cargo tank shall be provided with a level alarm device which is activated at the latest when a degree of filling of 90% is reached.

The level alarm device shall give a visual and audible warning on board when actuated. The level alarm device shall be independent of the level gauge.

10.4 High level sensor

10.4.1 Cargo tank shall be provided with a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached.

10.5 Cargo tank pressure monitoring

10.5.1 When the pressure or temperature exceeds a set value, instruments for measuring the vacuum or overpressure of the gaseous phase in the cargo tank or the temperature of the cargo shall activate a visual and audible alarm in the wheelhouse and on deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

10.5.2 When the pressure exceeds the set value during loading and unloading, the instrument for measuring the pressure shall initiate immediately an electrical contact which shall put into effect measures to interrupt the loading or unloading operation. If the vessel's own discharge pump is used, it shall be switched off automatically.

10.5.3 The instrument for measuring the overpressure or vacuum shall activate the alarm at latest when:

a) An overpressure equal to 1,15 times the opening pressure of the pressure relief valves/high velocity vent valves is reached; or

b) The lower threshold of the design pressure of the vacuum valves, but not exceeding a vacuum of 5 kPa (0,05 bar), is reached.

10.5.4 The maximum permissible temperature is indicated in column (20) of Ch 3, App 3, Tab 2. The sensors for the alarms mentioned in this paragraph may be connected to the alarm device of the sensor.

When it is prescribed in column (20) of Ch 3, App 3, Tab 2, the instrument for measuring the overpressure of the gaseous phase in the cargo tank shall actuate a visible and audible alarm in the wheelhouse when the overpressure exceeds 40 kPa (0,4 bar) during the voyage. The alarm must be relayed to the accommodation automatically if it has not been switched off. It shall be possible to read the gauges in direct proximity to the control for the water spray system.

10.6 Cargo temperature monitoring

10.6.1 An instrument for measuring the temperature of the cargo shall be provided, if in column (9) of Ch 3, App 3, Tab 2 a heating installation is required, or if a possibility of heating the cargo is required, if a maximum temperature is indicated in column (20) of that list.

10.7 Cargo tank sampling equipment

10.7.1 Each cargo tank shall be equipped with a connection for a sampling device, closed or partially closed, and/or at least one sampling opening as required in column (13) of Ch 3, App 3, Tab 2.

11 Buoyancy and stability

11.1 General

11.1.1 General requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

11.1.2 The longitudinal centre bulkhead may be dispensed with only if sufficient stability is guaranteed.

11.1.3 Proof of sufficient stability shall be furnished including stability in damaged condition.

11.1.4 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined in compliance with Pt B, Ch 2, Sec 2, [2.2].

11.1.5 Proof of sufficient intact stability shall be furnished for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the vessel substance list according to Ch 3, Sec 1, [4.3.2].

11.1.6 For every loading case, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel shall comply with the intact and damage stability requirements.

Intermediate stages during operations shall also be taken into consideration.

11.2 Intact stability

11.2.1 The requirements for intact stability resulting from the damage stability calculation shall be fully complied with.

11.2.2 For vessels with cargo tanks of more than 0,70 B in width, the following intact stability requirements are to be complied with, bearing in mind the influence of all free surfaces in tanks for all stages of loading and unloading:

- in the positive area of the righting lever curve up to immersion of the first unprotected opening there shall be a righting lever (GZ) of not less than 0,10 m
- the surface of the positive area of the righting lever curve up to immersion of the first unprotected opening and in any event up to an angle of heel ≤ 27° shall not be less than 0,024 m.rad
- the metacentric height GM shall be not less than 0,10 m.

11.2.3 The most stringent requirement of [11.2.1] and [11.2.2] is applicable to the vessel.

11.3 Damage stability

11.3.1 The following assumptions shall be taken into consideration for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: $B_2 - 0{,}01$ m
   - vertical extent: from base line upwards without limit.

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to $D_2 - 0{,}01$ m upwards, except for pump well.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

11.3.2 In general, permeability shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the minimum values of permeability μ given in Tab 2 are to be used.

For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Table 2 : Permeability μ

Spaces	μ, in %
Engine rooms	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

11.3.3 The damage stability is generally regarded sufficient if (see Fig 1):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

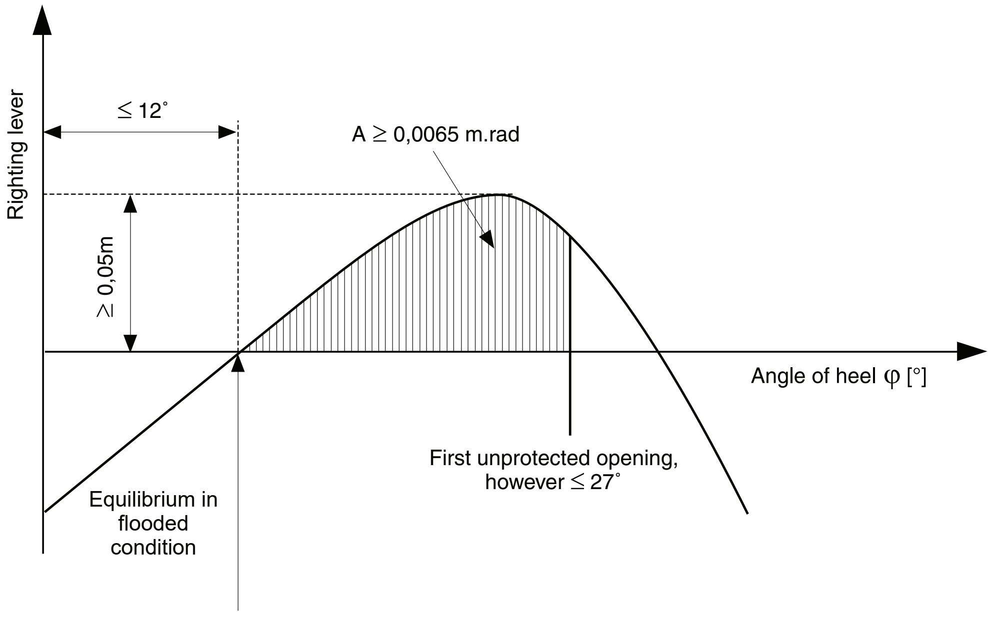
  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m.rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

11.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

11.3.5 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Figure 1 : Proof of damage stability



SECTION 4 DG-N

Symbols

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of one of the following additional service features:

- **DG-N closed** as defined in Pt A, Ch 1, Sec 3, [3.2.15]
- **DG-N open with flame arresters** as defined in Pt A, Ch 1, Sec 3, [3.2.16]
- **DG-N open** as defined in Pt A, Ch 1, Sec 3, [3.2.17].

1.1.2 These Rules apply in addition to Ch 1, Sec 3 and Ch 3, Sec 1.

1.2 Documents to be submitted

1.2.1 Tab 1 lists the plans and documents to be submitted in addition to the documents required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

2 Vessel arrangement

2.1 Protection against the penetration of gases

2.1.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.1.2 DG-N open vessels are only required to meet the requirement [2.1.1] if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

2.2 Protection against the penetration of gases - Additional requirements for DG-N closed and DG-N open with flame arresters

2.2.1 Liquid-tight protective coamings shall be fitted on deck at the height of the external bulkheads of the cargo tanks, at a maximum distance of 0,60 m from the outer cofferdam bulkheads or the hold end bulkheads. The protective coamings shall either extend over the entire width of the vessel or be fixed between the longitudinal spill coamings so as to prevent liquids from entering the forepeak and afterpeak. The height of the protective coamings and the spill coamings shall be at least 0,075 m. The protective coaming may correspond to the protection wall prescribed in [2.4.1] if the protection wall extends across the entire width of the vessel.

2.2.2 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the use of installations and equipment that are not of at least the “limited explosion risk” type is not permitted during loading and unloading operations in parts of the deck outside the cargo area, unless those parts are protected against the penetration of gases and liquids by a gas- and liquid-tight protection wall. The wall must either extend over the full width of the vessel or surround the areas to be protected in a U-shaped form. The wall must cover the whole width of the area to be protected and at least 1,00 m in the direction opposite to the cargo area (see Ch 3, App 1, Fig 1). The height of the wall shall be at least 1,00 m above the adjacent cargo deck area in the cargo area. The outer wall and side walls of the accommodation can be considered as a protection wall if they do not include openings and if the dimensions are complied with.

A protection wall is not required where the distance between the areas to be protected and the high velocity vent valve, the shore connections of the piping for loading and unloading, the compressor on deck and the opening of the closest pressure tanks is at least 12,00 m.

2.2.3 On deck, the lower edges of door-openings in the sidewalls of superstructures and the sills of hatches and ventilation openings of premises located under the deck shall have a height of not less than 0,50 m above the deck.

This requirement does not apply to access openings to double-hull spaces and double bottoms.

2.2.4 The bulwarks, foot-rails, etc., shall be provided with sufficiently large openings which are located directly above the deck.

2.3 Engine rooms

2.3.1 Internal combustion engines for the vessel’s propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

Table 1 : Plans and documents to be submitted

No.	A/I	Document
1	I	List of substances intended to be carried with their UN number (see Ch 3, App 3, Tab 2), including all design characteristics of substances and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks, void spaces
3	A	Hazardous areas plan and location of the electrical equipment installed in these areas
4	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
5	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, independent cargo tanks, etc.
6	A	Intact and damage stability calculations
7	A	Scantlings, material and arrangement of the cargo containment system
8	A	Details of cargo handling system, including arrangements and details of piping and fittings
9	A	Details of cargo pumps
10	A	Details of temperature and pressure control systems
11	A	Bilge and ballast system in cargo area
12	A	Gas freeing system in cargo tanks including inert gas system
13	A	Ventilation system in cargo area
14	A	List of the electrical equipment installed in hazardous areas comparable to zone 0 and 1, including the following equipment particulars: location, type of protection, type of protection against explosion, testing body and approval number
15	A	Schematic electrical wiring diagram
16	A	Pressure drop calculation note
17	A	Gas detection system
18	A	Cargo tank instrumentation
19	A	Details of fire-extinguishing appliances and systems in cargo area
20	A	Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar
21	I	Loading and unloading operation description, including cargo tank filling limits, where applicable
22	A	Gas return system
23	A	List of equipment installed in hazardous areas comparable to zone 2 which may be used during loading, unloading and gas-freeing and red equipment
Note 1: A = to be submitted for review I = to be submitted for information.		

2.3.2 The engine rooms shall be accessible from the deck; the entrances shall not face the cargo area. When the doors are not located in a recess whose depth is at least equal to the door width, the hinges shall face the cargo area.

2.4 Accommodation and service spaces

2.4.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area, see Ch 3, App 1, [1.7] for definition, forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1,00 m above the bottom of the wheelhouse may tilt forward.

2.4.2 Entrances to spaces and openings of superstructures shall not face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors shall have their hinges facing the cargo area.

2.4.3 Entrances from the deck and openings of spaces facing the weather shall be capable of being closed.

2.4.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. No wheelhouse doors and windows shall be located within 2,00 m from any hazardous area comparable to zone 0 or 1, except where there is no direct connection between the wheelhouse and the accommodation.

2.4.5

a) Driving shafts of the bilge or ballast pumps in the cargo area may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with [2.6.6].

b) The penetration of the shaft through the bulkhead shall be gastight and shall have been approved by the Society.

c) Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations have been approved by the Society. The penetrations shall be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), shall have an equivalent fire protection.

d) Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

e) Notwithstanding [2.6.4], pipes from the engine room may penetrate the service space in the cargo area or a cofferdam or a hold space or a double hull space to the outside provided that within the service space or cofferdam or hold space or doublehull space they are of the thick-walled type and have no flanges or openings.

2.4.6 A service space located within the cargo area below deck shall not be used as a cargo pump room for the loading and unloading system, except where the cargo pump room is provided with a permanent gas detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system shall be placed at suitable positions at the bottom and directly below the deck.

Measurement shall be continuous.

The audible and visual alarms are installed in the wheelhouse and in the cargo pump room and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system shall be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms.

2.5 Accommodation and service spaces - Additional requirements for DG-N closed and DG-N open with flame arresters

2.5.1 Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration shall be gastight.

2.5.2 A service space located within the cargo area below deck shall not be used as a cargo pump room for the loading and unloading system, except where:

- the cargo pump room is separated from the engine room or from service spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), or by a service space or a hold space
- the "A-60" bulkhead required above does not include penetrations referred to in [2.4.5], item a)
- ventilation exhaust outlets are located not less than 6,00 m from entrances and openings of the accommodation and service spaces outside the cargo area
- the access hatches and ventilation inlets can be closed from the outside
- all piping for loading and unloading as well as those of stripping systems are provided with shut-off devices at the pump suction side in the cargo pump room immediately at the bulkhead. The necessary operation of the control devices in the pump room, starting of pumps and necessary control of the liquid flow rate shall be effected from the deck
- the bilge of the cargo pump room is equipped with a gauging device for measuring the filling level which activates a visual and audible alarm in the wheelhouse when a liquid is accumulating in the cargo pump room bilge
- the ventilation system prescribed in [2.8] and [2.9] has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

2.6 Hold spaces

2.6.1 The cargo tanks shall be separated by cofferdams of at least 0,60 m in width from the accommodation, engine room and service spaces outside the cargo area below deck or, if there are no such accommodation, engine room and service spaces, from the vessel's ends. Where the cargo tanks are installed in a hold space, a space of not less than 0,50 m shall be provided between such tanks and the end bulkheads of the hold space. In this case an end bulkhead meeting at least the definition for Class "A-60" (see Pt C, Ch 4, Sec 1, [2.2]), shall be deemed equivalent to a cofferdam. For pressure cargo tanks, the 0,50 m distance may be reduced to 0,20 m.

2.6.2 Hold spaces, cofferdams and cargo tanks shall be capable of being inspected.

2.6.3 All spaces in the cargo area shall be capable of being ventilated. Means for checking their gas-free condition shall be provided.

2.6.4 The bulkheads bounding the cargo tanks, cofferdams and hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck.

The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of [2.4.5].

The bulkhead between the cargo tank and the cargo pump-room below deck may be fitted with penetrations provided that they conform to the provisions of [2.5.2]. The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading and unloading pipes are fitted with shut-off devices in the cargo tank from which they come. The shut-off devices shall be operable from the deck.

These pipes shall be at least 0,60 m above the bottom.

2.6.5 Double hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with [2.11].

2.6.6

a) A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space shall only be accessible from the deck.

b) The service space shall be watertight with the exception of its access hatches and ventilation inlets.

2.6.7 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

2.6.8 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area shall be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings, except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks, shall be in compliance with Pt B, Ch 2, Sec 1, [3.2.2].

2.7 Hold spaces - Additional requirements for DG-N closed and DG-N open with flame arresters

2.7.1 No piping for loading and unloading shall be fitted within the service space referred to in [2.6.6], item a).

Piping for loading and unloading may be fitted in the cargo pump-rooms below deck only when they conform to the provisions of [2.5.2].

2.8 Ventilation

2.8.1 Each hold space shall have two openings the dimensions and location of which shall be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it shall be possible to fill the hold spaces with inert gas or dry air.

2.8.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams, shall be provided with ventilation systems.

2.8.3 A service space located within the cargo area below deck shall be provided with a ventilation system. The capacity of the fans shall be sufficient to ensure 20 complete changes of air per hour based on the volume of the service space.

The ventilation exhaust ducts shall extend down to 50 mm above the bottom of the service space. The air shall be supplied through a duct at the top of the service space.

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the air inlets shall be located not less than 2,00 m above the deck, at a distance of not less than 2,00 m from tank openings and 6,00 m from the outlets of safety valves.

The extension pipes which may be necessary may be of the hinged type.

On board DG-N open vessels, other suitable installations without ventilator fans shall be sufficient.

2.8.4 Ventilation of accommodation and service spaces shall be possible.

2.9 Ventilation - Additional requirements for DG-N closed and DG-N open with flame arresters

2.9.1 All ventilation inlets of accommodation, wheelhouse and service spaces leading to the open air outside the cargo area shall be fitted with devices permanently fixed according to Pt C, Ch 4, Sec 4, [4.2], enabling them to be closed rapidly. It shall be clear whether they are open or closed.

Such ventilation inlets shall be located not less than 2,00 m from the cargo area.

Ventilation inlets of service spaces in the cargo area may be located within that area.

2.9.2 The flame-arresters prescribed in [3.6.3] and [3.6.4] shall be of a type approved for this purpose by the Society.

2.10 Engines

2.10.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.10.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, the air intakes of the engines shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.11 Oil fuel tanks

2.11.1 When the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0,60 m.

Oil fuel pipes and openings of such tanks are not permitted in the hold space.

2.11.2 The open ends of the air pipes of all liquid oil fuel tanks shall extend to not less than 0,50 m above the open deck. Their open ends and the open ends of overflow pipes leading on the deck shall be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

2.12 Exhaust pipes

2.12.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.12.2 Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

2.13 Bilge pumping and ballasting arrangements

2.13.1 Bilge and ballast pumps for spaces within the cargo area shall be installed within such area.

This provision does not apply to:

- double hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks
- cofferdams, double hull spaces, hold spaces and double bottoms where ballasting is carried out using the piping of the fire fighting system in the cargo area and bilge-pumping is performed using eductors which are installed in the cargo area.

2.13.2 Where the double bottom is used as oil fuel tank, it shall not be connected to the bilge piping system.

2.13.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water shall be located within the cargo area but outside the cargo tanks.

2.13.4 A cargo pump-room below deck shall be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation shall be provided outside the cargo pump-room.

2.14 Ventilation of cargo pump rooms

2.14.1 Cargo pump rooms must be provided with extraction type ventilation systems, independent of other vessel's spaces, providing at least 30 cycles of air change per hour. Warning notices shall be placed requiring that the ventilation is in operation for at least 15 minutes prior to entering these spaces.

2.14.2 Portable means must be provided for gas-freeing of cargo tanks and other spaces not equipped with fixed ventilation.

2.15 Arrangements of cofferdams

2.15.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with [2.6.6] and [2.7.1] shall be accessible through an access hatch.

2.15.2 No fixed pipe shall permit connection between a cofferdam and other piping of the vessel outside the cargo area.

3 Cargo containment

3.1 General

3.1.1 DG-N may be arranged in three different designs in respect of cargo tank venting with due regard to the products allowed to be carried:

- DG-N, open venting
- DG-N, open venting, flame arresters
- DG-N, closed.

3.1.2 The scantlings and structural arrangements are to be in compliance with applicable requirements of Ch 1, Sec 3, [6] to Ch 1, Sec 3, [11].

3.2 Cargo area hull design

3.2.1 In the cargo area, the vessel shall be designed according to [3.2.2] and [3.2.3].

Alternative constructions will be specially considered by the Society on a case-by-case basis.

3.2.2 Where independent cargo tanks are used, or for double-hull construction where the cargo tanks are integrated in vessel’s structure, the space between the wall of the vessel and wall of the cargo tanks shall be not less than 0,60 m.

The space between the bottom of the vessel and the bottom of the cargo tanks shall be not less than 0,50 m. The space may be reduced to 0,40 m under the pump sumps. The vertical space between the suction well of a cargo tank and the bottom structures shall be not less than 0,10 m.

When a hull is constructed in the cargo area as a double hull with independent cargo tanks located in hold spaces, the above values are applicable to the double hull. If in this case the minimum values for inspections of independent tanks referred to in [2.6.8] are not feasible, it must be possible to remove the cargo tanks easily for inspection.

3.2.3 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulties, if necessary by means of fixed equipment.

3.3 Cargo tank arrangements

3.3.1 The cargo tank is to comply with the following:

- for vessels with a length not more than 50,00 m, the length of a cargo tank shall not exceed 10,00 m
- for vessels with a length of more than 50,00 m, the length of a cargo tank shall not exceed 0,20 L, where L is the vessel rule length. This provision does not apply to vessels with independent built-in cylindrical tanks having a length to diameter ratio ≤ 7.

3.3.2 The capacity of a suction well shall be limited to not more than 0,10 m^3.

3.4 Integrated tank scantlings

3.4.1 The scantlings of the integrated tank structure are to be determined in compliance with Ch 1, Sec 3.

3.5 Independent cargo tank scantlings

3.5.1 Tank scantlings

The scantlings of independent cargo tank structure are to be determined in compliance with Ch 1, Sec 3, [6.1.2].

When the vessel is provided with pressure cargo tanks, these tanks shall be designed in compliance with Pt C, Ch 1, Sec 3, for a working pressure of 400 kPa.

3.5.2 Supports and fastenings

The cargo tanks independent of the vessel's hull shall be fixed so that they cannot float.

The scantlings of the tank supports and fastenings are to be in compliance with Ch 1, Sec 3, [9].

3.6 Cargo tank openings

3.6.1

a) Cargo tank openings shall be located on deck in the cargo area.

b) Cargo tank openings with a cross-section of more than 0,10 m^2 and openings of safety devices for preventing overpressures shall be located not less than 0,50 m above deck.

3.6.2 For DG-N closed, cargo tank openings shall be fitted with gastight closures capable of withstanding the test pressure in accordance with Pt B, Ch 3, Sec 4, [5].

3.6.3 Safety devices

Each cargo tank or group of cargo tanks connected to a common venting piping shall be fitted with:

DG-N open:

- devices to prevent unacceptable overpressures or vacuums and constructed so as to prevent any accumulation of water and penetration of water into the cargo tank.

DG-N open with flame arresters:

- devices to prevent unacceptable overpressures or vacuums, equipped with flame arresters capable of withstanding steady burning and constructed so as to prevent any accumulation of water and penetration of water into the cargo tank.

DG-N closed:

a) a connection for the safe return ashore of gases expelled during loading

b) a safe depressurization device for the cargo tanks, on which the position of the shut-off valve indicates clearly whether it is open or shut

c) safety valves for preventing unacceptable overpressures or vacuums;

   The opening pressure of the safety valves shall be marked indelibly on the valves

d) If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then:

   - at the connection to each cargo tank, the venting piping shall be equipped with a flame arrester capable of withstanding a detonation
   - the vacuum valve and the safe depressurization device for cargo tanks shall be deflagration safe. The deflagration safety may also be ensured by a flame arrester; and
   - the pressure relief device shall be designed as a high velocity vent valve, with the gases discharged upwards

   The setting of the pressure relief valves shall be such that during the transport operation they do not blow off until the maximum permissible working pressure of the cargo tanks is reached

   The protection systems shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2);

   If the high velocity vent valve, the vacuum valve, the flame arresters and the venting piping are required to be heatable for carriage, the safety devices concerned shall be suitable for the relevant temperature;

   The opening pressure of the pressure relief valves, the vacuum valve and the high velocity vent valves shall be marked indelibly on the valves;

   If a shut-off device is to be mounted between the venting piping and the cargo tank, it shall be placed between the cargo tank and the flame arrester, and each cargo tank shall be equipped with pressure relief valves;

e) The outlets of the pressure relief devices/high velocity vent valves shall be located not less than 2,00 m above the deck and at a distance of not less than 6,00 m from the openings of the accommodations, the wheelhouse and the service spaces outside the cargo area. This height may be reduced to 1,00 m when there is no equipment and no work is being carried out within a radius of 1,00 m around the pressure relief valve outlet. This area shall be marked as a danger zone.

3.6.4 Venting piping - DG-N closed

a) When two or more cargo tanks are connected to common venting piping, it is sufficient that the equipment according to [3.6.3] (safety valves to prevent unacceptable overpressures and vacuums, high velocity vent valve, vacuum valve protected against deflagrations, safe pressure relief device for cargo tanks protected against deflagrations) is installed on the joint venting piping.

b) When each cargo tank is connected to its own venting piping, each cargo tank or the associated venting piping shall be equipped according to [3.6.3].

3.6.5 Additional requirement for DG-N closed and DG-N open with flame arrester

Closures which are normally used during loading or unloading operations shall not cause sparking when operated.

4 Cargo piping system

4.1 General

4.1.1 The requirements [4.1.2], [4.1.4], [4.2.2], [4.2.5] and [4.4.1] do not apply unless the substance carried has corrosive properties.

4.1.2 Pumps and accessory loading and unloading piping shall be placed in an area between the fore vertical plane and the aft vertical plane bounding the part of the cargo area below deck.

4.1.3 Cargo pumps shall be capable of being shut down from the area described in [4.1.2] and from a position outside this area.

4.1.4 Cargo pumps situated on deck shall be located not less than 6,00 m from entrances to, or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2 Arrangement of cargo piping

4.2.1 Piping for loading and unloading shall be independent of any other piping of the vessel.

4.2.2 No cargo piping shall be located below deck, except those inside the cargo tanks and inside the cargo pump room.

4.2.3 The piping for loading and unloading shall be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's tanks or the tanks ashore.

4.2.4 Piping for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

4.2.5 The shore connections shall be located not less than 6,00 m from the entrances to or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2.6 Each shore connection of the venting pipe and shore connections of the pipes for loading and unloading, through which the loading or unloading operation is carried out, shall be fitted with a shut-off device. However, each shore connection shall be fitted with a blind flange when it is not in operation.

4.2.7 Piping for loading and unloading, and venting pipes, shall not have flexible connections fitted with sliding seals.

4.2.8 If the vessel is carrying several dangerous substances liable to react dangerously with each other, a separate pump with its own piping for loading and unloading shall be installed for each substance. The piping shall not pass through a cargo tank containing dangerous substances with which the substance in question is liable to react.

4.3 Control, monitoring and alarm devices

4.3.1 Stop valves

The stop valves or other shut-off devices of the piping for loading and unloading shall indicate whether they are open or shut.

4.3.2 Pressure gauges

The piping for loading and unloading shall be fitted with pressure gauges at the outlet of the pumps.

The permissible maximum overpressure or vacuum value shall be indicated on each measuring device.

4.4 Bonding

4.4.1 Every component of the piping for loading and unloading shall be electrically connected to the hull.

4.5 Supply of cargo tanks with washing or ballast water

4.5.1 When piping for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes shall be located within the cargo area but outside the cargo tanks.

Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that suction is not possible through that part.

A spring-loaded non-return valve shall be provided to prevent any gases from being expelled from the cargo area through the tank washing system.

4.5.2 A non-return valve shall be fitted at the junction between the water suction pipe and the cargo loading pipe.

4.6 Permissible loading and unloading flows

4.6.1 The permissible loading and unloading flows shall be calculated.

4.6.2 Calculations concern the permissible maximum loading and unloading flow for each cargo tank or each group of cargo tanks, taking into account the design of the ventilation system. These calculations shall take into consideration the fact that in the event of an unforeseen cut-off of the gas return piping or the compensation piping of the shore facility, the safety devices of the cargo tanks will prevent pressure in the cargo tanks from exceeding the following values:

- over-pressure: 1.15 times the opening pressure of the pressure relief valve/high velocity vent valve
- vacuum pressure: not more than the design pressure, but not exceeding a vacuum of 5 kPa (0,05 bar).

4.7 Additional requirements for DG-N closed and DG-N open with flame arrester

4.7.1 The piping for loading shall extend down to the bottom of the cargo tank.

5 Cargo pressure and temperature control

5.1 Regulation of cargo pressure and temperature

5.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks shall be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

- a system for the regulation of cargo tank pressure using mechanical refrigeration
- a system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, shall be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system shall be deemed acceptable by the Society and shall ensure safety for a minimum time of three times the operation period
- other systems deemed acceptable by the Society.

5.1.2 The systems prescribed in [5.1.1] shall be constructed, installed and tested to the satisfaction of the Society. The materials used in their construction shall be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits shall be:

- air: + 30°C
- water: + 20°C.

5.2 Refrigeration system

5.2.1 The refrigeration system referred to in [5.1.1] shall be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by the Society is provided, provision shall be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. Provision shall be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity.

Cargo tanks, piping and accessories shall be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

5.2.2 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care shall be given to the refrigeration systems so as to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in [5.2.1], shall be provided for each cargo.

5.2.3 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care shall be given to the refrigeration systems to prevent any mixing of the cargoes.

5.2.4 All primary and secondary coolant fluids shall be compatible with each other and with the cargo with which they may come into contact.

5.2.5 When the refrigeration system is installed in a separate service space, this service space shall meet the requirements of [2.5.2].

5.3 Cargo tank heating

5.3.1 Cargo tank heating system is to be installed as a separate system, equipped with a heat exchanger located in the cargo area. Where special heat transfer media are used, this requirement may be dispensed with upon approval by the Society.

5.3.2 Boilers which are used for heating the cargo shall be fuelled with a liquid fuel having a flashpoint of more than 55°C. They shall be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.3.3 The cargo heating system shall be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught shall be ignited electrically.

5.3.4 The ventilation system of the engine room shall be designed taking into account the air required for the boiler.

5.3.5 Where the cargo heating system is used during loading, unloading or gas-freeing, the service space which contains this system shall fully comply with [8.1.1]. This requirement does not apply to the inlets of the ventilation system. These inlets shall be located at a minimum distance of 2,00 m from any hazardous area comparable to zone 0 or 1 and 6,00 m from the openings of cargo tanks or residual cargo tanks, loading pumps situated on deck, openings of high velocity vent valves, pressure relief devices and shore connections of loading and unloading pipes and must be located not less than 2,00 m above the deck.

The requirements of [8.1.1] are not applicable to the unloading of substances having a flash point of 60 °C or more when the temperature of the product is at least 15 K lower at the flash point.

5.4 Water spray system

5.4.1 When water-spraying is required in column (9) of Ch 3, App 3, Tab 2, a water-spray system shall be installed in the cargo area on deck for the purpose of cooling the tops of cargo tanks by spraying water over the whole surface so as to avoid safely the activation of the pressure relief valves/high velocity vent valves at 10 kPa or as regulated.

5.4.2 The spray nozzles shall be so installed that the entire cargo deck area is covered and the gases released are precipitated safely. The system shall be capable of being put into operation from the wheelhouse and from the deck. Its capacity shall be such that when all the spray nozzles are in operation, the outflow is not less than 50 litres per square metre of deck area and per hour.

6 Residual cargo tanks and receptacles for residual products

6.1 General

6.1.1 When vessels are provided with tanks for residual products or receptacles for residual products, they shall be located in the cargo area and comply with the provisions of [6.1.2] and [6.1.3]. Receptacles for residual products shall be located only in the cargo area on deck and not less than a quarter of the vessel's breadth from the outer shell.

6.1.2 Tanks for residual products shall be equipped with:

In the case of an open system:

- an ullage opening
- a device for ensuring pressure equilibrium
- connections, with stop valves, for pipes and hoses

In the case of an open system with flame arrester:

- an ullage opening
- connections, with stop valves, for pipes and hose assemblies
- a device for ensuring pressure equilibrium, fitted with a flame arrester capable of withstanding steady burning.

In the case of a closed system:

- a level indicator
- connections, with stop valves, for pipes and hose assemblies
- a vacuum valve and a pressure relief valve

The pressure relief valve shall be sized so that, during the transport operation, it does not open when in normal operation. This condition is met when the opening pressure of the valve meets the conditions required in column (10) of Ch 3, App 3, Tab 2 for the substance to be carried.

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the pressure relief valve shall be a high velocity vent valve and the vacuum valve shall be deflagration safe. The deflagration safety may also be ensured by a flame arrester.

The high velocity vent valve and the deflagration safe vacuum valve shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

The maximum permissible capacity is 30 m^3.

6.1.3 Receptacles for residual products shall be equipped with:

- a possibility of indicating the degree of filling
- connections, with stop valves, for pipes and hose assemblies
- a connection enabling gases released during filling to be evacuated safely

7 Environmental control

7.1 Inerting facility

7.1.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel shall be equipped with an inerting system.

7.1.2 This system shall be capable of maintaining a permanent minimum pressure of 7 kPa (0,07 bar) in the spaces to be inerted. In addition, the inerting system shall not increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve shall be 3,5 kPa (0,035 bar).

7.1.3 The premises to be inerted shall be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

8 Electrical installations

8.1 Type and location of electrical installations and equipment

8.1.1 Electrical installations and equipment shall be of at least the "limited explosion risk" type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.8] and [2.9]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m of the cargo area.

8.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

8.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [8.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

8.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

8.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [8.1.4].

8.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [8.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

8.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

8.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

8.1.9 Sockets for the connection of signal lights and gangway lighting shall be solidly fitted to the vessel close to the signal mast or the gangway. The sockets used in this area shall be designed so as to prevent connection or disconnection except when they are not live.

8.1.10 DG-N open vessels are only required to meet the requirements of [8.1.1] and [8.1.3], if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

8.2 Type and location of electrical and non-electrical installations and equipment intended to be used in explosion hazardous areas

8.2.1 On board vessels covered by the classification of zones as defined in Ch 3, App 1, Tab 1, electrical and non-electrical installations and equipment used in explosion hazardous areas shall meet at least the requirements for use in the area concerned.

They shall be selected on the basis of the explosion groups/subgroups and temperature classes to which the substances to be carried belong (see columns (15) and (16) of Ch 3, App 3, Tab 2).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T4, T5 or T6 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 135°C (T4), 100° (T5) or 85°C (T6).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T1 or T2 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 200°C.

8.2.2 Except in the case of optical fibres, electrical cables shall be armoured or placed in a metallic sheath or in protective tubes.

Electrical cables for the active cathodic protection of the shell plating shall be led through thick-walled steel tubes with gastight connections up to the main deck.

8.2.3 Movable electric cables are prohibited in the explosion danger area, except for electric cables for intrinsically safe electric circuits or for connecting:

- Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway
- The power network on a vessel to a land-based power network; provided
  - The electric cables and the power supply unit conform with a valid standard
  - The power supply unit and connectors are located outside of the explosion danger area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

8.2.4 Electrical cables of intrinsically safe circuits shall be separated from other cables not intended for use in such circuits and shall be marked (they shall not be installed together in the same string of cables and they shall not be fixed by the same cable clamps).

8.2.5 For movable electrical cables permitted under, only sheathed cables of type H07RN-F in accordance with standard IEC 60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.50 mm^2 shall be used.

8.3 Earthing

8.3.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service shall be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

8.3.2 The provisions of [8.3.1] apply also to equipment having service voltages of less than 50 V.

8.3.3 Independent cargo tanks, metal intermediate bulk containers and tank-containers shall be earthed.

8.3.4 Receptacles for residual products shall be capable of being earthed.

8.4 Storage batteries

8.4.1 Storage batteries shall be located outside any hazardous area comparable to zone 0 or 1.

9 Fire protection and fire extinction

9.1 Fire and naked light

9.1.1 The outlets of funnels shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

9.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

9.1.3 Only electrical lamps are permitted.

9.2 Fire extinguishing arrangements

9.2.1 In addition to the requirements of Part C, Chapter 4, the fire extinguishing arrangements in [9.3] to [9.5] are to be complied with.

9.3 Portable fire extinguishers

9.3.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], the vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

9.4 Fire extinguishing system

9.4.1 A fire-extinguishing system complying with the following requirements shall be installed on the vessel:

- It shall be supplied by two independent fire or ballast pumps, one of which shall be ready for use at any time. These pumps and their means of propulsion and electrical equipment shall not be installed in the same space.
- It shall be provided with a water main fitted with at least three hydrants in the cargo area above deck. Three suitable and sufficiently long hoses with spray nozzles having a diameter of not less than 12 mm shall be provided.
- It shall be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water not supplied from the same hydrant.

  A spring-loaded non-return valve shall be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the cargo area.
- The capacity of the system shall be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.

9.5 Fixed fire extinguishing system

9.5.1 In addition the machinery spaces and the cargo pump room shall be provided with a permanently fixed fire-extinguishing system, in compliance with Pt C, Ch 4, Sec 4, [4].

10 Safety and control installations

10.1 General

10.1.1 Cargo tanks shall be provided with the following equipment:

a) a level gauge

b) a level alarm device which is activated at the latest when a degree of filling of 90% is reached

c) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached

d) for N closed, an instrument for measuring the pressure of the vapour phase inside the cargo tank

e) an instrument for measuring the temperature of the cargo, if in column (9) of Ch 3, App 3, Tab 2, a cargo heating installation or a possibility of heating the cargo is required on board, or if a maximum temperature is indicated in column (20) of Ch 3, App 3, Tab 2

f) A connection for a closed-type or partly closed-type sampling device, and/or at least one sampling opening as required in column (13) of Ch 3, App 3, Tab 2. The connection shall be fitted with a shut-off device resistant to the internal pressure at the connection.

   If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the flame arrester plate stack capable of withstanding steady burning of the sampling opening shall be selected according to the explosion groups/subgroups of the substances foreseen for inclusion in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

10.2 Cargo tank level indicators

10.2.1 Each cargo tank is to be equipped with a closed gauging device approved by the Society.

The level gauge shall allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling level of the cargo tank shall be marked on each level gauge.

10.3 Level alarm device

10.3.1 Cargo tank shall be provided with a level alarm device which is activated at the latest when a degree of filling of 90% is reached.

The level alarm device shall give a visual and audible warning on board when actuated. The level alarm device shall be independent of the level gauge.

10.4 High level sensor

10.4.1 Cargo tank shall be provided with a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached.

10.5 Cargo tank pressure monitoring - DG-N closed

10.5.1 When the pressure or temperature exceeds a set value, instruments for measuring the vacuum or overpressure of the gaseous phase in the cargo tank or the temperature of the cargo shall activate a visual and audible alarm in the wheelhouse and on deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

10.5.2 When the pressure exceeds the set value during loading and unloading, the instrument for measuring the pressure shall initiate immediately an electrical contact which shall put into effect measures to interrupt the loading or unloading operation. If the vessel's own discharge pump is used, it shall be switched off automatically.

10.5.3 The instrument for measuring the overpressure or vacuum shall activate the alarm at latest when:

a) An overpressure equal to 1,15 times the opening pressure of the pressure relief valves/high velocity vent valves is reached; or

b) The lower threshold of the design pressure of the vacuum valves, but not exceeding a vacuum of 5 kPa (0,05 bar), is reached.

10.5.4 The maximum permissible temperature is indicated in column (20) of Ch 3, App 3, Tab 2. The sensors for the alarms mentioned in this paragraph may be connected to the alarm device of the sensor.

When it is prescribed in column (20) of Ch 3, App 3, Tab 2, the instrument for measuring the overpressure of the gaseous phase in the cargo tank shall actuate a visible and audible alarm in the wheelhouse when the overpressure exceeds 40 kPa (0,4 bar) during the voyage. The alarm must be relayed to the accommodation automatically if it has not been switched off. It shall be possible to read the gauges in direct proximity to the control for the water spray system.

10.6 Cargo temperature monitoring

10.6.1 An instrument for measuring the temperature of the cargo is to be provided, if in column (9) of Ch 3, App 3, Tab 2 a heating installation is required, or if a possibility of heating the cargo is required, or if a maximum temperature is indicated in column (20).

10.7 Cargo tank sampling equipment

10.7.1 Each cargo tank shall be equipped with a connection for a sampling device, closed or partially closed, and/or at least one sampling opening as required in column (13) of Ch 3, App 3, Tab 2.

11 Buoyancy and stability

11.1 General

11.1.1 General requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

11.1.2 The longitudinal centre bulkhead may be dispensed with only if sufficient stability is guaranteed.

11.1.3 Proof of sufficient stability shall be furnished. This proof is not required for single hull vessels with cargo tanks the width of which is not more than 0,70B.

11.1.4 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined in compliance with Pt B, Ch 2, Sec 2, [2.2].

11.1.5 Proof of sufficient intact stability shall be furnished for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the vessel substance list according to Ch 3, Sec 1, [4.3.2].

11.1.6 For every loading case, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel shall comply with the intact and damage stability requirements.

Intermediate stages during operations shall also be taken into consideration.

11.2 Intact stability

11.2.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the requirements for intact stability resulting from the damage stability calculation shall be fully complied with.

11.2.2 For vessels with cargo tanks of more than 0,70 B in width, the following intact stability requirements are to be complied with, bearing in mind the influence of all free surfaces in tanks for all stages of loading and unloading:

- in the positive area of the righting lever curve up to immersion of the first unprotected opening there shall be a righting lever (GZ) of not less than 0,10 m
- the surface of the positive area of the righting lever curve up to immersion of the first unprotected opening and in any event up to an angle of heel ≤ 27° shall not be less than 0,024 m.rad
- the initial metacentric height GM_0 shall be not less than 0,10 m.

11.3 Damage stability

11.3.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the following assumptions shall be taken into consideration for the damaged condition.

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: B_2 – 0,01 m
   - vertical extent: from base line upwards without limit.

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to D_2 – 0,01 m upwards, except for pump well.

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

11.3.2 In general, permeability shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the minimum values of permeability μ given in Tab 2 are to be used.

For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

11.3.3 The damage stability is generally regarded sufficient if (see Fig 1):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered flooded for the purpose of stability calculation.
- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m.rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

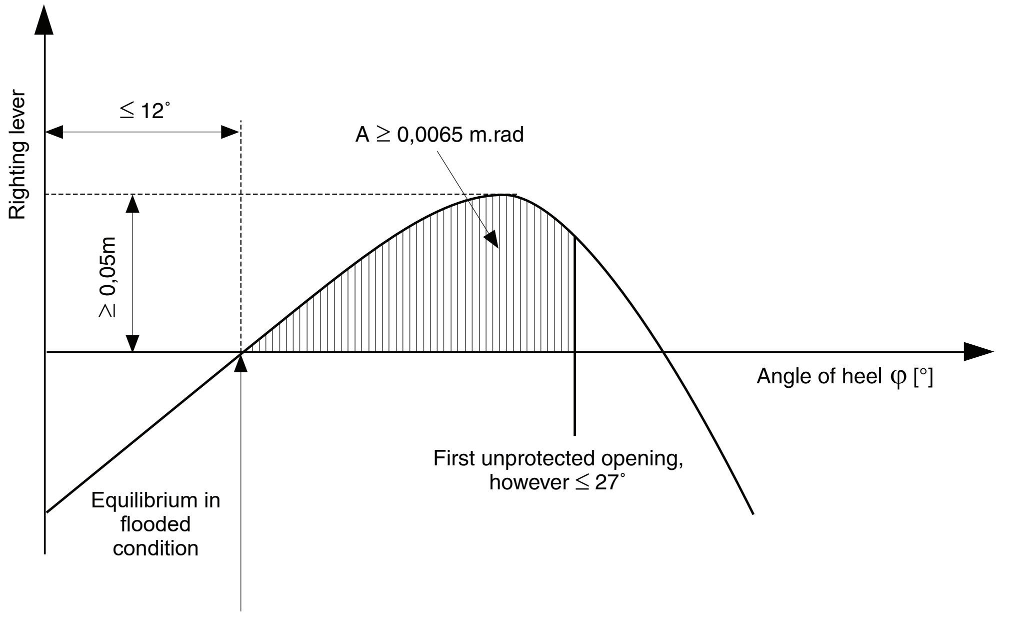
11.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

11.3.5 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Table 2 : Permeability μ

Spaces	μ, in %
Engine rooms	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

Figure 1 : Proof of damage stability



SECTION 5 OIL SEPARATOR VESSEL

Symbols

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional service feature **Oil separator vessel** as defined in Pt A, Ch 1, Sec 3, [3.2.18].

1.1.2 These Rule requirements apply in addition to Ch 1, Sec 3 and Ch 3, Sec 1.

1.1.3 Vessels without cargo tanks are considered to be subject to Ch 3, Sec 7.

1.2 Documents to be submitted

1.2.1 Tab 1 lists the plans and documents to be submitted in addition to the documents required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

2 Vessel arrangement

2.1 Protection against penetration of gases

2.1.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.1.2 The requirement [2.1.1] is to be met only if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

2.2 Engine rooms

2.2.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.2.2 The engine rooms shall be accessible from the deck; the entrances shall not face the cargo area.

2.3 Accommodation and service spaces

2.3.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1,00 m above the bottom of the wheelhouse may tilt forward.

2.3.2 Entrances to spaces and openings of superstructures shall not face the cargo area.

2.3.3 Entrances from the deck and openings of spaces facing the weather shall be capable of being closed.

2.3.4

a) Driving shafts of the bilge or ballast pumps in the cargo area may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with [2.4.6].

b) The penetration of the shaft through the bulkhead shall be gastight and shall have been approved by the Society.

c) Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations have been approved by the Society. The penetrations shall be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), shall have an equivalent fire protection.

d) Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

e) Notwithstanding [2.4.4], pipes from the engine room may penetrate the service space in the cargo area or a cofferdam or a hold space or a double-hull space to the outside provided that within the service space or cofferdam or hold space or doublehull space they are of the thick-walled type and have no flanges or openings.

Table 1 : Documents to be submitted

No.	A/I	Document
1	I	List of substances intended to be carried with their UN number (see Ch 3, App 3, Tab 2), including all design characteristics of substances and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks, void spaces
3	A	Hazardous areas plan and location of the electrical equipment installed in these areas
4	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
5	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, independent cargo tanks, etc.
6	A	Intact and damage stability calculations
7	A	Scantlings, material and arrangement of the cargo containment system
8	A	Details of cargo handling system, including arrangements and details of piping and fittings
9	A	Details of cargo pumps
10	A	Bilge and ballast system in cargo area
11	A	Gas freeing system in cargo tanks
12	A	Ventilation system in cargo area
13	A	List of the electrical equipment installed in hazardous areas comparable to zone 0 and 1, including the following equipment particulars: location, type of protection, type of protection against explosion, testing body and approval number
14	A	Schematic electrical wiring diagram
15	A	Gas detection system
16	A	Cargo tank instrumentation
17	A	Details of fire-extinguishing appliances and systems in cargo area
18	A	Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar
19	I	Loading and unloading operation description, including cargo tank filling limits, where applicable
20	A	List of equipment installed in hazardous areas comparable to zone 2 which may be used during loading, unloading and gas-freeing and red equipment

Note 1:
A = to be submitted for review
I = to be submitted for information.

2.3.5 A service space located within the cargo area below deck shall not be used as a cargo pump room for the loading and unloading system, except where the cargo pump room is provided with a permanent oxygen detection system which automatically indicates the amount of oxygen and which actuates a visual and audible alarm when the oxygen concentration has reached 19.5% by volume.

The sensors of this system shall be placed at suitable positions at the bottom and at a height of 2,00 m. Measurement shall be continuous and displayed near to the entrance. Audible and visual alarms shall be installed in the wheelhouse and in the cargo pump-room and, when the alarm is actuated, the loading and unloading system shall be shut down.

Failure of the oxygen measuring system shall activate a visual and audible alarm in the wheelhouse and on deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

2.4 Hold spaces

2.4.1 The cargo tanks shall be separated by cofferdams of at least 0,60 m in width from the accommodation, engine room and service spaces outside the cargo area below deck or, if there are no such accommodation, engine room and service spaces, from the vessel's ends. Where the cargo tanks are installed in a hold space, a space of not less than 0,50 m shall be provided between such tanks and the end bulkheads of the hold space. In this case an end bulkhead meeting at least the definition for Class "A-60" (see Pt C, Ch 4, Sec 1, [2.2]), shall be deemed equivalent to a cofferdam. For pressure cargo tanks, the 0,50 m distance may be reduced to 0,20 m.

2.4.2 Hold spaces, cofferdams and cargo tanks shall be capable of being inspected.

2.4.3 All spaces in the cargo area shall be capable of being ventilated. Means for checking their gas-free condition shall be provided.

2.4.4 The bulkheads bounding the cargo tanks, cofferdams and hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck.

The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of [2.3.4].

The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading and unloading pipes are fitted with shut-off devices in the cargo tank from which they come. The shut-off devices shall be operable from the deck.

These pipes shall be at least 0,60 m above the bottom.

2.4.5 Double hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with [2.7].

2.4.6

a) A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space shall only be accessible from the deck.

b) The service space shall be watertight with the exception of its access hatches and ventilation inlets.

2.4.7 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

2.4.8 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area shall be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings, except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks, shall be in compliance with Pt B, Ch 2, Sec 1, [3.2.2].

2.5 Ventilation

2.5.1 Each hold space shall have two openings the dimensions and location of which shall be such as to permit effective ventilation of any part of the hold space.

2.5.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams, shall be provided with ventilation systems.

2.5.3 Any service spaces located in the cargo area below deck shall be provided with a suitable ventilation installation.

2.5.4 Ventilation of accommodation and service spaces shall be possible.

2.6 Engines

2.6.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.7 Oil fuel tanks

2.7.1 When the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0,60 m.

Oil fuel pipes and openings of such tanks are not permitted in the hold space.

2.7.2 The open ends of the air pipes of all liquid oil fuel tanks shall extend to not less than 0,50 m above the open deck. Their open ends and the open ends of overflow pipes leading on the deck shall be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

2.8 Exhaust pipes

2.8.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.8.2 Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

2.9 Bilge pumping and ballasting arrangements

2.9.1 Bilge and ballast pumps for spaces within the cargo area shall be installed within such area.

This provision does not apply to:

- double-hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks
- cofferdams, double hull spaces, hold spaces and double bottoms where ballasting is carried out using the piping of the firefighting system in the cargo area and bilge-pumping is performed using eductors which are installed in the cargo area.

2.9.2 Where the double bottom is used as oil fuel tank, it shall not be connected to the bilge piping system.

2.9.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water shall be located within the cargo area but outside the cargo tanks.

2.9.4 A cargo pump-room below deck shall be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation shall be provided outside the cargo pump-room.

2.10 Ventilation of cargo pump rooms

2.10.1 Cargo pump rooms must be provided with extraction type ventilation systems, independent of other vessel's spaces, providing at least 30 cycles of air change per hour. Warning notices shall be placed requiring that the ventilation is in operation for at least 15 minutes prior to entering these spaces.

2.10.2 Portable means must be provided for gas-freeing of cargo tanks and other spaces not equipped with fixed ventilation.

2.11 Arrangements of cofferdams

2.11.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with [2.4.6] shall be accessible through an access hatch. If, however, the cofferdam is connected to a double-hull space, it is sufficient for it to be accessible from that space.

2.11.2 No fixed pipe shall permit connection between a cofferdam and other piping of the vessel outside the cargo area.

2.11.3 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the ventilation openings of cofferdams shall be fitted with a flame arrester capable of withstanding a deflagration. The flame arresters shall be chosen according to the explosion groups/subgroups of the substances foreseen for inclusion in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

3 Cargo containment

3.1 General

3.1.1 The scantlings and structural arrangements are to be in compliance with applicable requirements of Ch 1, Sec 3, [6] to Ch 1, Sec 3, [11].

3.2 Cargo area hull design

3.2.1 Where independent cargo tanks are used, or for double-hull construction where the cargo tanks are integrated in vessel's structure, the space between the wall of the vessel and wall of the cargo tanks shall be not less than 0,60 m.

The space between the bottom of the vessel and the bottom of the cargo tanks shall be not less than 0,50 m. The space may be reduced to 0,40 m under the pump sumps. The vertical space between the suction well of a cargo tank and the bottom structures shall be not less than 0,10 m.

When a hull is constructed in the cargo area as a double hull with independent cargo tanks located in hold spaces, the above values are applicable to the double hull. If in this case the minimum values for inspections of independent tanks referred to in [2.4.8] are not feasible, it must be possible to remove the cargo tanks easily for inspection.

3.2.2 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulties, if necessary by means of fixed equipment.

3.3 Cargo tank arrangements

3.3.1 The cargo tank is to comply with the following:

- for vessels with a length not more than 50,00 m, the length of a cargo tank shall not exceed 10,00 m
- for vessels with a length of more than 50,00 m, the length of a cargo tank shall not exceed 0,20 L, where L is the vessel rule length. This provision does not apply to vessels with independent built-in cylindrical tanks having a length to diameter ratio ≤ 7.

3.3.2 The capacity of a suction well shall be limited to not more than 0,10 m^3.

3.4 Integrated tank scantlings

3.4.1 The scantlings of the integrated tank structure are to be determined in compliance with Ch 1, Sec 3.

3.5 Independent cargo tank scantlings

3.5.1 Cargo tank scantlings

The scantlings of independent cargo tanks are to be determined in compliance with Ch 1, Sec 3, [6.1.2].

3.5.2 Supports and fastenings

The scantlings of the tank supports and fastenings are to be in compliance with Ch 1, Sec 3, [9].

3.6 Cargo tank openings

3.6.1

a) Cargo tank openings shall be located on deck in the cargo area.

b) Cargo tank openings with a cross-section of more than 0,10 m^2 and openings of safety devices for preventing overpressures shall be located not less than 0,50 m above deck.

3.6.2 Safety devices

Each cargo tank or group of cargo tanks connected to a common venting pipe shall be fitted with devices to prevent unacceptable overpressures or vacuums and constructed so as to prevent any accumulation of water and penetration of water into the cargo tank.

4 Cargo piping system

4.1 General

4.1.1 The requirements [4.1.2], [4.1.4], [4.2.2], [4.2.5] and [4.4.1] do not apply unless the substance carried has corrosive properties.

4.1.2 Pumps and accessory loading and unloading piping shall be placed in an area between the fore vertical plane and the aft vertical plane bounding the part of the cargo area below deck.

4.1.3 Cargo pumps shall be capable of being shut down from the area described in [4.1.2] and from a position outside this area.

4.1.4 Cargo pumps situated on deck shall be located not less than 6,00 m from entrances to, or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2 Arrangement of cargo piping

4.2.1 Piping for loading and unloading shall be independent of any other piping of the vessel.

4.2.2 No cargo piping shall be located below deck, except those inside the cargo tanks and inside the cargo pump room.

4.2.3 The piping for loading and unloading shall be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's tanks or the tanks ashore.

4.2.4 Piping for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

4.2.5 The shore connections shall be located not less than 6,00 m from the entrances to or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2.6 Each shore connection of the venting pipe and shore connections of the pipes for loading and unloading, through which the loading or unloading operation is carried out, shall be fitted with a shut-off device.

4.2.7 Piping for loading and unloading, and venting pipes, shall not have flexible connections fitted with sliding seals.

4.2.8 If the vessel is carrying several dangerous substances liable to react dangerously with each other, a separate pump with its own piping for loading and unloading shall be installed for each substance. The piping shall not pass through a cargo tank containing dangerous substances with which the substance in question is liable to react.

4.3 Control and monitoring

4.3.1 Stop valves

The stop valves or other shut-off devices of the pipes for loading and unloading shall indicate whether they are open or shut.

4.4 Supply of cargo tanks with washing or ballast water

4.4.1 When pipes for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes shall be located within the cargo area but outside the cargo tanks.

Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that suction is not possible through that part.

4.4.2 A non-return valve shall be fitted at the junction between the water suction pipe and the cargo loading pipe.

5 Cargo temperature control

5.1 Cargo tank heating

5.1.1 Cargo tank heating system is to be installed as a separate system, equipped with a heat exchanger located in the cargo area. Where special heat transfer media are used this requirement may be dispensed with upon approval by the Society.

5.1.2 Boilers which are used for heating the cargo shall be fuelled with a liquid fuel having a flashpoint of more than 55°C. They shall be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.1.3 The cargo heating system shall be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught shall be ignited electrically.

5.1.4 The ventilation system of the engine room shall be designed taking into account the air required for the boiler.

6 Residual cargo tanks and receptacles for residual products

6.1 General

6.1.1 Tanks for residual products shall be equipped with:

In the case of an open system:

- an ullage opening
- a device for ensuring pressure equilibrium
- connections, with stop valves, for pipes and hoses

In the case of an open system with flame arrester:

- an ullage opening
- connections, with stop valves, for pipes and hose assemblies
- a device for ensuring pressure equilibrium, fitted with a flame arrester capable of withstanding steady burning.

In the case of a closed system:

a) A level indicator
   - connections, with stop valves, for pipes and hose assemblies
   - a vacuum valve and a pressure relief valve

   The pressure relief valve shall be sized so that, during the transport operation, it does not open when in normal operation. This condition is met when the opening pressure of the valve meets the conditions required in column (10) of Ch 3, App 3, Tab 2 for the substance to be carried.

b) If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the pressure relief valve shall be a high velocity vent valve and the vacuum valve shall be deflagration safe. The deflagration safety may also be ensured by a flame arrester.

   The high velocity vent valve and the deflagration safe vacuum valve shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

7 Electrical installations

7.1 Type and location of electrical equipment

7.1.1 Electrical installations and equipment shall be of at least the "limited explosion risk" type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.5]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m of the cargo area.

7.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

7.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [7.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

7.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

7.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [7.1.4].

7.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [7.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

7.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

7.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

7.1.9 Sockets for the connection of signal lights and gangway lighting shall be solidly fitted to the vessel close to the signal mast or the gangway. The sockets used in this area shall be designed so as to prevent connection or disconnection except when they are not live.

7.1.10 Vessels are only required to meet the requirements of [7.1.1] and [7.1.2], if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

7.2 Type and location of electrical and non-electrical installations and equipment intended to be used in explosion hazardous areas

7.2.1 On board vessels covered by the classification of zones as defined in Ch 3, App 1, Tab 1, electrical and non-electrical installations and equipment used in explosion hazardous areas shall meet at least the requirements for use in the area concerned.

They shall be selected on the basis of the explosion groups/subgroups and temperature classes to which the substances to be carried belong (see columns (15) and (16) of Ch 3, App 3, Tab 2).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T4, T5 or T6 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 135°C (T4), 100° (T5) or 85°C (T6).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T1 or T2 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 200°C.

7.2.2 Except in the case of optical fibres, electrical cables shall be armoured or placed in a metallic sheath or in protective tubes.

Electrical cables for the active cathodic protection of the shell plating shall be led through thick-walled steel tubes with gastight connections up to the main deck.

7.2.3 Movable electric cables are prohibited in the explosion danger area, except for electric cables for intrinsically safe electric circuits or for connecting:

- Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway
- The power network on a vessel to a land-based power network; provided
  - The electric cables and the power supply unit conform with a valid standard
  - The power supply unit and connectors are located outside of the explosion danger area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

7.2.4 Electrical cables of intrinsically safe circuits shall be separated from other cables not intended for use in such circuits and shall be marked (they shall not be installed together in the same string of cables and they shall not be fixed by the same cable clamps).

7.2.5 For movable electrical cables permitted under, only sheathed cables of type H07RN-F in accordance with standard IEC 60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.50 mm^2 shall be used.

7.3 Earthing

7.3.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service shall be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

7.3.2 The provisions of [7.3.1] apply also to equipment having service voltages of less than 50 V.

7.3.3 Independent cargo tanks, metal intermediate bulk containers and tank-containers shall be earthed.

7.3.4 Receptacles for residual products shall be capable of being earthed.

7.4 Storage batteries

7.4.1 Storage batteries shall be located outside any hazardous area comparable to zone 0 or 1.

8 Fire protection and fire extinction

8.1 Fire and naked light

8.1.1 The outlets of funnels shall be located not less than 2,00 m from the cargo area. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

8.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

8.1.3 Only electrical lamps are permitted.

8.2 Portable fire extinguishers

8.2.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], the vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

9 Safety and control installations

9.1 General

9.1.1 Cargo tanks shall be provided with the following equipment:

a) a mark inside the tank indicating the liquid level of 97%

b) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached

c) An instrument for measuring the temperature of the cargo shall be provided, if in column (9) of Ch 3, App 3, Tab 2 a cargo heating installation is required, or if a possibility of heating the cargo is required on board, or if a maximum temperature is indicated in column (20).

10 Buoyancy and stability

10.1 General

10.1.1 Exceptions to the requirements stated in these Rules are possible where they are permitted by the statutory Regulations.

10.1.2 General requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

10.1.3 The longitudinal centre bulkhead may be dispensed with only if sufficient stability is guaranteed.

10.1.4 Proof of sufficient stability shall be furnished. This proof is not required for single hull vessels with cargo tanks the width of which is not more than 0,70 B.

10.1.5 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined in compliance with Pt B, Ch 2, Sec 2, [2.2].

10.1.6 Proof of sufficient intact stability shall be furnished for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the vessel substance list according to Ch 3, Sec 1, [4.3.2].

10.1.7 For every loading case, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel shall comply with the intact and damage stability requirements.

Intermediate stages during operations shall also be taken into consideration.

10.2 Intact stability

10.2.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the requirements for intact stability resulting from the damage stability calculation shall be fully complied with.

10.2.2 For vessels with cargo tanks of more than 0,70 B in width, the following intact stability requirements are to be complied with, bearing in mind the influence of all free surfaces in tanks for all stages of loading and unloading:

- in the positive area of the righting lever curve up to immersion of the first unprotected opening there shall be a righting lever (GZ) of not less than 0,10 m
- the surface of the positive area of the righting lever curve up to immersion of the first unprotected opening and in any event up to an angle of heel ≤ 27° shall not be less than 0,024 m.rad
- the initial metacentric height GM_0 shall be not less than 0,10 m.

10.3 Damage stability

10.3.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the following assumptions shall be taken into consideration for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: B_2 – 0,01 m
   - vertical extent: from base line upwards without limit

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to D_2 – 0,01 m upwards, except for pump well

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

10.3.2 In general, permeability shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the minimum values of permeability μ given in Tab 2 are to be used.

For the main engine room, only the one-compartment status need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Table 2 : Permeability μ

Spaces	μ, in %
Engine room	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

10.3.3 The damage stability is generally regarded sufficient if (see Fig 1):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

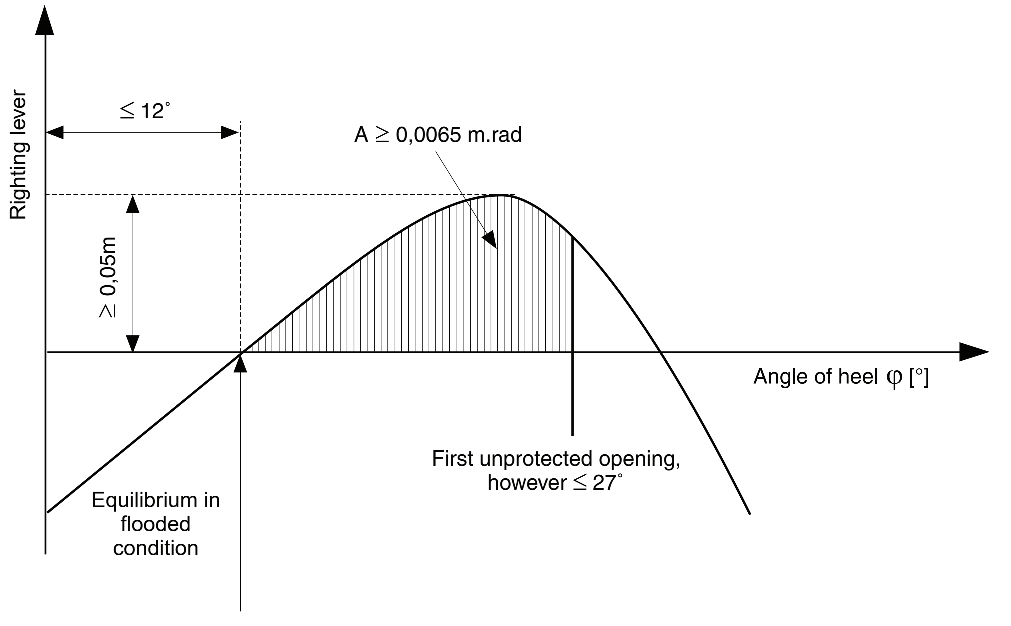
  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m.rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

10.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

10.3.5 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Figure 1 : Proof of damage stability



SECTION 6 SUPPLY VESSEL

Symbols

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the additional service feature **Supply vessel** as defined in Pt A, Ch 1, Sec 3, [3.2.19].

1.2 Documents to be submitted

1.2.1 Tab 1 lists the plans and documents to be submitted in addition to the documents required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

2 Vessel arrangement

2.1 Protection against penetration of gases

2.1.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.1.2 The requirement [2.1.1] is to be met only if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

2.2 Engine rooms

2.2.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.2.2 The engine rooms shall be accessible from the deck; the entrances shall not face the cargo area.

2.3 Accommodation and service spaces

2.3.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1,00 m above the bottom of the wheelhouse may tilt forward.

2.3.2 Entrances to spaces and openings of superstructures shall not face the cargo area.

2.3.3 Entrances from the deck and openings of spaces facing the weather shall be capable of being closed.

2.3.4

a) Driving shafts of the bilge or ballast pumps in the cargo area may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with [2.4.6].

b) The penetration of the shaft through the bulkhead shall be gastight and shall have been approved by the Society.

c) Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations have been approved by the Society. The penetrations shall be gastight. Penetrations through a bulkhead with an “A-60” fire protection insulation (see Pt C, Ch 4, Sec 1, [2.2]), shall have an equivalent fire protection.

d) Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

e) Notwithstanding [2.4.4], pipes from the engine room may penetrate the service space in the cargo area or a cofferdam or a hold space or a double-hull space to the outside provided that within the service space or cofferdam or hold space or doublehull space they are of the thick-walled type and have no flanges or openings.

Table 1 : Documents to be submitted

No.	A/I	Document
1	I	List of substances intended to be carried with their UN number (see Ch 3, App 3, Tab 2), including all design characteristics of substances and other important design conditions
2	I	General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks, void spaces
3	A	Hazardous areas plan and location of the electrical equipment installed in these areas
4	A	Ventilation duct arrangement in gas-dangerous spaces and adjacent zones
5	A	Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, independent cargo tanks, etc.
6	A	Intact and damage stability calculations
7	A	Scantlings, material and arrangement of the cargo containment system
8	A	Details of cargo handling system, including arrangements and details of piping and fittings
9	A	Details of cargo pumps
10	A	Bilge and ballast system in cargo area
11	A	Gas freeing system in cargo tanks
12	A	Ventilation system in cargo area
13	A	List of the electrical equipment installed in hazardous areas comparable to zone 0 and 1, including the following equipment particulars: location, type of protection, type of protection against explosion, testing body and approval number
14	A	Schematic electrical wiring diagram
15	A	Pressure drop calculation note
16	A	Gas detection system
17	A	Cargo tank instrumentation
18	A	Details of fire-extinguishing appliances and systems in cargo area
19	A	Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar
20	I	Loading and unloading operation description, including cargo tank filling limits, where applicable
21	A	Gas return system
22	A	List of equipment installed in hazardous areas comparable to zone 2 which may be used during loading, unloading and gas-freeing and red equipment

Note 1:
A = to be submitted for review
I = to be submitted for information.

2.3.5 A service space located within the cargo area below deck shall not be used as a cargo pump room for the loading and unloading system, except where the cargo pump room is provided with a permanent oxygen detection system which automatically indicates the amount of oxygen and which actuates a visual and audible alarm when the oxygen concentration has reached 19.5% by volume.

The sensors of this system shall be placed at suitable positions at the bottom and at a height of 2,00 m. Measurement shall be continuous and displayed near to the entrance. Audible and visual alarms shall be installed in the wheelhouse and in the cargo pump-room and, when the alarm is actuated, the loading and unloading system shall be shut down.

Failure of the oxygen measuring system shall activate a visual and audible alarm in the wheelhouse and on deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

2.4 Hold spaces

2.4.1 The cargo tanks shall be separated by cofferdams of at least 0,60 m in width from the accommodation, engine room and service spaces outside the cargo area below deck or, if there are no such accommodation, engine room and service spaces, from the vessel’s ends. Where the cargo tanks are installed in a hold space, a space of not less than 0,50 m shall be provided between such tanks and the end bulkheads of the hold space. In this case an end bulkhead meeting at least the definition for Class “A-60” (see Pt C, Ch 4, Sec 1, [2.2]), shall be deemed equivalent to a cofferdam. For pressure cargo tanks, the 0,50 m distance may be reduced to 0,20 m.

2.4.2 Hold spaces, cofferdams and cargo tanks shall be capable of being inspected.

2.4.3 All spaces in the cargo area shall be capable of being ventilated. Means for checking their gas-free condition shall be provided.

2.4.4 The bulkheads bounding the cargo tanks, cofferdams and hold spaces shall be watertight. The cargo tanks and the bulkheads bounding the cargo area shall have no openings or penetrations below deck.

The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of [2.3.4].

The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading and unloading pipes are fitted with shut-off devices in the cargo tank from which they come. The shut-off devices shall be operable from the deck.

These pipes shall be at least 0,60 m above the bottom.

2.4.5 Double hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with [2.7].

2.4.6

a) A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space shall only be accessible from the deck.

b) The service space shall be watertight with the exception of its access hatches and ventilation inlets.

2.4.7 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

2.4.8 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area shall be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings, except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks, shall be in compliance with Pt B, Ch 2, Sec 1, [3.2.2].

2.5 Ventilation

2.5.1 Each hold space shall have two openings the dimensions and location of which shall be such as to permit effective ventilation of any part of the hold space.

2.5.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams, shall be provided with ventilation systems.

2.5.3 Any service spaces located in the cargo area below deck shall be provided with a suitable ventilation installation.

2.5.4 Ventilation of accommodation and service spaces shall be possible.

2.6 Engines

2.6.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.7 Oil fuel tanks

2.7.1 When the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0,60 m.

Oil fuel pipes and openings of such tanks are not permitted in the hold space.

2.7.2 The open ends of the air pipes of all liquid oil fuel tanks shall extend to not less than 0,5 m above the open deck. Their open ends and the open ends of overflow pipes leading on the deck shall be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

2.8 Exhaust pipes

2.8.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.8.2 Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

2.9 Bilge pumping and ballasting arrangements

2.9.1 Bilge and ballast pumps for spaces within the cargo area shall be installed within such area.

This provision does not apply to:

- double-hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks
- cofferdams, double hull spaces, double bottoms and hold spaces where ballasting is carried out using the piping of the firefighting system in the cargo area and bilge-pumping is performed using eductors which are installed in the cargo area.

2.9.2 Where the double bottom is used as oil fuel tank, it shall not be connected to the bilge piping system.

2.9.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water shall be located within the cargo area but outside the cargo tanks.

2.9.4 A cargo pump-room below deck shall be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation shall be provided outside the cargo pump-room.

2.10 Ventilation of cargo pump rooms

2.10.1 Cargo pump rooms must be provided with extraction type ventilation systems, independent of other vessel's spaces, providing at least 30 cycles of air change per hour. Warning notices shall be placed requiring that the ventilation is in operation for at least 15 minutes prior to entering these spaces.

2.10.2 Portable means must be provided for gas-freeing of cargo tanks and other spaces not equipped with fixed ventilation.

2.11 Arrangements of cofferdams

2.11.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with [2.4.6] shall be accessible through an access hatch. If, however, the cofferdam is connected to a double hull space, it is sufficient for it to be accessible from that space.

2.11.2 No fixed pipe shall permit connection between a cofferdam and other piping of the vessel outside the cargo area.

2.11.3 If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the ventilation openings of cofferdams shall be fitted with a flame arrester capable of withstanding a deflagration. The flame arresters shall be chosen according to the explosion groups/subgroups of the substances foreseen for inclusion in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

3 Cargo containment

3.1 General

3.1.1 The scantlings and structural arrangements are to be in compliance with applicable requirements of Ch 1, Sec 3, [6] to Ch 1, Sec 3, [11].

3.2 Cargo area hull design

3.2.1 Where independent cargo tanks are used, or for double-hull construction where the cargo tanks are integrated in vessel's structure, the space between the wall of the vessel and wall of the cargo tanks shall be not less than 0,60 m.

The space between the bottom of the vessel and the bottom of the cargo tanks shall be not less than 0,50 m. The space may be reduced to 0,40 m under the pump sumps. The vertical space between the suction well of a cargo tank and the bottom structures shall be not less than 0,10 m.

When a hull is constructed in the cargo area as a double hull with independent cargo tanks located in hold spaces, the above values are applicable to the double hull. If in this case the minimum values for inspections of independent tanks referred to in [2.4.8] are not feasible, it must be possible to remove the cargo tanks easily for inspection.

3.2.2 Where service spaces are located in the cargo area under deck, they shall be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They shall be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulties, if necessary by means of fixed equipment.

3.3 Cargo tank arrangements

3.3.1 The cargo tank is to comply with the following:

- for vessels with a length not more than 50,00 m, the length of a cargo tank shall not exceed 10,00 m
- for vessels with a length of more than 50,00 m, the length of a cargo tank shall not exceed 0,20 L, where L is the vessel rule length. This provision does not apply to vessels with independent built-in cylindrical tanks having a length to diameter ratio ≤ 7.

3.3.2 The capacity of a suction well shall be limited to not more than 0,1 m^3.

3.4 Integrated tank scantlings

3.4.1 The scantlings of the integrated tank structure are to be determined in compliance with Ch 1, Sec 3.

3.5 Independent cargo tank scantlings

3.5.1 Cargo tank scantlings

The scantlings of independent cargo tanks are to be determined in compliance with Ch 1, Sec 3, [6.1.2].

3.5.2 Supports and fastenings

The scantlings of the tank supports and fastenings are to be in compliance with Ch 1, Sec 3, [9].

3.6 Cargo tank openings

3.6.1

a) Cargo tank openings shall be located on deck in the cargo area.

b) Cargo tank openings with a cross-section of more than 0,10 m^2 and openings of safety devices for preventing overpressures shall be located not less than 0,50 m above deck.

3.6.2 Safety devices

Each cargo tank or group of cargo tanks connected to a common venting pipe shall be fitted with devices to prevent unacceptable overpressures or vacuums and constructed so as to prevent any accumulation of water and penetration of water into the cargo tank.

4 Cargo piping system

4.1 Arrangement for cargo pumps

4.1.1 The requirements [4.1.2], [4.1.4], [4.2.2], [4.2.5] and [4.4.1] do not apply unless the substance carried has corrosive properties.

4.1.2 Pumps and accessory loading and unloading piping shall be placed in an area between the fore vertical plane and the aft vertical plane bounding the part of the cargo area below deck.

4.1.3 Cargo pumps shall be capable of being shut down from the area described in [4.1.2] and from a position outside this area.

4.1.4 Cargo pumps situated on deck shall be located not less than 6,00 m from entrances to, or openings of, the accommodation and service spaces outside any hazardous area comparable to zone 0 or 1.

4.2 Arrangement of cargo piping

4.2.1 Pipes for loading and unloading shall be independent of any other piping of the vessel.

4.2.2 The pipes for loading and unloading shall be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's tanks or the tanks ashore.

4.2.3 Piping for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

4.2.4 The shore connections shall be located not less than 6 m from the entrances to or openings of, the accommodation and service spaces outside the cargo area.

4.2.5 Each shore connection of the venting pipe and shore connections of the pipes for loading and unloading, through which the loading or unloading operation is carried out, shall be fitted with a shut-off device.

4.3 Control and monitoring

4.3.1 Stop valves

The stop valves or other shut-off devices of the pipes for loading and unloading shall indicate whether they are open or shut.

4.4 Supply of cargo tanks with washing or ballast water

4.4.1 When pipes for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes shall be located within the cargo area but outside the cargo tanks.

Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that suction is not possible through that part.

4.4.2 A non-return valve shall be fitted at the junction between the water suction pipe and the cargo loading pipe.

4.5 Permissible loading and unloading flows

4.5.1 The permissible loading and unloading flows shall be calculated. For open type N with flame-arrester and open type N the loading and unloading flows depend on the total cross section of the exhaust ducts.

4.5.2 Calculations concern the permissible maximum loading and unloading flow for each cargo tank or each group of cargo tanks, taking into account the design of the ventilation system. These calculations shall take into consideration the fact that in the event of an unforeseen cut-off of the gas return piping or the compensation piping of the shore facility, the safety devices of the cargo tanks will prevent pressure in the cargo tanks from exceeding the following values:

- over-pressure: 115% of the opening pressure of the high-velocity vent valve
- vacuum pressure: not more than the construction vacuum pressure but not exceeding 5 kPa.

5 Cargo temperature control

5.1 Cargo tank heating

5.1.1 Cargo tank heating system is to be installed as a separate system, equipped with a heat exchanger located in the cargo area. Where special heat transfer media are used this requirement may be dispensed with upon approval by the Society.

5.1.2 Boilers which are used for heating the cargo shall be fuelled with a liquid fuel having a flashpoint of more than 55°C. They shall be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.1.3 The cargo heating system shall be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught shall be ignited electrically.

5.1.4 The ventilation system of the engine room shall be designed taking into account the air required for the boiler.

6 Residual cargo tanks and receptacles for residual products

6.1 General

6.1.1 When vessels are provided with tanks for residual products or receptacles for residual products, they shall be located in the cargo area and comply with the provisions of [6.1.2] and [6.1.3]. Receptacles for residual products shall be located only in the cargo area on deck and not less than a quarter of the vessel's breadth from the outer shell.

6.1.2 Tanks for residual products shall be equipped with:

In the case of an open system:

- an ullage opening
- a device for ensuring pressure equilibrium
- connections, with stop valves, for pipes and hoses

In the case of an open system with flame arrester:

- an ullage opening
- connections, with stop valves, for pipes and hose assemblies
- a device for ensuring pressure equilibrium, fitted with a flame arrester capable of withstanding steady burning.

In the case of a closed system:

a) A level indicator
   - connections, with stop valves, for pipes and hose assemblies
   - a vacuum valve and a pressure relief valve

   The pressure relief valve shall be sized so that, during the transport operation, it does not open when in normal operation. This condition is met when the opening pressure of the valve meets the conditions required in column (10) of Ch 3, App 3, Tab 2 for the substance to be carried.

b) If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances that require explosion protection in accordance with column (17) of Ch 3, App 3, Tab 2, then the pressure relief valve shall be a high velocity vent valve and the vacuum valve shall be deflagration safe. The deflagration safety may also be ensured by a flame arrester.

   The high velocity vent valve and the deflagration safe vacuum valve shall be chosen according to the explosion groups/subgroups of the substances listed in the list of substances on the vessel (see column (16) of Ch 3, App 3, Tab 2).

The maximum permissible capacity is 30 m^3.

6.1.3 Receptacles for residual products shall be equipped with:

- a possibility of indicating the degree of filling
- connections, with stop valves, for pipes and hose assemblies
- a connection enabling gases released during filling to be evacuated safely

7 Electrical installations

7.1 Type and location of electrical equipment

7.1.1 Electrical installations and equipment shall be of at least the “limited explosion risk” type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.5]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m of the cargo area.

7.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

7.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [7.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

7.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

7.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [7.1.4].

7.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [7.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

7.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

7.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

7.1.9 Sockets for the connection of signal lights and gangway lighting shall be solidly fitted to the vessel close to the signal mast or the gangway. The sockets used in this area shall be designed so as to prevent connection or disconnection except when they are not live.

7.1.10 Vessels are only required to meet the requirements of [7.1.1] and [7.1.2], if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

7.2 Type and location of electrical and non-electrical installations and equipment intended to be used in explosion hazardous areas

7.2.1 On board vessels covered by the classification of zones as defined in Ch 3, App 1, Tab 1, electrical and non-electrical installations and equipment used in explosion hazardous areas shall meet at least the requirements for use in the area concerned.

They shall be selected on the basis of the explosion groups/subgroups and temperature classes to which the substances to be carried belong (see columns (15) and (16) of Ch 3, App 3, Tab 2).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T4, T5 or T6 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 135°C (T4), 100° (T5) or 85°C (T6).

If the list of substances on the vessel according to Ch 3, Sec 1, [4.3.2] is going to include substances for which temperature classes T1 or T2 are indicated in column (15) of Ch 3, App 3, Tab 2, then the corresponding surface temperatures within the assigned zones shall not exceed 200°C.

7.2.2 Except in the case of optical fibres, electrical cables shall be armoured or placed in a metallic sheath or in protective tubes.

Electrical cables for the active cathodic protection of the shell plating shall be led through thick-walled steel tubes with gastight connections up to the main deck.

7.2.3 Movable electric cables are prohibited in the explosion danger area, except for electric cables for intrinsically safe electric circuits or for connecting:

- Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway
- The power network on a vessel to a land-based power network; provided
    - The electric cables and the power supply unit conform with a valid standard
    - The power supply unit and connectors are located outside of the explosion danger area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

7.2.4 Electrical cables of intrinsically safe circuits shall be separated from other cables not intended for use in such circuits and shall be marked (they shall not be installed together in the same string of cables and they shall not be fixed by the same cable clamps).

7.2.5 For movable electrical cables permitted under, only sheathed cables of type H07RN-F in accordance with standard IEC 60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.50 mm^2 shall be used.

7.3 Earthing

7.3.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service shall be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

7.3.2 The provisions of [7.3.1] apply also to equipment having service voltages of less than 50 V.

7.3.3 Independent cargo tanks, metal intermediate bulk containers and tank-containers shall be earthed.

7.3.4 Receptacles for residual products shall be capable of being earthed.

7.4 Storage batteries

7.4.1 Storage batteries shall be located outside any hazardous area comparable to zone 0 or 1.

8 Fire protection and fire extinction

8.1 Fire and naked light

8.1.1 The outlets of funnels shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

8.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

8.1.3 Only electrical lamps are permitted.

8.2 Portable fire extinguishers

8.2.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], the vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

9 Safety and control installations

9.1 General

9.1.1 Cargo tanks shall be provided with the following equipment:

a) a mark inside the tank indicating the liquid level of 97%

b) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97,5% is reached.

10 Buoyancy and stability

10.1 General

10.1.1 Exceptions to the requirements stated in these Rules are possible where they are permitted by the statutory Regulations.

10.1.2 General requirements of Pt B, Ch 2, Sec 2, [1] to Pt B, Ch 2, Sec 2, [3] are to be complied with.

10.1.3 The longitudinal centre bulkhead may be dispensed with only if sufficient stability is guaranteed.

10.1.4 Proof of sufficient stability shall be furnished. This proof is not required for single hull vessels with cargo tanks the width of which is not more than 0,70 B.

10.1.5 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined in compliance with Pt B, Ch 2, Sec 2, [2.2].

10.1.6 Proof of sufficient intact stability shall be furnished for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the vessel substance list according to Ch 3, Sec 1, [4.3.2].

10.1.7 For every loading case, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel shall comply with the intact and damage stability requirements.

Intermediate stages during operations shall also be taken into consideration.

10.2 Intact stability

10.2.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the requirements for intact stability resulting from the damage stability calculation shall be fully complied with.

10.2.2 For vessels with cargo tanks of more than 0,70 B in width, the following intact stability requirements are to be complied with, bearing in mind the influence of all free surfaces in tanks for all stages of loading and unloading:

- in the positive area of the righting lever curve up to immersion of the first unprotected opening there shall be a righting lever (GZ) of not less than 0,10 m
- the surface of the positive area of the righting lever curve up to immersion of the first unprotected opening and in any event up to an angle of heel ≤ 27° shall not be less than 0,024 m.rad
- the initial metacentric height GM_0 shall be not less than 0,10 m.

10.3 Damage stability

10.3.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the following assumptions shall be taken into consideration for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: B_2 – 0,01 m
   - vertical extent: from base line upwards without limit

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA} but not less than 5,00 m
   - transverse extent: 3,00 m
   - vertical extent: from base line to D_2 – 0,01 m upwards, except for pump well

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of bulkheads shall be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

   The following provisions are applicable:
   - for bottom damage, adjacent athwartship compartments shall also be assumed flooded
   - the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways) shall, at the final stage of flooding, be not less than 0,10 m above the damage waterline.

10.3.2 In general, permeability shall be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used.

However, the minimum values of permeability μ given in Tab 2 are to be used.

For the main engine room, only the one-compartment status need be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

Table 2 : Permeability μ

Spaces	μ, in %
Engine room	85
Accommodation spaces	95
Double bottoms, oil fuel tanks, ballast tanks, etc., depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

10.3.3 The damage stability is generally regarded sufficient if (see Fig 1):

- At the stage of equilibrium (in the final stage of flooding), the angle of heel is not greater than 12°.

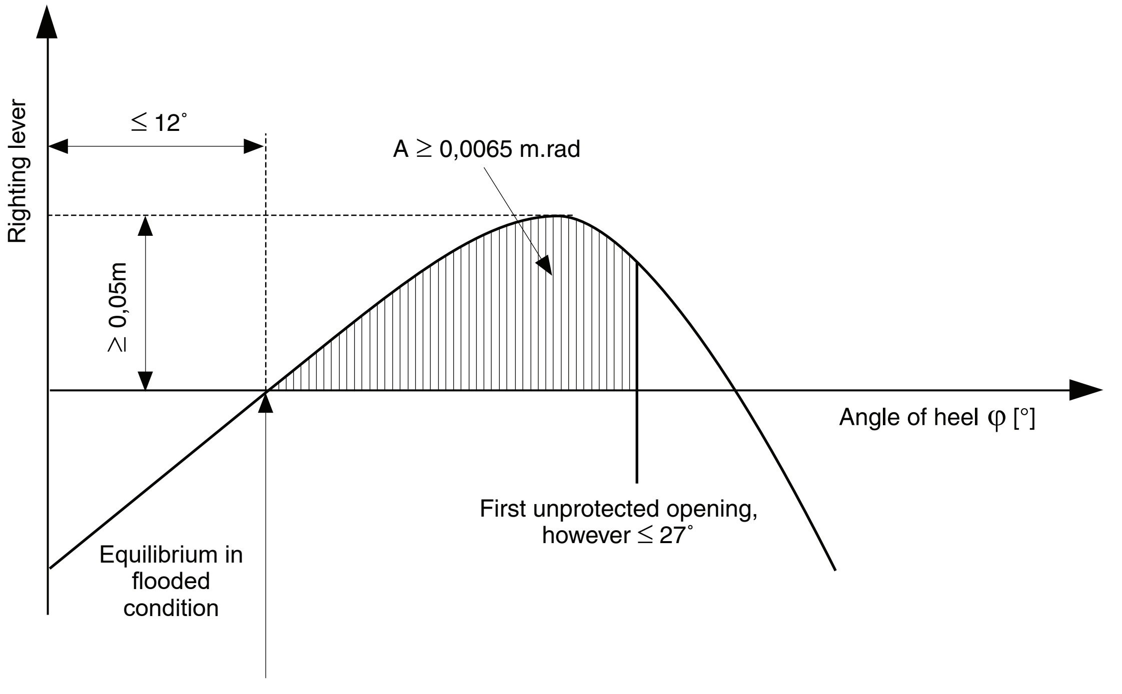
  Non-watertight openings shall not be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

- The positive range of the righting lever curve beyond the stage of equilibrium has a righting lever of ≥ 0,05 m in association with an area under the curve of ≥ 0,0065 m.rad. The minimum values of stability shall be satisfied up to immersion of the first unprotected (non-weathertight) opening and in any event up to an angle of heel ≤ 27°. If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered flooded for the purpose of stability calculation.

10.3.4 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly.

10.3.5 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalisation shall not exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

Figure 1 : Proof of damage stability



SECTION 7 TRANSPORT OF DRY DANGEROUS GOODS

Symbols

L_{OA} : Length overall, in m, defined in Pt B, Ch 1, Sec 2, [2.5]

B : Breadth, in m, defined in Pt B, Ch 1, Sec 2, [2.2]

B_2 : Breadth of the side tank, in m

D_2 : Height of the double bottom, in m.

1 General

1.1 Application

1.1.1 The additional service feature **DG1** is assigned, in compliance with Pt A, Ch 1, Sec 3, [2.2.6], to vessels intended to carry dry dangerous goods in quantities exceeding those indicated in Ch 3, App 2, [1].

1.1.2 The additional service feature **DG2** is assigned, in compliance with Pt A, Ch 1, Sec 3, [2.2.7], to vessels intended to carry dry dangerous goods in quantities limited to those indicated in Ch 3, App 2, [1].

1.1.3 Vessels dealt with in this Section are to comply with the requirements stated under Part A, Part B and Part C, as applicable, and with the requirements of this Section, which are specific to dry cargo vessels for the transport of dangerous goods.

1.1.4 The requirements in this section are to be applied for the additional service features **DG1** and **DG2** according to Tab 1.

Table 1 : Rules applicable for additional service features DG1 and DG2

Additional service feature	Applicable Articles
DG1	[2] to [6]
DG2	[2] to [5]

1.2 Documents to be submitted

1.2.1 Tab 2 lists the plans and documents to be submitted in addition to the documents required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

2 Vessel arrangement

2.1 Accommodation and service spaces

2.1.1 The accommodation shall be separated from the holds by metal bulkheads having no openings.

2.1.2 Gastight closing appliances shall be provided for openings in the accommodation and wheelhouse facing the holds.

2.1.3 No entrances or openings of the engine rooms and service spaces shall face the protected area.

2.2 Water ballast

2.2.1 The double-hull spaces and double bottoms may be arranged for being filled with water ballast.

Table 2 : Documents to be submitted

No.	A/I	Document
1	I	List of products to be carried
2	I	General arrangement plan, showing location of cargo holds and fuel oil, ballast and other tanks
3	A	Location of void spaces and accesses to dangerous zones
4	A	Details of hull structure in way of cargo holds
5	A	Intact and damage stability calculations
6	A	Bilge and ballast system in cargo area
7	A	Ventilation system in cargo area
8	A	Details of electrical equipment installed in cargo area
9	A	Schematic electrical wiring diagram
10	A	Details of fire-extinguishing appliances and systems in cargo area
Note 1: A = to be submitted for review I = to be submitted for information.		

2.3 Ventilation

2.3.1 Ventilation of each hold shall be provided by means of two mutually independent extraction ventilators having a capacity of not less than five changes of air per hour based on the volume of the empty hold. The extraction ducts shall be positioned at the extreme ends of the hold and extend down to not more than 50 mm above the bottom. The extraction of gases and vapours through the duct shall also be ensured for carriage in bulk.

If the extraction ducts are movable, they shall be suitable for the ventilator assembly and capable of being firmly fixed. Protection shall be ensured against bad weather and spray. The air intake shall be ensured during ventilation.

2.3.2 The ventilation system of a hold shall be arranged so that dangerous gases cannot penetrate into the accommodation, wheelhouse or engine rooms.

2.3.3 Ventilation shall be provided for the accommodation, wheelhouse and for service spaces.

2.4 Engines

2.4.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.4.2 The air vents in the engine rooms and the air intakes of the engines which do not take air in directly from the engine room shall be located not less than 2,00 m from the protected area.

2.4.3 Sparking shall not be possible within the cargo area.

2.5 Oil fuel tanks

2.5.1 Double bottoms within the hold area may be arranged as oil fuel tanks provided their depth is not less than 0,6 m. Oil fuel pipes and openings to such tanks are not permitted in the holds.

2.5.2 The air pipes of all oil fuel tanks shall be led to 0,50 m above the open deck. Their open ends and the open ends of the overflow pipes leaking to the deck shall be fitted with a protective device consisting of a gauze grid or by a perforated plate.

2.6 Exhaust pipes

2.6.1 Exhausts shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from the hatchway openings. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within the protected area.

2.6.2 Exhaust pipes shall be provided with a device pre venting the escape of sparks, e.g. spark arresters.

3 Cargo holds

3.1 General arrangements

3.1.1 Each cargo hold shall be bounded fore and aft by watertight metal bulkheads.

3.1.2 The cargo holds shall have no common bulkhead with the fuel oil tanks.

3.1.3 The bottom of the holds shall be such as to permit them to be cleaned and dried.

3.1.4 Hatch covers for the cargo holds must be spraytight and weathertight. The use of waterproof tarpaulins is also possible to cover the cargo holds, if the tarpaulin shall not readily ignite.

3.2 Heating installation

3.2.1 It is not allowed to arrange heating appliances in the cargo holds.

3.3 Stripping installation

3.3.1 The stripping pumps intended for the holds shall be located in the protected area. This requirement shall not apply when stripping is effected by eductors.

4 Electrical installations

4.1 Type and location of electrical installations and equipment

4.1.1 If the vessel is located within or in the immediate vicinity of an onshore assigned zone, electrical installations and equipment outside the protected area shall be at least of the 'limited explosion risk' type. This provision does not apply to:

a) Lighting installations in the accommodation and in the wheelhouse, except for switches located near to the entrances

b) Mobile phones, fixed telephone installations as well as stationary and portable computers in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone, are:
   - not live, or
   - Installed in spaces which are equipped with a ventilation system according to [2.3]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and in the wheelhouse if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m from the protected area.

4.1.2 Fixed electrical installations and equipment which do not meet the requirements set out in [4.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

4.1.3 Sockets for the connection of signal lights, gangway lighting and containers shall be fitted to the vessel close to the signal mast or the gangway or the containers. Sockets intended to supply the submerged pumps and hold ventilators shall be permanently fitted to the vessel in the vicinity of the hatches. The sockets shall be designed to ensure that it is only possible to connect or disconnect them when they are not live

4.1.4 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

4.1.5 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

4.1.6 The requirements of [4.1.1] and [4.1.2] shall be met only if the vessel is located within or in the immediate vicinity of an onshore assigned zone.

4.2 Type and location of electrical and non-electrical installations and equipment for use in the protected area

4.2.1 It shall be possible to switch off the electrical installations and equipment in the protected area by means of centrally located isolation switches except where:

- In the holds, they are appropriate at least for use in zone 1, for temperature class T4 and explosion group II B; and
- In the protected area on the deck, they are of the limited explosion risk type.

The corresponding electrical circuits shall have control lamps to indicate whether or not the circuits are live.

The isolation switches shall be protected against unintended operation. Submerged pumps installed or used in the holds shall be appropriate at least for use in zone 1, temperature class T4 and explosion group II B.

4.2.2 The sockets used in the protected area shall be designed so as to prevent connection or disconnection except when they are not live.

4.2.3 Except in the case of optical fibres, electrical cables within the protected area shall be armoured or placed in a metallic sheath or in protective tubes.

4.2.4 Movable electric cables are prohibited in the protected area, except electric cables for intrinsically safe electric circuits or for connecting:

a) Signal lights and lighting for gangways, provided the connection point (for example, the socket) is permanently fitted to the vessel close to the signal mast or gangway

b) Containers

c) Electrically operated hatch cover gantries

d) Submerged pumps

e) Hold ventilators

f) The power network on a vessel to a land-based power network; provided that:
   - The electric cables and the power supply unit conform to a valid standard
   - The power supply unit and connectors are located outside of the protected area.

Connecting and disconnecting sockets/connectors shall only be possible when they are not live.

4.2.5 For movable electrical cables permitted in accordance with [4.2.4], only rubber-sheathed electrical cables of type H07 RN-F in accordance with IEC-60245-4:2011 or electrical cables of at least equivalent design having conductors with a cross-section of not less than 1.5 mm^2, shall be used.

4.2.6 Non-electrical installations and equipment in the protected area which are intended for use during loading and unloading or stay in the immediate vicinity of or within a shoreside assigned zone shall meet at least the requirements for use in the area concerned. They shall meet at least the requirements for temperature class T4 and explosion group II B.

4.3 Metal wires, masts

4.3.1 All metal wires passing over the holds and all masts shall be earthed, unless they are electrically bonded to the metal hull of the vessel through their installation.

4.4 Storage batteries

4.4.1 The installation of storage batteries inside the protected area is not permissible.

5 Fire protection and fire extinction

5.1 Fire and naked light

5.1.1 The outlets of funnels shall be located not less than 2,00 m from the cargo area. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

5.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

5.1.3 Only electrical lamps are permitted.

5.2 Fire extinguishing arrangements

5.2.1 In addition to the requirements of Part C, Chapter 4, the fire extinguishing arrangements in [5.3] to [5.5] are to be complied with.

5.3 Portable fire extinguishers

5.3.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], the vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in the protected area or in proximity with it.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

5.4 Water fire extinguishing system

5.4.1 A water fire-extinguishing system complying with the following requirements shall be installed on the vessel:

- It shall be supplied by two independent fire or ballast pumps one of which shall be ready for use at any time. These pumps and their means of propulsion and electrical equipment shall not be installed in the same space.
- It shall be provided with a water main fitted with at least three hydrants in the cargo area above deck. Three suitable and sufficiently long hoses with spray/jet nozzles having a diameter of not less than 12 mm shall be provided.
- It shall be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water not supplied from the same hydrant.

  A spring-loaded non-return valve shall be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the cargo area.
- The capacity of the system shall be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.
- The water supply system shall be capable of being put into operation from the wheelhouse and from the deck.

5.5 Fixed fire extinguishing system

5.5.1 In addition the machinery spaces shall be provided with a fixed fire-extinguishing system, in compliance with Pt C, Ch 4, Sec 4, [4].

6 Additional rules applicable to double hull vessels

6.1 Application

6.1.1 The requirements of this Article are applicable to double hull vessels intended to carry dangerous goods in quantities exceeding those indicated in Ch 3, App 2, [1.1.1].

6.2 Holds

6.2.1 Within the protected area, the vessel shall be built as a double-hull vessel with double-hull spaces and double bottom in compliance with [6.2.2] and [6.2.3].

Alternative constructions will be specially considered by the Society on a case-by-case basis.

6.2.2 The distance between the sides of the vessel and the longitudinal bulkheads of the cargo hold shall be not less than 0,80 m.

6.2.3 The depth of the double bottom shall be at least 0,50 m. The depth below the suction wells may, however, be locally reduced, but the space between the bottom of the suction well and the bottom of the vessel floor shall be at least 0,40 m. If spaces are between 0,40 m and 0,49 m, the surface area of the suction well shall not exceed 0,5 m^2.

The capacity of the suction wells shall not exceed 0,120 m^3.

6.3 Emergency exit

6.3.1 Spaces not flooded of which the entrances or exits are partly or fully immersed in damage condition shall be provided with an emergency exit not less than 0,10 m above the damage waterline. This requirement does not apply to fore peak and aft peak.

6.4 Damage stability

6.4.1 The basic values for the stability calculation (the vessel's lightweight and location of the centre of gravity) shall be determined:

- either by means of an heeling experiment, or
- by detailed mass and moment calculation, in which case the lightweight of the vessel shall be verified by checking the draught, with a tolerance limit of ± 5% between the mass determined by calculation and the displacement determined by the draught readings.

6.4.2 Sufficient buoyancy and stability of the vessel in the event of flooding shall be proven with a cargo corresponding to its maximum draught and evenly distributed among all the holds and with maximum supplies and fully fuelled.

For diversified cargo, the stability calculation shall be performed for the most unfavourable loading condition.

For this purpose, mathematical proof of sufficient stability shall be determined for the intermediate stages of flooding (25%, 50% and 75% of flood build up, and, where appropriate, for the stage immediately prior to transverse equilibrium) and for the final stage of flooding, in the loading conditions specified above.

6.4.3 The following assumptions shall be taken into account for the damaged condition:

a) Extent of side damage:
   - longitudinal extent: at least 0,10 L_{OA}
   - transverse extent: $B_2 - 0{,}01$ m
   - vertical extent: from base line upwards without limit

b) Extent of bottom damage:
   - longitudinal extent: at least 0,10 L_{OA}
   - transverse extent: 3,00 m
   - vertical extent: from base line to $D_2 - 0{,}01$ m upwards, the sump excepted

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the subdivision shall be chosen so that the vessel remains afloat after flooding of two or more adjacent compartments in the longitudinal direction.

For the main engine room only the one-compartment status needs to be taken into account, i.e. the end bulkheads of the engine room shall be assumed as not damaged.

For bottom damage, adjacent athwartship compartments shall also be assumed as flooded.

d) Permeability

Permeability shall be assumed to be 95%.

If a calculation proves that the average permeability of a compartment is less than 95%, the calculated value may be used instead.

The values used shall not be less than those given in Tab 3.

e) The calculation of free surface effect in intermediate stages of flooding shall be based on the gross surface area of the damaged compartments.

Table 3 : Permeability μ

Spaces	μ, in %
Engine and service rooms	85
Cargo holds	70
Double bottoms, fuel tanks, ballast tanks, etc. depending on whether, according to their function, they have to be assumed as full or empty for the vessel floating at the maximum permissible draught	0 or 95

6.4.4 For all intermediate stages of flooding referred to in [6.4.2], the following criteria shall be met:

a) the heeling angle φ at the equilibrium position of the intermediate stage in question shall not exceed 15° (5° where containers are not secured)

b) beyond the heel in the equilibrium position of the intermediate stage of flooding in question, the positive part of the righting lever curve shall display a righting lever value of GZ ≥ 0,02 m (0,03 m where containers are not secured) before the first unprotected opening becomes immersed or a heeling angle φ of 27° is reached (15° where containers are not secured)

c) non-watertight openings shall not be immersed before the heel in the equilibrium position of the intermediate stage in question has been reached.

6.4.5 During the final stage of flooding, the following criteria shall be met:

a) the lower edge of non-watertight openings (e.g., doors, windows, access hatches) shall be not less than 0,10 m above the damaged waterline

b) the heeling angle φ at the equilibrium position shall not exceed 12° (5° where containers are not secured), see Fig 1.

c) beyond the heel in the equilibrium position of the intermediate stage of flooding in question, the positive part of the righting lever curve shall display a righting lever value of GZ ≥ 0,05 m and the area under the curve shall reach at least 0,0065 m.rad before the first unprotected (non-weathertight) opening becomes immersed or a heeling angle φ of 27° (10° where containers are not secured) is reached

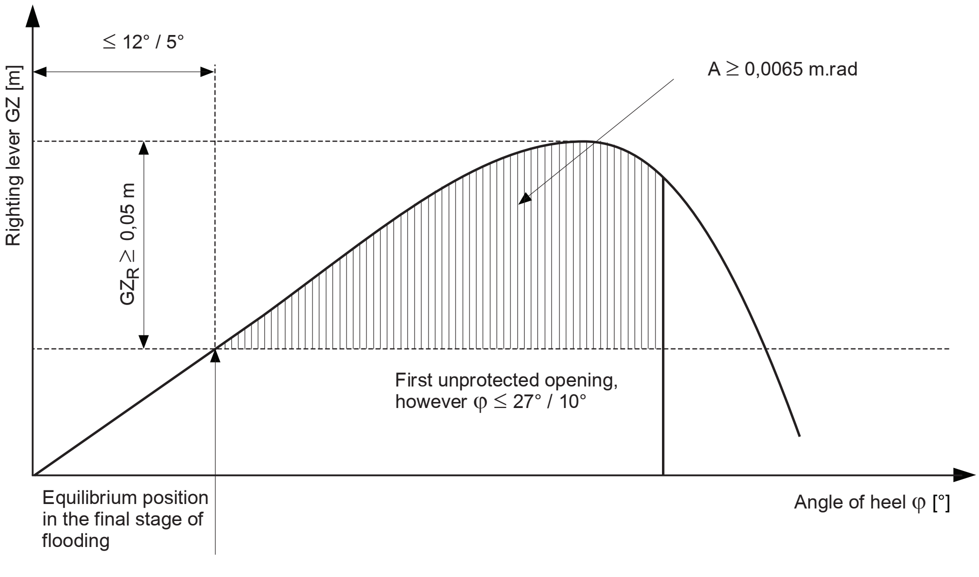
d) if non-weathertight openings are immersed before the equilibrium position is reached, the rooms affording access shall be deemed flooded for the purposes of the damaged stability calculation.

6.4.6 When cross- or down-flooding openings are provided to reduce unsymmetrical flooding, the time for equalisation shall not exceed 15 minutes, if during the intermediate stages of flooding sufficient damaged stability has been demonstrated.

6.4.7 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked according to their operating instructions.

6.4.8 Where necessary in order to meet the requirements in [6.4.2], the plane of maximum draught shall be re-established.

Figure 1 : Proof of damage stability (final stage of flooding)



SECTION 8 DGL

1 General

1.1 Application

1.1.1 The additional service feature **DGL** is assigned, in compliance with Pt A, Ch 1, Sec 3, to propulsion vessels involved in a pushed convoy or a side-by-side formation comprising a tank vessel carrying dangerous substances.

1.1.2 These vessels are to comply with the requirements stated under Part A, Part B and Part C, as applicable, and with the requirements of this Section, which are specific to additional service feature **DGL**.

1.1.3 Other vessels (in the convoy or side-by-side formation) not carrying dangerous goods shall comply with the requirements of Ch 3, Sec 9.

2 Vessel arrangements

2.1 Materials

2.1.1 The vessel's hull shall be constructed of shipbuilding steel or other at least equivalent metal.

All permanently fitted materials in the accommodation or wheelhouse, with the exception of furniture, shall not readily ignite. They shall not evolve fumes or toxic gases in dangerous quantities, if involved in a fire.

The use of plastic material for vessel's boats is permitted only if the material does not readily ignite.

2.2 Protection against penetration of gases

2.2.1 The vessel shall be designed so as to prevent dangerous gases and liquids from penetrating into the accommodation, wheelhouse and the service spaces. None of the windows in these spaces shall be capable of being opened unless its intended use is as an emergency exit and it is marked as such.

2.2.2 Liquid-tight protective coamings shall be fitted on deck at the height of the external bulkheads of the cargo tanks, at a maximum distance of 0,60 m from the outer cofferdam bulkheads or the hold end bulkheads. The protective coamings shall either extend over the entire width of the vessel or be fixed between the longitudinal spill coamings so as to prevent liquids from entering the forepeak and afterpeak. The height of the protective coamings and the spill coamings shall be at least 0,075 m. The protective coaming may correspond to the protection wall if the protection wall extends across the entire width of the vessel.

2.2.3 The bulwarks, foot-rails, etc. shall be provided with sufficiently large openings which are located directly above the deck.

2.3 Ventilation

2.3.1 Ventilation of accommodation shall be possible.

Any ventilation inlets of accommodation leading outside shall be fitted with fire flaps. Such ventilation inlets shall be located not less than 2,00 m from the cargo area.

2.4 Engine rooms

2.4.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery shall be located outside the cargo area. Entrances and other openings of engine rooms shall be at a distance of not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

The engine rooms shall be accessible from the deck; the entrances shall not face the cargo area. Where the doors are not located in a recess whose depth is at least equal to the door width, the hinges shall face the cargo area.

2.5 Accommodation and service spaces

2.5.1 Accommodation spaces and the wheelhouse shall be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of the cargo area below deck. Windows of the wheelhouse which are located not less than 1 m above the bottom of the wheelhouse may tilt forward.

2.5.2 Entrances to spaces and openings of superstructures shall not face the cargo area. Doors opening outward and not located in a recess whose depth is at least equal to the width of the doors shall have their hinges face the cargo area.

2.5.3 Entrances from the deck and openings of spaces facing the weather shall be capable of beingclosed.

2.5.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces shall be located not less than 2,00 m from the cargo area. No wheelhouse doors and windows shall be located within 2,00 m from the cargo area, except where there is no direct connection between the wheelhouse and the accommodation.

2.6 Engines

2.6.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.6.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, air intakes of the engines shall be located not less than 2,00 m from any hazardous area comparable to zone 0 or 1.

2.6.3 The ventilation in the closed engine room shall be designed so that, at an ambient temperature of 20°C, the average temperature in the engine room does not exceed 40°C.

2.7 Fuel oil tanks

2.7.1 The open ends of the air pipes of each liquid fuel oil tank shall extend to 0,5 m above the open deck. These open ends and the open ends of overflow pipes leading to the deck shall be provided with a protecting screen.

2.8 Exhaust pipes

2.8.1 Exhaust shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from the cargo area. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within any hazardous area comparable to zone 0 or 1.

2.8.2 Exhaust pipes shall be provided with spark arresters.

3 Electrical installations

3.1 Type and location of electrical installations and equipment

3.1.1 Electrical installations and equipment shall be of at least the “limited explosion risk” type.

This provision does not apply to:

a) Lighting installations in the accommodation and the wheelhouse, except for switches near to the entrances

b) Mobile phones, fixed telephone installations, stationary and portable computers and loading instruments in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone:

   1) are extinguished; or

   2) are placed in premises equipped with a ventilation system according to [2.3]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and the wheelhouse, if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m of the cargo area.

3.1.2 In the cofferdams, double-hull spaces, double bottoms and hold spaces, only hermetically sealed echo sounding devices are allowed, the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck.

3.1.3 The fixed electrical installations and equipment which do not meet the requirements set out in [3.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

3.1.4 Every insulated distribution network shall be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

3.1.5 Only distribution systems without return connection to the hull are permitted. This provision does not apply to:

- Active cathodic corrosion protection
- Certain limited sections of the installations situated outside the cargo area (e.g., connections of starters of diesel engines)
- The device for checking the insulation level referred to in [3.1.4].

3.1.6 An electric generator which is permanently driven by an engine and which does not meet the requirements of [3.1.1], shall be fitted with a switch capable of shutting down the generator. A notice board with the operating instructions shall be displayed near the switch.

3.1.7 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

3.1.8 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

3.1.9 Vessels are only required to meet the requirements of [3.1.1] and [3.1.3], if the vessel remains in the immediate vicinity of or within a shoreside assigned zone.

4 Fire protection and fire extinction

4.1 Fire and naked light

4.1.1 The outlets of funnels shall be located not less than 2,00 m from the cargo area. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

4.1.2 Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels.

The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flash-point above 55°C is, however, permitted.

Cooking and refrigerating appliances are permitted only in the accommodation.

4.1.3 Only electrical lamps are permitted.

4.2 Fire extinguishing arrangements

4.2.1 In addition to the requirements of Part C, Chapter 4, the fire extinguishing arrangements in [4.3] to [4.5] are to be complied with.

4.3 Portable fire extinguishers

4.3.1 In addition to the fire-extinguishing appliances prescribed in Pt C, Ch 4, Sec 4, [2], the vessel shall be equipped with at least two additional portable fire-extinguishers having the same capacity in cargo area.

These additional portable fire-extinguishers shall be suitable for fighting fires involving the dangerous goods carried.

4.4 Water fire extinguishing system

4.4.1 A water fire-extinguishing system complying with the following requirements shall be installed on the vessel:

- It shall be supplied by one independent fire or ballast pump ready for use at any time.
- It shall be provided with a water main fitted with at least three hydrants in the cargo area above deck. Three suitable and sufficiently long hoses with spray/jet nozzles having a diameter of not less than 12 mm shall be provided.
- It shall be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water not supplied from the same hydrant.

  A spring-loaded non-return valve shall be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the cargo area.
- The capacity of the system shall be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.
- The water supply system shall be capable of being put into operation from the wheelhouse and from the deck.

4.5 Fixed fire extinguishing system

4.5.1 In addition machinery spaces shall be provided with a fixed fire-extinguishing system, in compliance with Pt C, Ch 4, Sec 4, [4].

SECTION 9 DGD

1 General

1.1 Application

1.1.1 The additional service feature **DGD** is assigned, in compliance with Pt A, Ch 1, Sec 3, to vessels (not carrying dangerous goods) involved in a pushed convoy or a side-by-side formation comprising a cargo vessel or a tanker carrying dangerous substances.

1.1.2 These vessels are to comply with the requirements stated under Part A, Part B and Part C, as applicable, and with the requirements of this Section, which are specific to additional service feature **DGD**.

2 Vessel arrangements

2.1 Materials

2.1.1 The vessel's hull shall be constructed of shipbuilding steel or other metal, provided that this metal has at least equivalent mechanical properties and resistance to the effects of temperature and fire.

2.2 Ventilation

2.2.1 Ventilation shall be provided for the accommodation, wheelhouse and for service spaces.

2.3 Accommodation and service spaces

2.3.1 Gastight closing appliances shall be provided for openings in the accommodation and wheelhouse facing the holds.

No entrances or openings of the engine rooms and service spaces shall face the protected area.

2.4 Engines

2.4.1 Only internal combustion engines running on fuel having a flash point above 55°C are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems fitted onboard vessels assigned one of the additional service features **Dualfuel** or **Gasfuel** according to Pt A, Ch 1, Sec 3, [1.3.5].

2.4.2 The air vents of the engine rooms and the air intakes of the engines which do not take air in directly from the engine room shall be located not less than 2,00 m from the protected area.

Equipment producing sparks shall not be located in the protected area.

2.5 Fuel oil tanks

2.5.1 Double bottoms within the hold area may be arranged as fuel oil tanks provided their depth is not less than 0,60 m. Fuel oil pipes and openings to such tanks are not permitted in the holds.

The air pipes of all fuel oil tanks shall be led to 0,50 m above the open deck. Their open ends and the open ends of the overflow pipes leaking to the deck shall be fitted with a protective device consisting of a gauze gird or a perforated plate.

2.6 Exhaust pipes

2.6.1 Exhaust shall be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet shall be located not less than 2,00 m from the hatchway openings. The exhaust pipes of engines shall be arranged so that the exhausts are led away from the vessel. The exhaust pipes shall not be located within the protected area.

Exhaust pipes shall be provided with a device preventing the escape of sparks, e.g. spark arresters.

3 Electrical installations

3.1 Type and location of electrical installations and equipment

3.1.1 Electrical installations and equipment outside the protected area shall be at least of the 'limited explosion risk' type. This provision does not apply to:

a) Lighting installations in the accommodation and in the wheelhouse, except for switches located near to the entrances

b) Mobile phones, fixed telephone installations as well as stationary and portable computers in the accommodation or the wheelhouse

c) Electrical installations and equipment which, during a stay in the immediate vicinity of or within a shoreside assigned zone, are:

- not live, or
- Installed in spaces which are equipped with a ventilation system according to [2.2]

d) Radiotelephone installations and inland AIS (automatic identification systems) stations in the accommodation and in the wheelhouse if no part of an aerial for radiotelephone installations or AIS stations is situated above or within 2,00 m from the protected area.

3.1.2 Fixed electrical installations and equipment which do not meet the requirements set out in [3.1.1] and their switches shall be marked in red. The disconnection of such equipment shall be controlled from a centralized location on board.

3.1.3 Sockets for the connection of signal lights, gangway lighting and containers shall be fitted to the vessel close to the signal mast or the gangway or the containers. Sockets intended to supply the submerged pumps and hold ventilators shall be permanently fitted to the vessel in the vicinity of the hatches. The sockets shall be designed to ensure that it is only possible to connect or disconnect them when they are not live

3.1.4 Failure of the power supply for the safety and control equipment shall be immediately indicated by visual and audible signals in the wheelhouse and on the deck. The alarm must be relayed to the accommodation automatically if it has not been switched off.

3.1.5 Electrical switches, sockets and cables on deck shall be protected against mechanical damage.

3.1.6 The requirements of [3.1.1] and [3.1.2] shall be met only if the vessel is located within or in the immediate vicinity of an onshore assigned zone.

4 Fire protection and fire extinction

4.1 Fire and naked light

4.1.1 The outlets of funnels shall be located not less than 2,00 m from the hatchway openings. Arrangements shall be provided to prevent the escape of sparks and the entry of water.

Heating, cooking and refrigerating appliances shall not be fuelled with liquid fuels, liquid gas or solid fuels. The installation in the engine room or in another separate space of heating appliances fuelled with liquid fuel having a flashpoint above 55°C is, however, permitted. Cooking and refrigerating appliances are permitted only in wheelhouses with metal floor and in the accommodation.

Electrical lamps only are permitted outside the accommodation and the wheelhouse.

4.2 Fire-extinguishing arrangements

4.2.1 The vessel shall comply with applicable requirements of Pt C, Ch 3, Sec 4.

APPENDIX 1 DEFINITIONS

1 Definitions

1.1 Accommodation

1.1.1 Accommodation means spaces intended for the use of persons normally living on board, including galleys, food stores, lavatories, washrooms, bathrooms, laundries, halls, alleyways, etc., but excluding the wheelhouse.

1.2 ADN

1.2.1 ADN means European agreement concerning the international carriage of dangerous goods by inland waterways.

1.3 Auto-ignition temperature

1.3.1 Auto-ignition temperature (EN 1127-1:1997, No. 331) means the lowest temperature determined under prescribed test conditions of a hot surface on which a flammable substance in the form of a gas/air or vapour/air mixture ignites.

1.4 Bilge water

1.4.1 Bilge water means oily water from the engine room bilges, the peaks, the cofferdams and the double hull spaces.

1.5 Bulk container

1.5.1 Bulk container means a containment system (including any liner or coating) intended for the carriage of solid substances which is in direct contact with the containment system. Packagings, intermediate bulk containers (IBCs), large packagings and tanks are not included.

e.g.: containers, load compartments of vehicles or wagons.

1.6 Bulkhead

1.6.1 Bulkhead means a metal wall, generally vertical, inside the vessel and which is bounded by the bottom, the side plating, a deck, the hatchway covers or by another bulkhead.

1.7 Cargo area of tank vessels

1.7.1 Cargo area of tank vessels means the whole of the spaces defined in [1.7.2] and [1.7.3] (see Fig 1).

1.7.2 Cargo area of tank vessels (part above deck)

Cargo area of tank vessels (part above deck) means the space which is bounded:

a) at the sides, by the shell plating extending upwards from the decks sides

b) fore and aft, by planes inclined at 45° towards the cargo area, starting at the boundary of the cargo area part below deck

c) vertically, by a horizontal plane at a height H above the deck, in m, to be determined as follows:

- for vessels with superstructure (see Pt B, Ch 1, Sec 2, [2.8.1] for definition):

  $H = \text{Min}(z_S - z_D\ ;\ 3)$

  where:

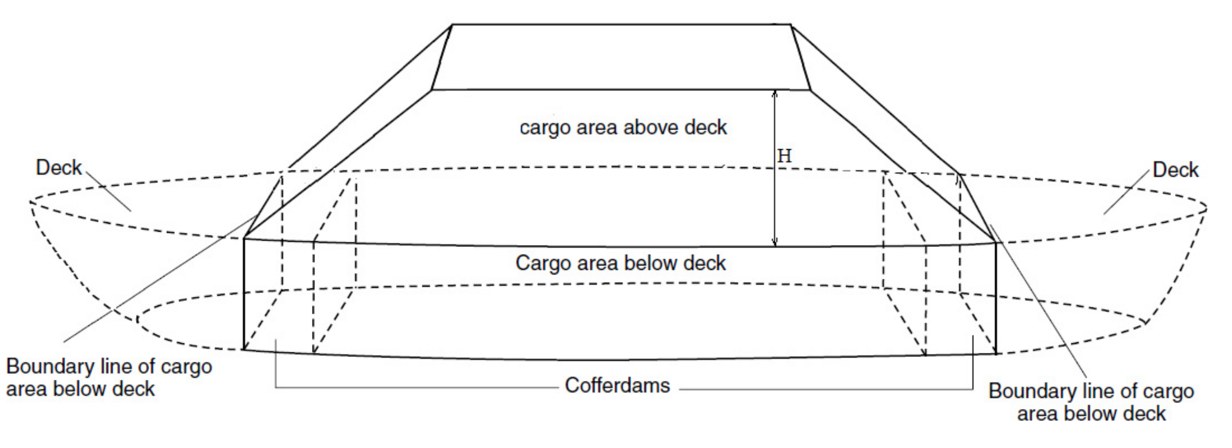
  z_S : Z-coordinate of the superstructure deck

  z_D : Z-coordinate of the main deck in way of the midship section

- for vessels without superstructure (e.g., non-propelled vessels):

  $H = 0$

Figure 1 : Cargo area



1.7.3 Cargo area of tank vessels (part below deck)

Cargo area of tank vessels (part below deck) means the space between two vertical planes perpendicular to the centre-line plane of the vessel, which comprises cargo tanks, hold spaces, cofferdams, double-hull spaces and double bottoms; these planes normally coincide with the outer cofferdam bulkheads or hold end bulkheads. Their intersection line with the deck is referred to as the boundary of the cargo area part below deck.

1.8 Cargo area of dry cargo vessels

1.8.1 See [1.30], Protected area.

1.9 Cargo pump room

1.9.1 Cargo pump-room means a service space where the cargo pumps and stripping pumps are installed together with their operational equipment.

1.10 Cargo tank

1.10.1 Cargo tank means a tank which is permanently attached to the vessel and intended for the carriage of dangerous goods.

1.10.2 Cargo tank design

a) Pressure cargo tank

Pressure cargo tank means a cargo tank independent of the vessel's hull, built according to dedicated recognised standards for a working pressure ≥ 400 kPa.

b) Closed cargo tank

Closed cargo tank means a cargo tank connected to the outside atmosphere through a device preventing unacceptable internal overpressure or underpressure.

c) Open cargo tank with flame arrester

Open cargo tank with flame arrester means a cargo tank connected to the outside atmosphere through a device fitted with a flame arrester.

d) Open cargo tank

Open cargo tank means a cargo tank in open connection with the outside atmosphere.

1.10.3 Cargo tank type

a) Independent cargo tank

Independent cargo tank means a cargo tank which is permanently built in, but which is independent of, the vessel's structure.

When, for an independent cargo tank, an anti-explosion protection is required, comparable to zone 0, see [1.21.2].

b) Integral cargo tank

Integral cargo tank means a cargo tank which is constituted by the vessel's structure itself and bounded by the outer hull or by walls separate from the outer hull.

c) Cargo tank with walls distinct from the outer hull

Cargo tank with walls distinct from the outer hull means an integral cargo tank of which the bottom and side walls do not form the outer hull of the vessel or an independent cargo tank.

1.11 Cargo residues

1.11.1 Cargo residues means liquid cargo which cannot be pumped out of the cargo tanks or cargo piping by means of the stripping system.

1.12 Closed-type sampling device

1.12.1 Closed-type sampling device means a device penetrating through the boundary of the cargo tank but constituting a part of a closed system designed so that during sampling no gas or liquid may escape from the cargo tank.

1.13 Cofferdam

1.13.1 Cofferdam means an athwartship compartment which is bounded by watertight bulkheads and which can be inspected. The cofferdam shall extend over the whole area of the end bulkheads of the tanks. The bulkheads not facing the cargo area (outer cofferdam bulkhead) shall extend from one side of the vessel to the other and from the bottom to the deck in one frame plane.

1.14 Design pressure

1.14.1 Design pressure means the pressure on the basis of which the cargo tank or the residual cargo tank has been designed and built.

1.15 Dangerous goods

1.15.1 Dangerous goods mean substances and articles the carriage of which is prohibited by ADN or equivalent standards, or authorized only under the conditions prescribed therein.

Equipment and articles which are assigned a UN number and transported as cargo are not included.

1.16 Equipment

1.16.1 Equipment means electrical or non-electrical machines, apparatus, fixed or mobile devices, control components and instrumentation thereof and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy and/or the processing of material and which are capable of causing an explosion through their own potential sources of ignition.

1.17 Explosion group

1.17.1 Explosion group/subgroup means a grouping of flammable gases and vapours according to their maximum experimental safe gaps and minimum ignition currents, and of electrical apparatus intended to be used in a potentially explosive atmosphere (see IEC 60079-0: 2012), installations, equipment and self-contained protection systems. For self-contained protection systems, the explosion group II B is subdivided into subgroups.

1.18 Explosion protection

1.18.1 Explosion protection means all of the requirements which have to be met and means which have to be taken to avoid damage caused by explosions.

This includes:

Organizational measures such as, for example:

a) Determining explosion hazardous areas (classification of zones): in which an explosive atmosphere consisting of a mixture with air of flammable gases, vapours or sprays is likely to occur:
   - continuously or for long periods or frequently (zone 0)
   - occasionally in normal operation (zone 1) or
   - exceptionally or only briefly (zone 2)

b) Prevention of ignition sources (use of low-sparking hand-tools, no smoking, use of personal protective equipment including dissipative shoes, non-isolating gloves, etc.)

c) Drafting of working instructions.

And technical requirements such as, for example:

a) Use of installations and equipment proven to be appropriate for use in the different explosion hazardous areas

b) Use of self-contained protection systems

c) Monitoring of potentially explosive atmospheres by the use of gas detection systems and gas detectors

1.19 Flame arrester

1.19.1 Flame arrester means a device mounted in the vent of part of an installation or in the interconnecting piping of a system of installations, the purpose of which is to permit flow but prevent the propagation of a flame front. The flame arrester shall be tested according to the international standard ISO 16852:20161 and evidence of compliance with the applicable requirements shall be supplied.

1.20 Flash-point

1.20.1 Flash-point means the lowest temperature of a liquid at which its vapours form a flammable mixture with air.

1.21 Hazardous areas

1.21.1 Hazardous areas are areas in which an explosive atmosphere is or may be expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Note 1: An explosive gas atmosphere is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

1.21.2 Hazardous areas are classified in the following zones based upon the frequency and the duration of the occurrence of explosive atmosphere:

- Zone 0: areas in which dangerous explosive atmospheres of gases, vapours or sprays exist permanently or during long periods
- Zone 1: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur occasionally
- Zone 2: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur rarely and, if so, for short periods only.

1.21.3 The different spaces of a tanker intended to carry substances for which anti-explosion protection is prescribed in column (17) of App 3, Tab 2, are to be classified according to Tab 1.

1.22 High-velocity vent valve

1.22.1 High-velocity vent valve means a pressure relief valve designed to have nominal flow velocities which exceed the flame velocity of the explosive mixture, thus preventing flame transmission. When the vessel substance list according to Ch 3, Sec 1, [4.3.2] contains substances for which explosion protection is required in column (17) of Ch 3, App 3, Tab 2, this pressure relief device shall be tested in accordance with international standard ISO 16852:2016 and evidence of compliance with the applicable requirements shall be supplied.

1.23 Intermediate bulk container (IBC)

1.23.1 Intermediate bulk container (IBC) means a rigid, or flexible portable packaging that:

a) has a capacity of not more than:
   - 3,0 m^3 for solids and liquids of packing groups II and III
   - 1,5 m^3 for solids of packing group I when packed in flexible, rigid plastics, composite, fibreboard and wooden IBCs
   - 3,0 m^3 for solids of packing group I when packed in metal IBCs
   - 3,0 m^3 for radioactive material of Class 7

b) is designed for mechanical handling

c) is resistant to the stresses produced in handling and transport in compliance with applicable standards.

Table 1 : Space descriptions and hazardous area zones for tankers

No.	Description of spaces	Hazardous area zone
1	The interior 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 and vapours	Zone 0
2	Void space adjacent to, above or below integral cargo tanks	Zone 1
3	Hold spaces	Zone 1
4	Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks	Zone 1
5	Cargo pump rooms and cargo compressor rooms	Zone 1
6	Spaces, other than cofferdam, adjacent to and below the top of a cargo tank (for example, trunks, passageways and hold)	Zone 1
7	Spaces on open deck located in the cargo area	Zone 1
8	Areas on open deck, or semi-enclosed spaces on open deck, within 2 m of any cargo tank outlet, gas or vapour outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets, and cargo tank openings for pressure release provided to permit the flow of gas or vapour mixtures caused by thermal variation	Zone 1
9	Areas on open deck, or semi-enclosed spaces on open deck, within 1 m of cargo pump entrances, cargo pump room ventilation inlet, openings into cofferdams, service spaces located in the cargo area below deck, or other zone 1 spaces	Zone 1
10	Compartments for cargo hoses	Zone 1
11	Enclosed or semi-enclosed spaces in which pipes containing cargoes are located	Zone 1
12	Spaces above deck, surrounding open or semi-enclosed spaces of zone 1	Zone 2
13	Spaces outside cargo area, below the level of the main deck, and having an opening on to the main deck or at a level less than 0,5 m above the main deck, unless: • the spaces are mechanically ventilated, or • the wall of the superstructure facing the cargo area extends from one side to the other and has doors the sills of which have a height of not less than 0,50 m	Zone 2

1.24 Large packaging

1.24.1 Large packaging means a packaging consisting of an outer packaging which contains articles or inner packagings and which:

- is designed for mechanical handling
- exceeds 400 kg net mass or 450 litres capacity but has a volume of not more than 3,0 m^3.

1.25 Limited explosion risk electrical apparatus

1.25.1 Limited explosion risk electrical apparatus means:

- an electrical apparatus which, during normal operation, does not cause sparks or exhibits surface temperatures which are above 200 °C, including e.g.:
  - three-phase squirrel cage rotor motors
  - brushless generators with contactless excitation
  - fuses with an enclosed fuse element
  - contactless electronic apparatus, or
- means an electrical apparatus with at least an enclosure protected against water jets (protection rating IP55 or higher) which during normal operation does not exhibit surface temperatures above 200 °C.

1.26 Multiple-element gas container (MEGC)

1.26.1 Multiple-element gas container (MEGC) means a unit containing elements which are linked to each other by a manifold and mounted on a frame. The following elements are considered to be elements of a multiple-element gas container: cylinders, tubes, pressure drums and bundles of cylinders as well as tanks for the carriage of gases having a capacity of more than 450 litres.

1.27 Packing group

1.27.1 Packing group means a group to which, for packing purposes, certain substances may be assigned in accordance with their degree of danger. The packing groups have the following meanings:

- packing group I: substances presenting high danger
- packing group II: substances presenting medium danger
- packing group III: substances presenting low danger.

1.28 Partly closed sampling device

1.28.1 Partly closed sampling device means a device penetrating through the boundary of the cargo tank such that during sampling only a small quantity of gaseous or liquid cargo can escape into the open air. As long as the device is not used it shall be closed completely.

1.29 Possibility of cargo heating

1.29.1 Possibility of cargo heating means a cargo heating installation in the cargo tanks using a heat insulator. The heat insulator may be heated by means of a boiler on board the tank vessel or from shore.

1.30 Protected area

1.30.1 Protected area means the whole of the following spaces on board of dry cargo vessels:

a) the cargo hold or holds of the vessel

b) the space situated above the deck, bounded:
   - athwartships, by vertical planes corresponding to the side plating
   - fore and aft, by vertical planes corresponding to the end bulkheads of the hold, and
   - upwards, by a horizontal plane 2 m above the upper level of the load, but at least by a horizontal plane 3 m above the deck.

1.31 Protective coaming, liquid-tight

1.31.1 Protective coaming, liquid-tight means a liquid-tight coaming on deck at the height of the outer cargo tank bulkhead (see Fig 1), but at a maximum distance of 0.60 m to the outer cofferdam bulkhead or hold end bulkheads, which prevents liquid from entering the fore and aft parts of the vessel. The connection between the protective coamings and the spill coaming shall be liquid tight.

1.32 Protection wall, gas- and liquid-tight

1.32.1 Protection wall, gas- and liquid-tight means a gas- and liquid-tight wall on deck at the height of the boundary plane of the cargo area preventing gases from entering areas outside the cargo area.

1.33 Residual cargo

1.33.1 Residual cargo means liquid cargo remaining in the cargo tank or cargo piping after unloading without the use of the stripping system.

1.34 Sampling opening

1.34.1 Sampling opening means a closable opening of a cargo tank with a diameter of not more than 0,30 m. When the vessel substance list according to Ch 3, Sec 1, [4.3.2] contains substances for which explosion protection is required in column (17) of Ch 3, App 3, Tab 2, it shall be deflagration safe, capable of withstanding steady burning for the most critical substance in the vessel substance list and so designed that the opening period will be as short as possible and that it cannot remain open without external intervention.

1.35 Slops

1.35.1 Slops means a mixture of cargo residues with washing water, rust or sludge which may or may not be suitable for pumping.

1.36 Service space

1.36.1 Service space means a space which is accessible during the operation of the vessel and which is neither part of the accommodation nor of the cargo tanks, with the exception of the fore peak and aft peak, provided no machinery has been installed in these latter spaces.

1.37 Temperature class

1.37.1 Temperature class means a grouping of flammable gases and vapours of flammable liquids according to their ignition temperature; and of the electrical apparatus intended to be used in the corresponding potentially explosive atmosphere according to their maximum surface temperature (see IEC publication 79 and EN 50014:1994).

1.38 Test pressure

1.38.1 Test pressure means the pressure at which a cargo tank, a residual cargo tank, a cofferdam or the loading and unloading pipes shall be tested prior to being brought into service for the first time and subsequently regularly within prescribed times.

1.39 UN Model Regulations

1.39.1 UN Model Regulations means the Model Regulations annexed to the latest edition of the Recommendations on the Transport of Dangerous Goods published by the United Nations.

1.40 UN number

1.40.1 UN number means the four-figure identification number of the substance or article taken from the United Nations Model Regulations.

APPENDIX 2 ADDITIONAL REQUIREMENTS CONCERNING CARRIAGE OF DRY CARGOES

1 Limitation of the quantities of dry cargo carried

1.1 Single hull vessels

1.1.1 Single hull vessels may carry goods of classes 1, 2, 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1, 7, 8 and 9 only in the limited quantities set out in Tab 1.This provision also applies to pushed barges and double hull vessels not complying with Ch 3, Sec 7.

1.1.2 Where substances and articles of different divisions of Class 1 are loaded in a single vessel in conformity with the provisions for prohibition of mixed loading, the entire load shall not exceed the smallest maximum mass given in Tab 1 for the goods of the most dangerous division loaded, the order of precedence being 1.1, 1.5, 1.2, 1.3, 1.6, 1.4.

1.1.3 For pushed convoy or side-by-side formations, the quantity limitations specified in Tab 1 apply to each unit. A maximum of 1 100 000 kg is permitted for each unit.

1.1.4 When a vessel is carrying several types of dangerous goods, the total quantity shall not exceed 1.100.000 kg.

1.2 Double hull vessels

1.2.1 Double hull vessels meeting the requirements of Ch 3, Sec 7, i.e. vessels assigned additional service feature DG1, may carry goods without limitation of the quantity carried, except for:

- goods of class 1, and
- goods of classes 2, 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1, 7. 8 and 9 for which a danger label of model N° 1 (see ADN) is required in column (5) of Ch 3, App 3, Tab 2,

for which the limitations set out in Tab 1 apply.

1.3 Handling and stowage of radioactive material

1.3.1 Fo activity limits, transport index (TI) limits and criticality safety indices (CSI), in the case of the carriage of radioactive material, see ADN Part 7, 7.1.4.14.7.

2 Additional requirements for specific classes

2.1 Additional requirements concerning Class 1

2.1.1 Definition of the divisions

division 1.1: Substances and articles which have a mass explosion hazard (a mass explosion is an explosion which affects almost the entire load virtually instantaneously)

division 1.2: Substances and articles which have a projection hazard but not a mass explosion hazard

division 1.3: Substances and articles which have a fire hazard and either a minor blast hazard, or a minor projection hazard, or both, but not a mass explosion hazard:

- combustion of which gives rise to considerable radiant heat, or
- which burn one after another, producing minor blast or projection effects, or both

division 1.4: Substances and articles which present only a slight risk of explosion in the event of ignition or initiation during carriage. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire shall not cause virtually instantaneous explosion of almost the entire contents of the package

division 1.5: Very insensitive substances having a mass explosion hazard which are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of carriage. As a minimum requirement they must not explode in the external fire test

division 1.6: Extremely insensitive articles which do not have a mass explosion hazard. The articles contain only extremely insensitive substances and demonstrate a negligible probability of accidental initiation or propagation.

2.1.2 Definition of the compatibility groups

group A : Primary explosive substance

group B : Article containing a primary explosive substance and not having two or more effective protective features. Some articles, such as detonators for blasting, detonator assemblies for blasting and primers, cap-type, are included, even though they do not contain primary explosives

Table 1 : Limitation of quantities carried

Class	Substances / Articles	Total gross mass, in kg
Class 1 **(1)**	All substances of division 1.1 of compatibility group A	90 **(2)**
	All substances of division 1.1 of compatibility groups B, C, D, E, F, G, J, or L	15 000 **(3)**
	All substances of division 1.2 of compatibility groups B, C, D, E, F, G, H, J or L	50 000
	All substances of division 1.3 of compatibility groups C, G, H, J, or L	300 000 **(4)**
	All substances of division 1.4 of compatibility groups B, C, D, E, F, G, or S	1 100 000
	All substances of division 1.5 of compatibility group D	15 000 **(3)**
	All substances of division 1.6 of compatibility group N	300 000 **(4)**
	Empty packagings, uncleaned	1 100 000
Class 2	All goods for which label No. 2.1 is required	300 000
	All goods for which label No. 2.3 is required	120 000
	Other goods	1 100 000
Class 3	All goods for which label No. 6.1 is required	120 000
	Other goods	300 000
Class 4.1	UN 3221, 3222, 3231,and 3232	15 000
	- All goods of packing group I - All goods of packing group II for which label No. 6.1 is required - Self-reactive substances of types C, D, E and F **(5)** (UN 3223 to 3230 and 3233 to 3240) - Other substances of classification code SR1 **(6)** or SR2 **(7)** (UN 2956, 3241, 3242 and 3251) - Desensitized explosive substances of packing group II (UN Nos. 2907, 3319 and 3344)	120 000
	Other goods	1 100 000
Class 4.2	All goods of packing groups I or II for which label No. 6.1 is required	300 000
	Other goods	1 100 000
Class 4.3	All goods of packing groups I or II for which label No. 3, 4.1 or 6.1 is required	300 000
	Other goods	1 100 000
Class 5.1	All goods of packing groups I or II for which label No. 6.1 is required	300 000
	Other goods	1 100 000
Class 5.2	UN 3101, 3102, 3111 and 3112	15 000
	Other goods	120 000
Class 6.1	All goods of packing group I	120 000
	All goods of packing group II	300 000
	All goods carried in bulk	0
	Other goods	1 100 000
Class 7	UN 2912, 2913, 2915, 2916, 2917, 2919, 2977, 2978 and 3321 to 3333	0
	Other goods	1 100 000
Class 8	All goods of packing group I Goods of packing group II for which label No. 3 or 6.1 is required	300 000
	Other goods	1 100 000
Class 9	All goods of packing group II	300 000
	UN No. 3077, for goods carried in bulk and classified as hazardous to the aquatic environment, categories Acute 1 or Chronic 1	0
	Other goods	1 100 000

(1) Divisions and compatibility groups of substances and articles are defined in [2.1]
(2) In not less than three batches of a maximum of 30 kg each, distance between batches not less than 10,00 m
(3) In not less than three batches of a maximum of 5 000 kg each, distance between batches not less than 10,00 m
(4) Not more than 100 000 kg per hold. A wooden partition is permitted for subdividing a hold
(5) See [2.2]
(6) SR1: Self-reactive substances not requiring temperature control
(7) SR2: Self-reactive substances requiring temperature control.

group C : Propellant explosive substance or other deflagrating explosive substance or article containing such explosive substance

group D : Secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and having two or more effective protective features

group E : Article containing a secondary detonating explosive substance, without means of initiation, with a propelling charge (other than one containing a flammable liquid or gel or hypergolic liquids)

group F : Article containing a secondary detonating explosive substance with its own means of initiation, with a propelling charge (other than one containing a flammable liquid or gel or hypergolic liquids), or without a propelling charge

group G : Pyrotechnic substance, or article containing a pyrotechnic substance, or article containing both an explosive substance and an illuminating, incendiary, tear- or smoke-producing substance (other than a water-activated article or one which contains white phosphorus, phosphides, a pyrophoric substance, a flammable liquid or gel or hypergolic liquids)

group H : Article containing both an explosive substance and white phosphorus

group J : Article containing both an explosive substance and a flammable liquid or gel

group K : Article containing both an explosive substance and a toxic chemical agent

group L : Explosive substance or article containing an explosive substance and presenting a special risk (e.g. due to water activation or the presence of hypergolic liquids, phosphides or a pyrophoric substance) necessitating isolation of each type

group N : Articles containing only extremely insensitive substances

group S : Substance or article so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder or prevent fire-fighting or other emergency response efforts in the immediate vicinity of the package.

2.2 Additional requirements concerning Class 4.1

2.2.1 Types of self-reactive substances

Self-reactive substances are classified into seven types according to the degree of danger they present. The types of self-reactive substances range from type A, which is not accepted for carriage in the packaging in which it is tested, to type G, which is not subject to the provisions for self-reactive substances of Class 4.1. The classification of types B to F is directly related to the maximum quantity allowed in one packaging. The principles to be applied for classification as well as the applicable classification procedures, test methods and criteria and an example of a suitable test report are given in Part II of the Manual of Tests and Criteria.

APPENDIX 3 LIST OF DANGEROUS GOODS ACCEPTED FOR CARRIAGE IN TANK VESSELS

1 General

1.1 Scope of the list

1.1.1 Tab 2 lists dangerous products permitted to be carried in tankers complying with these Rules.

1.2 Application

1.2.1 As a rule, each row ofTab 2 deals with the substance(s) covered by a specific UN number or identification number. However, when substances belonging to the same UN number or identification number have different chemical properties, physical properties and/or carriage conditions, several consecutive rows may be used for that UN number or identification number.

Each column ofTab 2 is dedicated to a specific subject as indicated in the explanatory notes given in [2]. The intersection of columns and rows (cell) contains information concerning the subject treated in that column, for the substance(s) of that row:

- the first four cells identify the substance(s) belonging to that row
- the following cells give the applicable special provisions, either in the form of complete information or in coded form. The codes cross-refer to detailed information that is to be found in the numbers indicated in the explanatory notes below. An empty cell means either that there is no special provision and that only the general requirements apply, or that the carriage restriction indicated in the explanatory notes is in force.

The applicable general requirements are not referred to in the corresponding cells.

2 Explanations concerning Table 2

2.1 Column 1: UN number or substance identification number

2.1.1 Column 1 contains the UN number or identification number of:

- the dangerous substance if the substance has been assigned its own specific UN number or identification number, or
- the generic or n.o.s. entry to which the dangerous substances not mentioned by name shall be assigned in accordance with the criteria ("decision trees") of ADN, Part 2.

2.2 Column 2: Name and description

2.2.1 Column 2 contains, in upper case characters, the name of the substance, if the substance has been assigned its own specific UN number or identification number or of the generic or n.o.s. entry to which the dangerous substances have been assigned in accordance with the criteria ("decision trees") of ADN, Part 2. This name shall be used as the proper shipping name or, when applicable, as part of the proper shipping name (see ADN, Part 3, 3.1.2 for further details on the proper shipping name).

A descriptive text in lower case characters is added after the proper shipping name to clarify the scope of the entry if the classification or carriage conditions of the substance may be different under certain conditions.

2.3 Column 3

2.3.1 Column 3a: Class

Column 3a contains the number of the Class, whose heading covers the dangerous substance. This Class number is assigned in accordance with the procedures and criteria of ADN, Part 2.

2.3.2 Column 3b: Classification code

Column 3b contains the classification code of the dangerous substance:

- for dangerous substances of Class 2, the code consists of a number and one or more letters representing the hazardous property group, which are explained in ADN, Part 2, 2.2.2.1.2 and 2.2.2.1.3
- for dangerous substances or articles of Classes 3, 4.1, 6.1 and 9, the codes are explained in ADN, Part 2, 2.2.x.1.2. (see Note 1).
- for dangerous substances or articles of Class 8, the codes are explained in ADN, Part 2, 2.2.8.1.4.1.

Note 1: x is the Class number of the dangerous substance or article, without dividing point if applicable.

2.4 Column 4: Packing group

2.4.1 Column 4 contains the packing group number(s) (I, II or III) assigned to the dangerous substance. These packing group numbers are assigned on the basis of the procedures and criteria of ADN, Part 2. Certain substances are not assigned to packing groups.

2.5 Column 5: Dangers

2.5.1 Column 5 contains information concerning the hazards inherent in the dangerous substance. These hazards are included on the basis of the danger labels of ADN, Part 3, Table A, column (5). In the case of a chemically unstable substance the code “unst.” is added to the information.

In the case of a substance or mixture hazardous to the aquatic environment, the code N1, N2 or N3 is added to the information.

In the case of a substance or mixture with CMR properties, the code CMR is added to the information.

CMR is used to indicate substances with long term effects on health (carcinogenic, mutagenic or toxic to reproduction, categories 1A and 1B in accordance with the criteria of Chapters 3.5, 3.6 and 3.7 of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS) as amended, published by the United Nations.

In the case of a substance or mixture that floats on the water surface, does not evaporate and is not readily soluble in water or that sinks to the bottom of the water and is not readily soluble, the code F (standing for Floater) or S (standing for Sinker), respectively, is added to the information.

Where the information is shown in brackets, only the relevant codes for the substance carried should be used.

2.6 Column 6: Type of tank vessel

2.6.1 Column 6 contains the type of tank vessel: G, C or N, where:

G : Stands for DG-G

C : Stands for DG-C

N : Stands for DG-N.

2.7 Column 7: Cargo tank design

2.7.1 Column 7 contains information concerning the design of the cargo tank:

1 = Pressure cargo tank

2 = Closed cargo tank

3 = Open cargo tank with flame arrester

4 = Open cargo tank.

2.8 Column 8: Cargo tank type

2.8.1 Column 8 contains information concerning the cargo tank type:

1 = Independent cargo tank

2 = Integral cargo tank

3 = Cargo tank with walls distinct from the outer hull

4 = Membrane tank.

2.9 Column 9: Cargo tank equipment

2.9.1 Column 9 contains information concerning the cargo tank equipment:

1 = Refrigeration system

2 = Possibility of cargo heating system

3 = Water-spray system

4 = Cargo heating system on board.

2.10 Column 10: Opening pressure of the pressure relief valve/high-velocity vent valve in kPa

2.10.1 Column 10 contains information concerning the opening pressure of the pressure relief valve/high-velocity vent valve in kPa.

2.11 Column 11: Maximum degree of filling in %

2.11.1 Column 11 contains information concerning the maximum degree of filling of cargo tanks as a percentage.

2.12 Column 12: Relative density at 20°C

2.12.1 Column 12 contains information concerning the relative density of the substance at 20°C. Data concerning the density are for information only.

2.13 Column 13: Type of sampling device

2.13.1 Column 13 contains information concerning the prescribed type of sampling device:

1 = Closed-type sampling device

2 = Partly closed-type sampling device

3 = Sampling opening.

2.14 Column 14: Pump-room below deck permitted

2.14.1 Column 14 contains an indication of whether a pump-room is permitted below deck:

yes = Pump-room below deck is permitted

no = Pump-room below deck is not permitted.

2.15 Column 15: Temperature class

2.15.1 Column 15 contains the temperature class of the substance.

2.16 Column 16: Explosion group

2.16.1 Column 16 contains the explosion group of the substance.

Note 1: Where autonomous protection systems for explosion group II B are in place, products in explosion group II A or II B, including subgroups II B3, II B2 and II B1 may be transported.

Where autonomous protection systems for explosion group II B3 are in place, products in explosion subgroups II B3, II B2 and II B1 or in explosion group II A, may be transported.

Where autonomous protection systems for explosion group II B2 are in place, products in explosion subgroups II B2 and II B1 or in explosion group II A, may be transported.

Where autonomous protection systems for explosion group II B1 are in place, products in explosion subgroups II B1 or in explosion group II A, may be transported.

2.17 Column 17: Anti-explosion protection required

2.17.1 Column 17 contains information on protection against explosions:

yes = Anti-explosion protection is required

no = Anti-explosion protection is not required.

2.18 Column 18: Equipment required

2.18.1 Column 18 contains the codes for the equipment required for the carriage of the dangerous substance:

PP : For each member of the crew, a pair of protective goggles, a pair of protective gloves, a protective suit and a suitable pair of protective shoes (or protective boots, if necessary). On board tank vessels, protective boots are required in all cases

EP : A suitable escape device for each person on board

EX : A flammable gas detector with the instructions for its use

TOX : A toximeter with the instructions for its use

A : A breathing apparatus ambient air-dependent.

2.19 Column 19: Number of cones/blue lights

2.19.1 Column 19 contains the number of cones/blue lights which should constitute the marking of the vessel during the carriage of this dangerous substance or article.

2.20 Column 20: Additional requirements / Remarks applicable to the vessel

2.20.1 Additional requirement / remark 1

Anhydrous ammonia is liable to cause stress crack corrosion in cargo tanks and cooling systems constructed of carbon-manganese steel or nickel steel.

In order to minimize the risk of stress crack corrosion, the following measures shall be taken:

a) Where carbon-manganese steel is used, cargo tanks, pressure vessels of cargo refrigeration systems and cargo piping shall be constructed of fine grained steel having a specified minimum yield stress of not more than 355 N/mm^2. The actual yield stress shall not exceed 440 N/mm^2. In addition, one of the following construction or operational measures shall be taken:
   - material with a low tensile strength shall be used (i.e. Rm < 410 N/mm^2); or
   - cargo tanks, etc., shall undergo a post-weld heat treatment for the purpose of stress relieving; or
   - the transport temperature shall preferably be maintained close to the evaporation temperature of the cargo of −33°C, but in no case above −20°C; or
   - ammonia shall contain not less than 0,1% water, by mass.

b) When carbon-manganese steel with yield stress values higher than those referred to in item a) above is used, the completed tanks, pipe sections, etc., shall undergo a post-weld heat treatment for the purpose of stress relieving.

c) Pressure vessels of the cargo refrigeration systems and the piping systems of the condenser of the cargo refrigeration system constructed of carbon-manganese steel or nickel steel shall undergo a post-weld heat treatment for the purpose of stress relieving.

d) The yield stress and the tensile strength of welding consumables may exceed only by the smallest value possible the corresponding values of the tank and piping material.

e) Nickel steels containing more than 5% nickel and carbon manganese steel which are not in compliance with the requirements of items a) and b) above may not be used for cargo tanks and piping systems intended for the transport of this substance.

f) Nickel steels containing not more than 5% nickel may be used if the transport temperature is within the limits referred to in item a) above.

g) The concentration of oxygen dissolved in the ammonia shall not exceed the values given inTab 1.

Table 1 : Maximum oxygen concentration

t, in °C	O_2 , in %, by volume
≤ −30	0,90
−20	0,50
−10	0,28
0	0,16
10	0,10
20	0,05
30	0,03

2.20.2 Additional requirement / remark 2

Before loading, air shall be removed and subsequently kept away to a sufficient extent from the cargo tanks and the accessory cargo piping by the means of inert gas (see also Ch 3, Sec 1, [4.7]).

2.20.3 Additional requirement / remark 3

Arrangements shall be made to ensure that the cargo is sufficiently stabilized in order to prevent a reaction at any time during carriage. The transport document shall contain the following additional particulars:

a) name and amount of inhibitor added

b) date on which inhibitor was added and expected duration of effectiveness under normal conditions

c) any temperature limits having an effect on the inhibitor.

When stabilization is ensured solely by blanketing with an inert gas it is sufficient to mention the name of the inert gas used in the transport document.

When stabilization is ensured by another measurement, e.g. the special purity of the substance, this measurement shall be mentioned in the transport document.

2.20.4 Additional requirement / remark 4

The substance shall not be allowed to solidify; the transport temperature shall be maintained above the melting point. In instances where cargo heating installations are required, they must be so designed that polymerisation through heating is not possible in any part of the cargo tank. Where the temperature of steam-heated coils could give rise to overheating, lower-temperature indirect heating systems shall be provided.

2.20.5 Additional requirement / remark 5

This substance is liable to clog the venting piping and its fittings or the fittings of cargo tanks. Careful surveillance should be ensured. If a closed-type tank vessel cargo tank is required for the carriage of this substance and explosion protection is necessary or the substance for which explosion protection is necessary is carried in a closed cargo tank, the cargo tank shall conform to Ch 3, Sec 3, [3.6.4] or Ch 3, Sec 4, [3.6.3] or the venting piping shall conform to Ch 3, Sec 3, [3.6.5] a) or Ch 3, Sec 3, [3.6.5] b) or to Ch 3, Sec 4, [3.6.4] a) or Ch 3, Sec 4, [3.6.4] b).

This requirement does not apply when the cargo tanks and the corresponding piping are inerted in accordance with Ch 3, Sec 1, [4.7].

2.20.6 Additional requirement / remark 6

When external temperatures are below or equal to that indicated in column (20), the substance may only be carried in tank vessels equipped with a possibility of heating the cargo.

In addition, in the event of carriage in a closed cargo tank, the venting piping, the safety valves and the flame arresters shall be heatable.

The temperature of the venting piping, safety valves and flame arresters shall be kept at least above the melting point of the substance.

2.20.7 Additional requirement / remark 7

If a closed cargo tank is required to carry this substance or if the substance is carried in a closed cargo tank, the venting piping, the safety valves and the flame arresters shall be heatable.

The temperature of the venting piping, safety valves and flame arresters shall be kept at least above the melting point of the substance.

2.20.8 Additional requirement / remark 8

Double-hull spaces, double bottoms and heating coils shall not contain any water.

2.20.9 Additional requirement / remark 9

a) While the vessel is underway, an inert-gas pad shall be maintained in the ullage space above the liquid level.

b) Cargo piping and vent lines shall be independent of the corresponding piping used for other cargoes.

c) Safety valves shall be made of stainless steel.

2.20.10 Additional requirement / remark 10

(Reserved)

2.20.11 Additional requirement / remark 11

a) Stainless steel of type 416 or 442 and cast iron shall not be used for cargo tanks and pipes for loading and unloading.

b) The cargo may be discharged only by deep-well pumps or pressure inert gas displacement. Each cargo pump shall be arranged to ensure that the substance does not heat significantly if the pressure discharge line from the pump is shut off or otherwise blocked.

c) The cargo shall be cooled and maintained at temperatures below 30°C.

d) The safety valves shall be set at a pressure of not less than 550 kPa (5,5 bar) gauge pressure. Special authorization is required for the maximum setting pressure.

e) While the vessel is underway, a nitrogen pad shall be maintained in the ullage space above the cargo (see also Ch 3, Sec 1, [4.7]). An automatic nitrogen supply system shall be installed to prevent the pressure from falling below 7 kPa (0,07 bar) gauge within the cargo tank in the event of a cargo temperature fall due to ambient temperature conditions or to some other reason. In order to satisfy the demand of the automatic pressure control a sufficient amount of nitrogen shall be available on board. Nitrogen of a commercially pure quality of 99,9%, by volume, shall be used for padding. A battery of nitrogen cylinders connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression “automatic” in this context.

   The required nitrogen pad shall be such that the nitrogen concentration in the vapour space of the cargo tank is not less than 45% at any time.

f) Before loading and while the cargo tank contains this substance in a liquid or gaseous form, it shall be inerted with nitrogen.

g) The water-spray system shall be fitted with remote-control devices which can be operated from the wheelhouse or from the control station, if any.

h) Transfer arrangements shall be provided for emergency transfer of ethylene oxide in the event of an uncontrollable self-reaction.

2.20.12 Additional requirement / remark 12

a) The substance shall be acetylene free.

b) Cargo tanks which have not undergone appropriate cleaning shall not be used for the carriage of these substances if one of the previous three cargoes consisted of a substance known to promote polymerisation, such as:
   - mineral acids (e.g. sulphuric acid, hydrochloric acid, nitric acid)
   - carboxylic acids and anhydrides (e.g. formic acid, acetic acid)
   - halogenated carboxylic acids (e.g. chloroacetic acid)
   - sulphonic acids (e.g. benzen sulphonic acid)
   - caustic alkalis (e.g. sodium hydroxide, potassium hydroxide)
   - ammonia and ammonia solutions
   - amines and amine solutions
   - oxidizing substances.

c) Before loading, cargo tanks and their piping shall be efficiently and thoroughly cleaned so as to eliminate all traces of previous cargoes, except when the last cargo was constituted of propylene oxide or a mixture of ethylene oxide and propylene oxide. Special precautions shall be taken in the case of ammonia in cargo tanks built of steel other than stainless steel.

d) In all cases the efficiency of the cleaning of cargo tanks and their piping shall be monitored by means of appropriate tests or inspections to check that no trace of acid or alkaline substance remains that could present a danger in the presence of these substances.

e) The cargo tanks shall be entered and inspected prior to each loading of these substances to ensure freedom from contamination, heavy rust deposits or visible structural defects.

When these cargo tanks are fitted in type C tank vessels, with cargo tank design 1 and cargo tank type 1, and are in continuous service for these substances, such inspections shall be performed at intervals of not more than two and a half years.

When these cargo tanks are fitted in type G tank vessels, with cargo tank design 1 and cargo tank type 1, and are in continuous service for these substances, such inspections shall be performed during the periodic inspection for the class renewal.

f) Cargo tanks which have contained these substances may be reused for other cargoes once they and their piping have been thoroughly cleaned by washing and flushing with an inert gas.

g) Substances shall be loaded and unloaded in such a way that there is no release of gas into the atmosphere. If gas is returned to the shore installation during loading, the gas return system connected to the tank containing that substance shall be independent from all other cargo tanks.

h) During discharge operations, the pressure in the cargo tanks shall be maintained above 7 kPa (0,07 bar) gauge.

i) The cargo shall be discharged only by deep-well pumps, hydraulically operated submerged pumps or pressure inert gas displacement. Each cargo pump shall be arranged to ensure that the substance does not heat significantly if the pressure discharge line from the pump is shut off or otherwise blocked.

j) Each cargo tank carrying these substances shall be ventilated by a system independent from the ventilation systems of other cargo tanks carrying other substances.

k) Hose assemblies for loading and unloading shall be marked as follows:

"To be used only for the transfer of alkylene oxide."

l) (Reserved)

m) No air shall be allowed to enter the cargo pumps and cargo piping system while these substances are contained within the system.

n) Before the shore connections are disconnected, piping containing liquids or gas shall be depressurised at the shore link by means of appropriate devices.

o) The piping system for cargo tanks to be loaded with these substances shall be separate from the piping system for all other cargo tanks, including empty cargo tanks. If the piping system for the cargo tanks to be loaded is not independent, separation shall be accomplished by the removal of spool pieces, shut-off valves, other pipe sections and by fitting blank flanges at these locations. The required separation applies to all liquid pipes and vapour vent lines and any other connections which may exist such as common inert gas supply lines.

p) These substances may be carried only in accordance with cargo handling plans that have been approved by a competent authority.

Each loading arrangement shall be shown on a separate cargo handling plan. Cargo handling plans shall show the entire cargo piping system and the locations for installations of blank flanges needed to meet the above piping separation requirements. A copy of each cargo handling plan shall be kept on board. Reference to the approved cargo handling plans shall be included in the certificate of approval.

q) Before loading of these substances and before carriage is resumed a qualified person approved by the competent authority shall certify that the prescribed separation of the piping has been effected; this certificate shall be kept on board. Each connection between a blank flange and a shut-off valve in the piping shall be fitted with a sealed wire to prevent the flange from being disassembled inadvertently.

r) During the voyage, the cargo shall be covered with nitrogen. An automatic nitrogen make-up system shall be installed to prevent the cargo tank pressure from falling below 7 kPa (0,07 bar) gauge in the event of a cargo temperature fall due to ambient temperature conditions or to some other reason. Sufficient nitrogen shall be available on board to satisfy the demand of automatic pressure control. Nitrogen of commercially pure quality of 99,9%, by volume, shall be used for padding. A battery of nitrogen cylinders connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression "automatic" in this context.

s) The vapour space of the cargo tanks shall be checked before and after each loading operation to ensure that the oxygen content is 2%, by volume, or less.

t) Loading flow

The loading flow (L_R) of cargo tank shall not exceed the following value:

$L_R = 3600\ U/t$ (m^3/h)

where:

U	:	Free volume, in m^3 during loading for the activation of the overflow prevention system
T	:	Time, in s, required between the activation of the overflow prevention system and the complete stop of the flow of cargo into the cargo tank.

The time is the sum of the partial times needed for successive operations, e.g. reaction time of the service personnel, the time needed to stop the pumps and the time needed to close the shut-off valves.

The loading flow shall also take account of the design pressure of the piping system.

2.20.13 Additional requirement / remark 13

If no stabilizer is supplied or if the supply is inadequate, the oxygen content in the vapour phase shall not exceed 0,1%. Overpressure must be constantly maintained in cargo tanks. This requirement applies also to voyages on ballast or empty with uncleaned cargo tanks between cargo transport operations.

2.20.14 Additional requirement / remark 14

The following substances may not be carried in a DG-N vessel:

- substances with self-ignition temperatures ≤ 200°C
- substances with a flash point < 23°C and an explosion range > 15 percentage points
- mixtures containing halogenated hydrocarbons
- mixtures containing more than 10% benzene
- substances and mixtures carried in a stabilized state.

2.20.15 Additional requirement / remark 15

Provision shall be made to ensure that alkaline or acidic substances such as sodium hydroxide solution or sulphuric acid do not contaminate this cargo.

2.20.16 Additional requirement / remark 16

If there is a possibility of a dangerous reaction such as polymerisation, decomposition, thermal instability or evolution of gases resulting from local overheating of the cargo in either the cargo tank or associated piping system, this cargo shall be loaded and carried adequately segregated from other substances the temperature of which is sufficiently high to initiate such reaction. Heating coils inside cargo tanks carrying this substance shall be blanked off or secured by equivalent means.

2.20.17 Additional requirement / remark 17

The melting point of the cargo shall be shown in the transport documents.

2.20.18 Additional requirement / remark 18

(Reserved)

2.20.19 Additional requirement / remark 19

Provision shall be made to ensure that the cargo does not come into contact with water. The following additional requirements apply:

Carriage of the cargo is not permitted in cargo tanks adjacent to slop tanks or cargo tanks containing ballast water, slops or any other cargo containing water. Pumps, piping and vent lines connected to such tanks shall be separated from similar equipment of tanks carrying these substances. Pipes from slop tanks or ballast water pipes shall not pass through cargo tanks containing this cargo unless they are encased in a tunnel.

2.20.20 Additional requirement / remark 20

The maximum permitted transport temperature given in column (20) shall not be exceeded.

2.20.21 Additional requirement / remark 21

(Reserved)

2.20.22 Additional requirement / remark 22

The relative density of the cargo shall be shown in the transport document.

2.20.23 Additional requirement / remark 23

The instrument for measuring the pressure of the vapour phase in the cargo tank shall activate the alarm when the internal pressure reaches 40 kPa (0,4 bar). The water-spray system shall immediately be activated and remain in operation until the internal pressure drops to 30 kPa (0,3 bar).

2.20.24 Additional requirement / remark 24

Substances having a flash-point above 61°C which are handed over for carriage or which are carried heated within a limiting range of 15 K below their flash-point shall be carried under the conditions of substance number 9001.

2.20.25 Additional requirement / remark 25

Type 3 cargo tank may be used for the carriage of this substance provided that the construction of the cargo tank has been accepted by a recognized classification society for the maximum permitted transport temperature.

2.20.26 Additional requirement / remark 26

Type 2 cargo tank may be used for the carriage of this substance provided that the construction of the cargo tank has been accepted by a recognized classification society for the maximum permitted transport temperature.

2.20.27 Additional requirement / remark 27

The requirements of ADN, Part 3, 3.1.2.8.1 are applicable.

2.20.28 Additional requirement / remark 28

a) When UN 2448 SULPHUR MOLTEN is carried, the forced ventilation of the cargo tanks shall be brought into service at latest when the concentration of hydrogen sulphide reaches 1,0%, by volume.

b) When during the carriage of UN 2448 SULPHUR MOLTEN, the concentration of hydrogen sulphide exceeds 1,85%, the boat master shall immediately notify the nearest competent authority.

   When a significant increase in the concentration of hydrogen sulphide in a hold space leads it to be supposed that the sulphur has leaked, the cargo tanks shall be unloaded as rapidly as possible. A new load may only be taken on board once the authority which issued the certificate of approval has carried out a further inspection.

c) When UN 2448 SULPHUR MOLTEN is carried, the concentration of hydrogen sulphide shall be measured in the vapour phase of the cargo tanks and concentrations of sulphur dioxide and hydrogen sulphide in the hold spaces.

d) The measurements prescribed in item c) shall be made every eight hours. The results of the measurements shall be recorded in writing.

2.20.29 Additional requirement / remark 29

Deleted.

2.20.30 Additional requirement / remark 30

When these substances are carried, the hold spaces of open type N tank vessels may contain auxiliary equipment.

2.20.31 Additional requirement / remark 31

When these substances are carried, the vessel shall be equipped with a rapid blocking valve placed directly on the shore connection.

2.20.32 Additional requirement / remark 32

In the case of transport of this substance, the following additional requirements are applicable:

a) The outside of the cargo tanks shall be equipped with insulation of low flammability. This insulation should be strong enough to resist shocks and vibration. Above deck, the insulation should be protected by a covering.

   The outside temperature of this covering should not exceed 70°C.

b) The spaces containing the cargo tanks should be provided with ventilation. Connections for forced ventilation should be fitted.

c) The cargo tanks should be equipped with forced ventilation installations which, in all transport conditions, will reliably keep the concentration of hydrogen sulphide above the liquid phase below 1,85% by volume.

   The ventilation installations should be fitted in such a way as to prevent the deposit of the goods to be transported.

   The exhaust line of the ventilation should be fitted in such a way as not to present a risk to personnel.

d) The cargo tank and the hold spaces should be fitted with outlets and piping to allow gas sampling.

e) The outlets of the cargo tanks shall be situated at a height such that for a trim of 2° and a list of 10°, no sulphur can escape. All the outlets shall be situated above the deck in the open air. Each outlet shall be equipped with a satisfactory fixed closing mechanism.

   One of these mechanisms shall be capable of being opened for slight overpressure within the tank.

f) The pipes for loading and unloading shall be equipped with adequate insulation. They shall be capable of being heated.

g) The heat transfer fluid shall be such that in the event of a leak into a tank, there is no risk of a dangerous reaction with the sulphur.

2.20.33 Additional requirement / remark 33

The following provisions are applicable to transport of this substance.

Note 1: **CONSTRUCTION REQUIREMENTS**

a) Hydrogen peroxide solutions may be transported only in cargo tanks equipped with deep-well pumps.

b) Cargo tanks and their equipment should be constructed of solid stainless steel of a type appropriate to hydrogen peroxide solutions (for example, 304, 304L, 316, 316L or 316 Ti). None of the non-metallic materials used for the system of cargo tanks shall be attacked by hydrogen peroxide solutions or cause the decomposition of the substance.

c) The temperature sensors shall be installed in the cargo tanks directly under the deck and at the bottom. Remote temperature read-outs and monitoring shall be provided for in the wheelhouse.

d) Fixed oxygen monitors (or gas-sampling lines) shall be provided in the areas adjacent to the cargo tanks so that leaks in such areas can be detected. Account shall be taken of the increased flammability arising from the increased presence of oxygen. Remote read-outs, continuous monitoring (if the sampling lines are used, intermittent monitoring will suffice) and visible and audible alarms similar to those for the temperature sensors shall also be located in the wheelhouse. The visible and audible alarms shall be activated if the oxygen concentration in these void spaces exceeds 30% by volume. Two additional oxygen monitors shall also be available.

e) The cargo tank venting systems which are equipped with filters shall be fitted with pressure/vacuum relief valves appropriate to closed-circuit ventilation and with an extraction installation should cargo tank pressure rise rapidly as a result of an uncontrolled breakdown (see item m) below). These air supply and extraction systems shall be so designed that water cannot enter the cargo tanks. In designing the emergency extraction installation account shall be taken of the design pressure and the size of the cargo tanks.

f) A fixed water-spray system shall be provided for diluting and washing away any hydrogen peroxide solutions spilled onto the deck. The area covered by the jet of water shall include the shore connections and the deck containing the cargo tanks designated for carrying hydrogen peroxide solutions.

   The following minimum requirements shall be complied with:

   1) The substance shall be diluted from the original concentration to a 35% concentration within five minutes from the spillage on the deck

   2) The rate and estimated size of the spill should be determined in the light of the maximum permissible loading or unloading rates, the time required to halt the spillage in the event of tank overfill or a pipe or hose assembly failure, and the time necessary to begin application of dilution water with actuation of the alarm at the cargo control location or in the wheelhouse.

g) The outlets of the pressure valves should be situated at least 2,00 metres from the walkways if they are less than 4,00 metres from the walkway.

h) A temperature sensor shall be installed by each pump to make it possible to monitor the temperature of the cargo during unloading and detect any overheating due to defective operation of the pump.

Note 2: **SERVICING REQUIREMENTS: CARRIER (Items i to l)**

i) Hydrogen peroxide solutions may only be carried in cargo tanks which have been thoroughly cleaned and passivated, in accordance with the procedure described in item j) below, of all traces of previous cargoes, their vapours or their ballast waters. A certificate stating that the procedure described in item j) has been duly complied with must be carried on board.

   Particular care in this respect is essential to ensure the safe carriage of hydrogen peroxide solutions:

   1) When a hydrogen peroxide solution is being carried, no other cargo may be carried simultaneously

   2) Tanks which have contained hydrogen peroxide solutions may be reused for other cargoes after they have been cleaned by persons or companies approved for this purpose by the competent authority

   3) In the design of the cargo tanks, efforts must be made to keep to a minimum any internal tank structure, to ensure free draining, no entrapment and ease of visual inspection.

j) Procedures for inspection, cleaning, passivation and loading for the transport of hydrogen peroxide solutions with a concentration of 8 to 60 per cent in cargo tanks which have previously carried other cargoes.

   Before their reuse for the transport of hydrogen peroxide solutions, cargo tanks which have previously carried cargoes other than hydrogen peroxide must be inspected, cleaned and passivated. The procedures described in items 1) to 7) below for inspection and cleaning apply to stainless steel cargo tanks. The procedure for passivating stainless steel is described in item 8). Failing any other instructions, all the measures apply to cargo tanks and to all their structures which have been in contact with other cargoes.

   1) After unloading of the previous cargo, the cargo tank must be degassed and inspected for any remaining traces, carbon residues and rust

   2) The cargo tanks and their equipment must be washed with clear filtered water. The water used must be at least of the same quality as drinking water and have a low chlorine content

   3) Traces of the residues and vapours of the previous cargo must be removed by the steam cleaning of the cargo tanks and their equipment

   4) The cargo tanks and their equipment must then be rewashed with clear water of the quality specified in item 2) above and dried in filtered, oil-free air

   5) Samples must be taken of the atmosphere in the cargo tanks and these must be analysed for their content of organic gases and oxygen

   6) The cargo tank must be reinspected for any traces of the previous cargo, carbon residues or rust or odours of the previous cargo

   7) If the inspection and the other measures point to the presence of traces of the previous cargo or of its gases, the measures described in items 2) to 4) above must be repeated

   8) Stainless steel cargo tanks and their structures which have contained cargoes other than hydrogen peroxide solutions and which have been repaired must, regardless whether or not they have previously been passivated, be cleaned and passivated in accordance with the following procedure:

      - the new weld seams and other repaired parts must be cleaned and scrubbed with stainless steel brushes, graving tools, sandpaper and polishers. Rough surfaces must be made smooth and a final polishing must be carried out
      - fatty and oily residues must be removed with the use of organic solvents or appropriate cleaning products diluted with water. The use of chlorinated products shall be avoided because these might seriously interfere with the passivation procedure
      - any residues that have been removed must be eliminated and the tanks must then be washed.

k) During the transfer of the hydrogen peroxide solutions, the related piping system must be separated from all other systems. Loading and unloading piping used for the transfer of hydrogen peroxide solutions must be marked as follows:

   "For Hydrogen Peroxide

   Solution Transfer only"

l) If the temperature in the cargo tanks rises above 35°C, visible and audible alarms shall activate in the wheelhouse.

Note 3: **SERVICING REQUIREMENTS: MASTER (Item m)**

m) If the temperature rise exceeds 4°C for 2 hours or if the temperature in the cargo tanks exceeds 40°C, the master must contact the consignor directly, with a view to taking any action that might be necessary.

Note 4: **SERVICING REQUIREMENTS: FILLER (Items n and o)**

n) Hydrogen peroxide solutions must be stabilized to prevent decomposition. The manufacturer must provide a stabilization certificate which must be carried on board and must specify:

   1) The disintegration date of the stabilizer and the duration of its effectiveness

   2) Actions to be taken should the product become unstable during the voyage.

o) Only those hydrogen peroxide solutions which have a maximum decomposition rate of 1,0 per cent per year at 25°C may be carried. A certificate from the filler stating that the product meets this standard must be presented to the master and kept on board.

An authorized representative of the manufacturer must be on board to monitor the transfer operations and to test the stability of the hydrogen peroxide solutions to be transported. He shall certify to the master that the cargo has been loaded in a stable condition.

2.20.34 Additional requirement / remark 34

For type N carriage, the flanges and stuffing boxes of the loading and unloading piping must be fitted with a protection device to protect against splashing.

2.20.35 Additional requirement / remark 35

Only an indirect system for the cargo refrigerating system is permitted for this substance. Direct or combined systems are not permitted.

2.20.36 Additional requirement / remark 36

Merged with remark 35.

2.20.37 Additional requirement / remark 37

For this substance, the cargo tank system shall be capable of resisting the vapour pressure of the cargo at higher ambient temperatures whatever the system that has been adopted for treating the boil-off gas.

2.20.38 Additional requirement / remark 38

When the initial melting point of these mixtures in accordance with standard ASTM D86-01 is above 60°C, the transport requirements for packing group II are applicable.

2.20.39 Additional requirement / remark 39

a) The joints, outlets, closing devices and other technical equipment shall be of such a sort that there cannot be any leakage of carbon dioxide during normal transport operations (cold, fracturing of materials, freezing of fixtures, run-off outlets etc.).

b) The loading temperature (at the loading station) shall be mentioned in the transport document.

c) An oxygen meter shall be kept on board, together with instructions on its use which can be read by everyone on board. The oxygen meter shall be used as a testing device when entering holds, pump rooms, areas situated at depth and when work is being carried out on board.

d) At the entry of accommodation and in other places where the crew may spend time there shall be a measuring device which lets off an alarm when the oxygen level is too low or when the CO_2 level is too high.

e) The loading temperature (established after loading) and the maximum duration of the journey shall be mentioned in the transport document.

2.20.40 Additional requirement / remark 40

Deleted.

2.20.41 Additional requirement / remark 41

n-BUTYLBENZENE is assigned to the entry UN No. 2709 BUTYLBENZENES (n-BUTYLBENZENE).

2.20.42 Additional requirement / remark 42

Loading of refrigerated liquefied gases shall be carried out in such a manner as to ensure that unsatisfactory temperature gradients do not occur in any cargo tank, piping or other ancillary equipment. When determining the holding time, it shall be assured that the degree of filling does not exceed 98% in order to prevent the safety valves from opening when the tank is in liquid full condition. When refrigerated liquefied gases are carried using a system according to Ch 3, Sec 2, [5.1.1], item 2) or item 3), a refrigeration system is not required.

2.20.43 Additional requirement / remark 43

It may be that the mixture has been classified as a floater as a precautionary measure, because some of its components meet the relevant criteria.

2.20.44 Additional requirement / remark 44

A substance shall only be assigned to this entry where there is measurement data or verified information in accordance with IEC 60079-20-1 or equivalent that allows for an assignment to subgroup II B3, II B2 or II B1 of explosion group II B or explosion group II A.

2.20.45 Additional requirement / remark 45

When this substance is received from seagoing vessels as waste related to the operation of the vessel, appropriate measures shall taken on board the vessels to avoid or minimise, to the extent possible, the exposure of personnel on board to gas/air mixtures escaping from the cargo tanks of the receiving vessel during loading and to ensure the protection of personnel on board during such activities. Appropriate personal protective equipment shall be made available to the employees in question and shall be worn for the duration of the increased exposure.

Table 2 : List of dangerous goods

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1005	AMMONIA, ANHYDROUS	2	2TC		2.3+8+N1	G	1	1	3		91		1	no	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	1; 2; 31
1010	BUTADIENES (1,2-BUTADIENE), STABILIZED	2	2F		2.1+unst.	G	1	1			91		1	no	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	2; 3; 31
1010	BUTADIENES (1,3-BUTADIENE), STABILIZED	2	2F		2.1+unst.+CMR	G	1	1			91		1	no	T2 **(12)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	2; 3; 31
1010	BUTADIENE STABILIZED or BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED, having a vapour pressure at 70°C not exceeding 1.1 MPa (11 bar) and a density at 50°C not lower than 0.525 kg/l (contains less than 0,1% 1.3-butadiene)	2	2F		2.1+unst.	G	1	1			91		1	no	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	2; 3; 31
1010	BUTADIENE STABILIZED or BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED, having a vapour pressure at 70°C not exceeding 1.1 MPa (11 bar) and a density at 50°C not lower than 0.525 kg/l (with 0,1% or more 1.3-butadiene)	2	2F		2.1+unst.+CMR	G	1	1			91		1	no	T2 **(12)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	2; 3; 31
1010	1,2-BUTADIENE, STABILIZED, REFRIGERATED	2	3F		2.1+unst.	G	2	4	1; 3		95		1	no	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	2; 3; 31
1010	1,3-BUTADIENE, STABILIZED, REFRIGERATED	2	3F		2.1+unst.+CMR	G	2	4	1; 3		95		1	no	T2 **(12)**	II B2	yes	PP, EP, EX, TOX, A	1	2; 3; 31

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1010	BUTADIENES STABILIZED or BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED, REFRIGERATED, having a vapour pressure at 70 °C not exceeding 1.1 MPa (11 bar) and a density at 50 °C not lower than 0.525 kg/l (contains less than 0.1% 1.3-butadiene)	2	3F		2.1+unst.	G	2	4	1; 3		95		1	no	T2 **(12)**	II B2	yes	PP, EX, A	1	2; 3; 31
1010	BUTADIENES, STABILIZED or BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED, REFRIGERATED, having a vapour pressure at 70° C not exceeding 1.1 MPa (11 bar) and a density at 50° C not lower than 0.525 kg/l, (with 0.1% or more 1.3-butadiene)	2	3F		2.1+unst.+CMR	G	2	4	1; 3		95		1	no	T2 **(12)**	II B2	yes	PP, EP, EX, TOX, A	1	2; 3; 31
1011	BUTANE (contains less than 0,1% 1.3-butadiene)	2	2F		2.1	G	1	1			91		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 31
1011	BUTANE (with 0,1% or more 1.3-butadiene)	2	2F		2.1+CMR	G	1	1			91		1	no	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	1	2; 31
1011	BUTANE, REFRIGERATED, (contains less than 0.1% 1.3-butadiene)	2	3F		2.1	G	2	4	1; 3		95		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 31
1011	BUTANE, REFRIGERATED, (with 0.1% or more 1.3-butadiene)	2	3F		2.1+CMR	G	2	4	1; 3		95		1	no	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	1	2; 31
1012	1-BUTYLENE	2	2F		2.1	G	1	1			91		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 31
1012	1-BUTYLENE, REFRIGERATED	2	3F		2.1	G	2	4	1; 3		95		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 31
1020	CHLOROPENTAFLUORO-ETHANE (refrigerant gas R 115)	2	2A		2.2	G	1	1			91		1	no			no	PP	0	31

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1020	CHLOROPENTAFLUORO-ETHANE, REFRIGERATED, (REFRIGERANT GAS R 115)	2	3A		2.2	G	2	4	1; 3		95		1	no			no	PP	0	31
1030	1,1-DIFLUOROETHANE (REFRIGERANT GAS R 152a)	2	2F		2.1	G	1	1			91		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1030	1,1-DIFLUOROETHANE, REFRIGER-ATED, (REFRIGERANT GAS R 152a)	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1033	DIMETHYL ETHER	2	2F		2.1	G	1	1			91		1	no	T3	II B	yes	PP, EX, A	1	2; 31
1033	DIMETHYL ETHER, REFRIGERATED	2	3F		2.1	G	2	4	1; 3		95		1	no	T3	II B2	yes	PP, EX, A	1	2; 31
1038	ETHYLENE, REFRIGERATED LIQUID	2	3F		2.1	G	1	1	1		95		1	no	T1 **(12)**	II B	yes	PP, EX, A	1	2; 31; 42
1038	ETHYLENE, REFRIGERATED LIQUID	2	3F		2.1	G	1	1	1		95		1	no	T1 **(12)**	II B3	yes	PP, EX, A	1	2; 31; 42
1038	ETHYLENE, REFRIGERATED LIQUID	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II B3	yes	PP, EX, A	1	2; 31; 42
1040	ETHYLENE OXIDE WITH NITROGEN up to a total pressure of 1 MPa (10 bar) at 50°C	2	2TF		2.3+2.1	G	1	1			91		1	no	T2 **(12)**	II B	yes	PP, EP, EX, TOX, A	2	2; 3; 11; 31
1055	ISOBUTYLENE	2	2F		2.1	G	1	1			91		1	no	T2 **(1)** **(12)**	II A	yes	PP, EX, A	1	2; 31
1055	ISOBUTYLENE, REFRIGERATED	2	3F		2.1	G	2	4	1; 3		95		1	no	T2 **(1)** **(12)**	II A	yes	PP, EX, A	1	2; 31
1063	METHYL CHLORIDE (REFRIGERANT GAS R 40)	2	2F		2.1	G	1	1			91		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1063	METHYL CHLORIDE, REFRIGERATED (REFRIGERANT GAS R 40)	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1077	PROPYLENE	2	2F		2.1	G	1	1			91		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1077	PROPYLENE, REFRIGERATED	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1083	TRIMETHYLAMINE, ANHYDROUS	2	2F		2.1	G	1	1			91		1	no	T4	II A	yes	PP, EX, A	1	2; 31
1086	VINYL CHLORIDE, STABILIZED	2	2F		2.1+unst.	G	1	1			91		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 3; 13; 31
1086	VINYL CHLORIDE, STABILIZED, REFRIGERATED	2	3F		2.1+unst.	G	2	4	1; 3		95		1	no	T2 **(12)**	II A	yes	PP, EX, A	1	2; 3; 13; 31
1088	ACETAL	3	F1	II	3	N	2	2		10	97	0.83	3	yes	T3	II B **(4)**	yes	PP, EX, A	1	
1089	ACETALDEHYDE (ethanal)	3	F1	I	3+N3	C	1	1			95	0.78	1	yes	T4	II A	yes	PP, EX, A	1	
1090	ACETONE	3	F1	II	3	N	2	2		10	97	0.79	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1092	ACROLEINE, STABILIZED	6.1	TF1	I	6.1+3+unst.+ N1	C	2	2	3	50	95	0.84	1	no	T3 **(2)**	II B	yes	PP, EP, EX, TOX, A	2	2; 3; 5; 23
1093	ACRYLONITRILE, STABILIZED	3	FT1	I	3+6.1+unst.+ N2+CMR	C	2	2	3	50	95	0.8	1	no	T1 **(12)**	II B	yes	PP, EP, EX, TOX, A	2	3; 5; 23
1098	ALLYL ALCOHOL	6.1	TF1	I	6.1+3+N1	C	2	2		40	95	0.85	1	no	T2 **(12)**	II B	yes	PP, EP, EX, TOX, A	2	
1100	ALLYL CHLORIDE	3	FT1	I	3+6.1+N1	C	2	2	3	50	95	0.94	1	no	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	23
1105	PENTANOLS (n- PENTANOL)	3	F1	III	3	N	3	2			97	0.81	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1106	AMYLAMINE (n-AMYLAMINE)	3	FC	II	3+8	C	2	2		40	95	0.76	2	yes	T4 **(3)**	II A **(6)**	yes	PP, EP, EX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1107	AMYL CHLORIDES (l-CHLOROPEN-TANE)	3	F1	II	3	C	2	2		40	95	0.88	2	yes	T3	II A	yes	PP, EX, A	1	
1107	AMYL CHLORIDES (1-CHLORO-3-METHYLBUTANE)	3	F1	II	3	C	2	2		45	95	0.89	2	yes	T3	II A	yes	PP, EX, A	1	
1107	AMYL CHLORIDES (2-CHLORO-2-METHYLBUTANE)	3	F1	II	3	C	2	2		50	95	0.87	2	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1107	AMYL CHLORIDES (1-CHLORO-2,2-DIMETHYL- PROPANE)	3	F1	II	3	C	2	2		50	95	0.87	2	yes	T3 **(2)**	II A	yes	PP, EX, A	1	
1107	AMYL CHLORIDES	3	F1	II	3	C	1	1			95	0.9	1	yes	T3 **(2)**	II A	yes	PP, EX, A	1	27
1108	1-PENTENE (n-amylene)	3	F1	I	3+N3	N	1	1			97	0.64	1	yes	T3	II B **(4)**	yes	PP, EX, A	1	
1114	BENZENE	3	F1	II	3+N3+CMR	C	2	2	3	50	95	0.88	2	yes	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	1	6:+10°C; 17; 23
1120	BUTANOLS (tert- BUTYLALCOHOL)	3	F1	II	3	N	2	2	2	10	97	0.79	3	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	1	7; 17
1120	BUTANOLS (sec-BUTYLALCOHOL)	3	F1	III	3	N	3	2			97	0.81	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1120	BUTANOLS (n- BUTYL ALCOHOL)	3	F1	III	3	N	3	2			97	0.81	3	yes	T2 **(12)**	II B	yes	PP, EX, A	0	
1123	BUTYL ACETATES (sec-BUTYLACETATE)	3	F1	II	3	N	2	2		10	97	0.86	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	1	
1123	BUTYL ACETATES (n-BUTYL ACETATE)	3	F1	III	3+N3	N	3	2			97	0.86	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1125	n-BUTYLAMINE	3	FC	II	3+8+N3	C	2	2	3	50	95	0.75	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	23

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1127	CHLOROBUTANES (1-CHLOROBU-TANE)	3	F1	II	3	C	2	2	3	50	95	0.89	2	yes	T3	II A	yes	PP, EX, A	1	23
1127	CHLOROBUTANES (2-CHLOROBU-TANE)	3	F1	II	3	C	2	2	3	50	95	0.87	2	yes	T3	II A	yes	PP, EX, A	1	23
1127	CHLOROBUTANES (1-CHLORO-2-METHYLPROPANE)	3	F1	II	3	C	2	2	3	50	95	0.88	2	yes	T3	II A	yes	PP, EX, A	1	23
1127	CHLOROBUTANES (2-CHLORO-2-METHYL- PROPANE)	3	F1	II	3	C	2	2	3	50	95	0.84	2	yes	T1 **(12)**	II A	yes	PP, EX, A	1	23
1127	CHLOROBUTANES	3	F1	II	3	C	1	1			95	0.89	1	yes	T4 **(3)**	II A	yes	PP, EX, A	1	27
1129	BUTYRALDEHYDE (n-BUTYRALDE-HYDE)	3	F1	II	3+N3	C	2	2	3	50	95	0.8	2	yes	T4	II A	yes	PP, EX, A	1	15; 23
1131	CARBON DISULPHIDE	3	FT1	I	3+6.1+N2	C	2	2	3	50	95	1.26	1	no	T6	II C	yes	PP, EP, EX, TOX, A	2	2; 9; 23
1134	CHLOROBENZENE (phenyl chloride)	3	F1	III	3+N2+S	C	2	2		30	95	1.11	2	yes	T1 **(12)**	II A **(7)**	yes	PP, EX, A	0	
1135	ETHYLENE CHLOROHYDRIN (2-CHLO-ROETHANOL)	6.1	TF1	I	6.1+3+N3	C	2	2		30	95	1.21	1	no	T2 **(12)**	II A **(7)**	yes	PP, EP, EX, TOX, A	2	
1143	CROTONALDEHYDE, STABILIZED	6.1	TF1	I	6.1+3+unst.+ N1	C	2	2		40	95	0.85	1	no	T3	II B	yes	PP, EP, EX, TOX, A	2	3; 5; 15
1145	CYCLOHEXANE	3	F1	II	3+N1	C	2	2	3	50	95	0.78	2	yes	T3	II A	yes	PP, EX, A	1	6:+11°C; 17
1146	CYCLOPENTANE	3	F1	II	3+N2	N	2	3		10	97	0.75	3	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1148	DIACETONE ALCOHOL	3	F1	III	3	N	3	2			97	0.93	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1150	1,2-DICHLOROETHYLENE (cis-1,2-DICHLOROETHYLENE)	3	F1	II	3+N2	C	2	2	3	50	95	1.28	2	yes	T2 **(1)** **(12)**	II A	yes	PP, EX, A	1	23
1150	1,2-DICHLOROETHYLENE (trans-1,2-DICHLOROETHYLENE)	3	F1	II	3+N2	C	2	2	3	50	95	1.26	2	yes	T2 **(12)**	II A	yes	PP, EX, A	1	23
1153	ETHYLENE GLYCOL DIETHYL ETHER	3	F1	III	3	N	3	2			97	0.84	3	yes	T4	II B	yes	PP, EX, A	0	
1154	DIETHYLAMINE	3	FC	II	3+8+N3	C	2	2	3	50	95	0.7	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	23
1155	DIETHYL ETHER	3	F1	I	3	C	1	1			95	0.71	1	yes	T4	II B	yes	PP, EX, A	1	
1157	DIISOBUTYL KETONE	3	F1	III	3+N3+F	N	3	3			97	0.81	3	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	0	
1159	DIISOPROPYL ETHER	3	F1	II	3+N2	C	2	2	3	50	95	0.72	2	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1160	DIMETHYLAMINE AQUEOUS SOLUTION	3	FC	II	3+8+N3	C	2	2	3	50	95	0.82	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	23
1163	DIMETHYLHYDRAZINE, UNSYMMETRICAL	6.1	TFC	I	6.1+3+8+N2+CMR	C	2	2	3	50	95	0.78	1	no	T3	II B (II B1)	yes	PP, EP, EX, TOX, A	2	23
1165	DIOXANE	3	F1	II	3	N	2	2		10	97	1.03	3	yes	T2 **(12)**	II B	yes	PP, EX, A	1	6:+14°C; 17
1167	DIVINYL ETHER, STABILIZED	3	F1	I	3+unst.	C	1	1			95	0.77	1	yes	T2 **(12)**	II B	yes	PP, EX, A	1	2; 3
1170	ETHANOL (ETHYL ALCOHOL) or ETHANOL SOLUTION (ETHYL ALCOHOL SOLUTION), aqueous solution with more than 70% alcohol by volume	3	F1	II	3	N	2	2		10	97	0.79 - 0.87	3	yes	T2 **(12)**	II B	yes	PP, EX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1170	ETHANOL SOLUTION (ETHYL ALCOHOL SOLUTION), aqueous solution with more than 24% and not more than 70% alcohol by volume	3	F1	III	3	N	3	2			97	0.87 - 0.96	3	yes	T2 **(12)**	II B	yes	PP, EX, A	0	
1171	ETHYLENE GLYCOL MONOETHYL ETHER	3	F1	III	3+CMR	N	2	3	3	10	97	0.93	3	yes	T3	II B	yes	PP, EP, EX, TOX, A	0	
1172	ETHYLENE GLYCOL MONOETHYL ETHER ACETATE	3	F1	III	3+N3+CMR	N	2	3	3	10	97	0.98	3	yes	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	0	
1173	ETHYL ACETATE	3	F1	II	3	N	2	2		10	97	0.9	3	yes	T1	II A	yes	PP, EX, A	1	
1175	ETHYLBENZENE	3	F1	II	3+N3	N	2	2		10	97	0.87	3	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1177	2-ETHYLBUTYL ACETATE	3	F1	III	3	N	3	2			97	0.88	3	yes	T3	II A **(6)**	yes	PP, EX, A	0	
1179	ETHYL BUTYL ETHER (ETHYL tert-BUTYL ETHER)	3	F1	II	3+N3	N	2	2		10	97	0.74	3	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1184	ETHYLENE DICHLORIDE (1,2-dichloroethane)	3	FT1	II	3+6.1+CMR	C	2	2		50	95	1.25	2	no	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	
1188	ETHYLENE GLYCOL MONOMETHYL ETHER	3	F1	III	3+CMR	N	2	3	3	10	97	0.97	3	yes	T3	II B (II B2)	yes	PP, EP, EX, TOX, A	0	
1191	OCTYL ALDEHYDES (2-ETHYLCAPRONALDEHYDE)	3	F1	III	3+N3+F	C	2	2		30	95	0.82	2	yes	T4	II A **(6)**	yes	PP, EX, A	0	
1191	OCTYL ALDEHYDES (n-OCTALDEHYDE)	3	F1	III	3+N3+F	N	3	3			97	0.82	3	yes	T3	II A	yes	PP, EX, A	0	
1193	ETHYL METHYL KETONE (methyl ethyl ketone)	3	F1	II	3	N	2	2		10	97	0.8	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1198	FORMALDEHYDE SOLUTION, FLAMMABLE	3	FC	III	3+8+N3	N	3	2			97	1.09	3	yes	T2 **(12)**	II B	yes	PP, EP, EX, A	0	34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1199	FURALDEHYDES (a-FURALDEHYDE) or FURFURALDEHYDES (a-FURFURYL-ALDEHYDE)	6.1	TF1	II	6.1+3	C	2	2		25	95	1.16	2	no	T3 **(2)**	II B	yes	PP, EP, EX, TOX, A	2	15
1202	GAS OIL complying with standard EN 590:2009 + A1:2010 or DIESEL FUEL or HEATING OIL (LIGHT) with flash- point as specified in EN 590:2009 + A1:2010	3	F1	III	3+N2+F	N	4	3			97	0.82 - 0.85	3	yes			no	PP	0	
1202	GAS OIL or DIESEL FUEL or HEATING OIL (LIGHT) (flash-point not more than 60°C)	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97	< 0,85	3	yes			no	PP	0	22
1202	GAS OIL or DIESEL FUEL or HEATING OIL (LIGHT) (flash-point more than 60°C but not more than 100°C)	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	4	2			97	< 1,1	3	yes			no	PP	0	22
1203	MOTOR SPIRIT or GASOLINE or PETROL	3	F1	II	3+N2+CMR+F	N	2	3	3	10	97	0.68 - 0.72 **(9)**	3	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	
1203	MOTOR SPIRIT or GASOLINE or PETROL, WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+N2+CMR+F	C	1	1			95		1	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	
1203	MOTOR SPIRIT or GASOLINE or PETROL WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+N2+CMR+F	C	2	2	3	50	95		2	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	23
1203	MOTOR SPIRIT or GASOLINE or PETROL WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+N2+CMR+F	C	2	2		50	95		2	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1203	MOTOR SPIRIT or GASOLINE or PETROL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+N2+CMR+F	C	2	2		35	95		2	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	
1206	HEPTANES	3	F1	II	3+N1	C	2	2	3	50	95	0.67 - 0,70	2	yes	T3	II A	yes	PP, EX, A	1	
1208	HEXANES	3	F1	II	3+N2	N	2	3		50	97	0.65 - 0.70	2	yes	T3	II A	yes	PP, EX, A	1	
1208	HEXANES	3	F1	II	3+N2	N	2	3	3	10	97	0.65 - 0.70	3	yes	T3	II A	yes	PP, EX, A	1	
1212	ISOBUTANOL (isobutyl alcohol)	3	F1	III	3	N	3	2			97	0.8	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1213	ISOBUTYLACETATE	3	F1	II	3+N3	N	2	2		10	97	0.87	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	1	
1214	ISOBUTYLAMINE	3	FC	II	3+8+N3	C	2	2	3	50	95	0.73	2	yes	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, A	1	23
1216	ISOOCTENES	3	F1	II	3+N2	N	2	3		10	97	0.73	3	yes	T3	II B1	yes	PP, EX, A	1	
1218	ISOPRENE, STABILIZED	3	F1	I	3+unst.+N2+ CMR	N	1	1			95	0.68	1	yes	T3	II B	yes	PP, EP, EX, TOX, A	1	2; 3; 5; 16
1219	ISOPROPANOL (isopropyl alcohol)	3	F1	II	3	N	2	2		10	97	0.78	3	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1220	ISOPROPYLE ACETATE	3	F1	II	3	N	2	2		10	97	0.88	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	1	
1221	ISOPROPYLAMINE	3	FC	I	3+8+N3	C	1	1			95	0.69	1	yes	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1223	KEROSENE	3	F1	III	3+N2+F	N	3	3			97	≤ 0.83	3	yes	T3	II A **(6)**	yes	PP, EX, A	0	14
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 29; 44
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1224	KETONES, LIQUID, N.O.S. Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1224	KETONES, LIQUID, N.O.S. Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1229	MESITYL OXYDE	3	F1	III	3	N	3	2			97	0.85	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1230	METHANOL	3	FT1	II	3+6.1	N	2	2	3	50	95	0.79	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	1	23
1231	METHYL ACETATE	3	F1	II	3	N	2	2		10	97	0.93	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1235	METHYLAMINE, AQUEOUS SOLUTION	3	FC	II	3+8+N3	C	2	2		50	95		2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	
1243	METHYL FORMATE	3	F1	I	3	C	1	1			95	0.97	1	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1244	METHYLHYDRAZINE	6.1	TFC	I	6.1+3+8	C	2	2		45	95	0.88	1	no	T4	II C **(5)**	yes	PP, EP, EX, TOX, A	2	
1245	METHYL ISOBUTYL KETONE	3	F1	II	3	N	2	2		10	97	0.8	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1247	METHYL METHACRYLATE MONOMER, STABILIZED	3	F1	II	3+unst.+N3	C	2	2		40	95	0.94	1	yes	T2 **(12)**	II A	yes	PP, EX, A	1	3; 5; 16
1262	OCTANES	3	F1	II	3+N1	C	2	2		45	95	0.69 - 0.71	2	yes	T3	II A	yes	PP, EX, A	1	
1264	PARALDEHYDE	3	F1	III	3	N	3	2			97	0.99	3	yes	T3	II A **(6)**	yes	PP, EX, A	0	6:+16°C; 17

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1265	PENTANES, liquid (2- METHYLBUTANE)	3	F1	I	3+N2	N	1	1			97	0.62	1	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
1265	PENTANES, liquid (n-PENTANE)	3	F1	II	3+N2	N	2	3		50	97	0.63	3	yes	T3	II A	yes	PP, EX, A	1	
1265	PENTANES, liquid (n-PENTANE)	3	F1	II	3+N2	N	2	3	3	10	97	0.63	3	yes	T3	II A	yes	PP, EX, A	1	
1265	PENTANES, liquid Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3 + N2	N	1	1			95		1	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3 + N2	N	2	3	1	50	95		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3 + N2	N	2	3		50	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3 + N2	N	2	3	3	10	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with vp50 < 110 kPa	3	F1	I	3 + N2	N	2	3		10	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3 + N2	N	1	1			95		1	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3 + N2	N	2	3	1	50	95		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3 + N2	N	2	3		50	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3 + N2	N	2	3	3	10	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1265	PENTANES, liquid Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3 + N2	N	2	3		10	97		3	yes	T4	II A	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	43

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	23; 38
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	III	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 38; 44

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING ≤ 85°C	3	F1	III	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 38; 44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	III	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	III	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kP a≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1267	PETROLEUM CRUDE OIL Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1267	PETROLEUM CRUDE OIL Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	43; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	23; 38; 44
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S, WITH MORE THAN 10% BENZENE, 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S, WITH MORE THAN 10% BENZENE, INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 43; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S, WITH MORE THAN 10% BENZENE, 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1268	PETROLEUM DISTILLATES, N.O.S. WITH MORE THAN 10% BENZENE or PETROLEUM PRODUCTS, N.O.S, WITH MORE THAN 10% BENZENE, INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. (NAPHTHA) 110 kPa < vp50 ≤ 175 kPa	3	F1	II	3+N2+CMR+F	N	2	3		50	97	0.735	3	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	14
1268	PETROLEUM DISTILLATES; N.O.S or PETROLEUM PRODUCTS, N.O.S. (NAPHTHA) 110 kPa < vp50 ≤ 150 kPa	3	F1	II	3+N2+CMR+F	N	2	3	3	10	97	0.735	3	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	14
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. (NAPHTHA) vp50 ≤ 110 kPa	3	F1	II	3+N2+CMR+F	N	2	3		10	97	0.735	3	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	14

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1268	PETROLEUM DISTILLATES, N.O.S, or PETROLEUM PRODUCTS, N.O.S. (BEN-ZENE HEART CUT) vp50 ≤ 110 kPa	3	F1	II	3+N2+CMR+F	N	2	3		10	97	0.765	3	yes	T3	II A	yes	PP, EP, EX, TOX, A	1	14
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa ≤ vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa ≤ vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1268	PETROLEUM DISTILLATES, N.O.S or PETROLEUM PRODUCTS, N.O.S. Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1274	n-PROPANOL (propyl alcohol, normal)	3	F1	II	3	N	2	2		10	97	0.8	3	yes	T2 **(12)**	II B (II B1)	yes	PP, EX, A	1	
1274	n-PROPANOL (propyl alcohol, normal)	3	F1	III	3	N	3	2			97	0.8	3	yes	T2 **(12)**	II B (II B1)	yes	PP, EX, A	0	
1275	PROPIONALDEHYDE	3	F1	II	3+N3	C	2	2	3	50	95	0.81	2	yes	T4	II B (II B2)	yes	PP, EX, A	1	15; 23
1276	n-PROPYL ACETATE	3	F1	II	3+N3	N	2	2		10	97	0.88	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1277	PROPYLAMINE (1-aminopropane)	3	FC	II	3+8	C	2	2	3	50	95	0.72	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	23
1278	1-CHLOROPROPANE (propyl chloride)	3	F1	II	3	C	2	2	3	50	95	0.89	2	yes	T1 **(12)**	II A	yes	PP, EX, A	1	23

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1279	1,2-DICHLOROPROPANE or PROPYL DICHLORIDE	3	F1	II	3+N2	C	2	2		45	95	1.16	2	yes	T1 **(12)**	II A **(7)**	yes	PP, EX, A	1	
1280	PROPYLENE OXIDE	3	F1	I	3+unst.+N3+CMR	C	1	1			95	0.83	1	yes	T2 **(12)**	II B (II B3)	yes	PP, EP, EX, TOX, A	1	2; 12; 31
1282	PYRIDINE	3	F1	II	3+N3	N	2	2		10	97	0.98	3	yes	T1 **(12)**	II A **(7)**	yes	PP, EX, A	1	
1289	SODIUM METHYLATE SOLUTION in alcohol	3	FC	III	3+8	N	3	2			97	0.969	3	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	0	34
1294	TOLUENE	3	F1	II	3+N3	N	2	2		10	97	0.87	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1296	TRIETHYLAMINE	3	FC	II	3+8+N3	C	2	2		50	95	0.73	2	yes	T3	II A **(7)**	yes	PP, EP, EX, A	1	
1300	TURPENTINE SUBSTITUTE	3	F1	III	3+N2+F	N	3	3			97	0.78	3	yes	T3	II B **(4)**	yes	PP, EX, A	0	
1301	VINYL ACETATE, STABILIZED	3	F1	II	3+unst.+N3	N	2	2		10	97	0.93	2	yes	T2 **(12)**	II A	yes	PP, EX, A	1	3; 5; 16
1307	XYLENES (o- XYLENE)	3	F1	III	3+N2	N	3	3			97	0.88	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	
1307	XYLENES (m- XYLENE)	3	F1	III	3+N2	N	3	3			97	0.86	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	
1307	XYLENES (p- XYLENE)	3	F1	III	3+N2	N	3	3	2		97	0.86	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	6:+17°C; 17
1307	XYLENES (mixture with melting point ≤ 0°C)	3	F1	II	3+N2	N	3	3			97		3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1307	XYLENES (mixture with melting point ≤ 0°C)	3	F1	III	3+N2	N	3	3			97		3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1307	XYLENES (mixture with 0°C < melting point < 13°C)	3	F1	III	3+N2	N	3	3	2		97		3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	6:+17°C; 17
1541	ACETONE CYANOHYDRIN, STABILIZED	6.1	T1	I	6.1+unst.+N1	C	2	2		50	95	0.932	1	no			no	PP, EP, TOX, A	2	3
1545	ALLYL ISOTHIOCYANATE, STABILIZED	6.1	TF1	II	6.1+3+unst.	C	2	2		30	95	1.02	1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	2; 3
1547	ANILINE	6.1	T1	II	6.1+N1	C	2	2		25	95	1.02	2	no			no	PP, EP, TOX, A	2	
1578	CHLORONITROBENZENES, SOLID, MOLTEN (p-CHLORONITROBENZENE)	6.1	T2	II	6.1+N2+S	C	2	1	2	25	95	1.37	2	no	T1 **(12)**	II B (II B3 **(11)**)	yes	PP, EP, EX, TOX, A	2	7; 17; 26
1578	CHLORONITROBENZENES, SOLID, MOLTEN (p-CHLORONITROBENZENE)	6.1	T2	II	6.1+N2+S	C	2	1	4	25	95	1.37	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+112°C; 26
1591	o-DICHLOROBENZENE	6.1	T1	III	6.1+N1+S	C	2	2		25	95	1.32	2	no			no	PP, EP, TOX, A	0	
1593	DICHLOROMETHANE (methyl chloride)	6.1	T1	III	6.1	C	2	2	3	50	95	1.33	2	no			no	PP, EP, TOX, A	0	23
1594	DIETHYL SULPHATE	6.1	T1	II	6.1+N2+CMR	C	2	2		25	95	1.18	2	no			no	PP, EP, TOX, A	2	
1595	DIMETHYL SULPHATE	6.1	TC1	I	6.1+8+N3+CMR	C	2	2		25	95	1.33	1	no			no	PP, EP, TOX, A	2	
1604	ETHYLENEDIAMINE	8	CF1	II	8+3+N3	N	3	2			97	0.9	3	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	6:+12°C; 17; 34
1605	ETHYLENE DIBROMIDE	6.1	T1	I	6.1+N2+CMR	C	2	2		30	95	2.18	1	no			no	PP, EP, TOX, A	2	6:+14°C; 17

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1648	ACETONITRILE (methyl cyanide)	3	F1	II	3	N	2	2		10	97	0.78	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1662	NITROBENZENE	6.1	T1	II	6.1+N2	C	2	2	2	25	95	1.21	2	no	T1 **(12)**	II B	yes	PP, EP, EX, TOX, A	2	6:+10°C; 17
1663	NITROPHENOLS	6.1	T2	III	6.1+N3+S	C	2	2	2	25	95		2	no	T1 **(12)**	II B (II B3 **(11)**)	yes	PP, EP, EX, TOX, A	0	7; 17
1663	NITROPHENOLS	6.1	T2	III	6.1+N3+S	C	2	2	4	25	95		2	no			no	PP, EP, TOX, A	0	7; 17; 20:+65°C
1664	NITROTOLUENES, LIQUID (o-NITRO-TOLUENE)	6.1	T1	II	6.1+N2+CMR+S	C	2	2		25	95	1.16	2	no			no	PP, EP, TOX, A	2	
1708	TOLUIDINES, LIQUID (o-TOLUIDINE)	6.1	T1	II	6.1+N1+CMR	C	2	2		25	95	1	2	no			no	PP, EP, TOX, A	2	
1708	TOLUIDINES, LIQUID (m-TOLUIDINE)	6.1	T1	II	6.1+N1	C	2	2		25	95	1.03	2	no			no	PP, EP, TOX, A	2	
1710	TRICHLOROETHYLENE	6.1	T1	III	6.1+N2+CMR	C	2	2		50	95	1.46	2	no			no	PP, EP, TOX, A	0	15
1715	ACETIC ANHYDRIDE	8	CF1	II	8+3	N	2	3		10	97	1.08	3	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	34
1717	ACETYL CHLORIDE	3	FC	II	3+8	C	2	2	3	50	95	1.1	2	yes	T2 **(12)**	II A **(7)**	yes	PP, EP, EX, A	1	23
1718	BUTYL ACIDE PHOSPHATE	8	C3	III	8+N3	N	4	3			97	0.98	3	yes			no	PP, EP	0	34
1719	CAUSTIC ALKALI LIQUID, N.O.S. vp50 ≤ 12.5 kPa	8	C5	II	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 30; 34
1719	CAUSTIC ALKALI LIQUID, N.O.S. vp50 > 12.5 kPa	8	C5	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 30; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1719	CAUSTIC ALKALI LIQUID, N.O.S.	8	C5	III	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 30; 34
1738	BENZYL CHLORIDE	6.1	TC1	II	6.1+8+3+N3+CMR+S	C	2	2		25	95	1.1	2	no	T1 **(12)**	II A **(7)**	yes	PP, EP, EX, TOX, A	2	
1742	BORON TRIFLUORIDE ACETIC ACID COMPLEX, LIQUID	8	C3	II	8	N	4	2			97	1.35	3	yes			no	PP, EP	0	34
1750	CHLORACETIC ACID SOLUTION	6.1	TC1	II	6.1+8+N1	C	2	2	2	25	95	1.58	2	no	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	7; 17
1750	CHLORACETIC ACID SOLUTION	6.1	TC1	II	6.1+8+N1	C	2	1	4	25	95	1.58	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+111°C; 26
1760	CORROSIVE LIQUID, N.O.S. (SODIUM MERCAPTOBENZOTHIAZOLE, 50% AQUEOUS SOLUTION)	8	C9	II	8+N1+F	C	2	2		40	95	1.25	2	yes			no	PP, EP	0	
1760	CORROSIVE LIQUID, N.O.S. (FATTY ALCOHOL, C12-C14)	8	C9	III	8+F	N	4	3			97	0.89	3	yes			no	PP, EP	0	34
1760	CORROSIVE LIQUID, N.O.S. (ETH-YLENEDIAMINE- TETRAACETIC ACID, TETRASODIUM SALT, 40% AQUEOUS SOLUTION)	8	C9	III	8+N2	N	4	3			97	1.28	3	yes			no	PP, EP	0	34
1760	CORROSIVE LIQUID, N.O.S. vp50≤12.5kPa	8	C9	I	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
1760	CORROSIVE LIQUID, N.O.S. vp50>12.5kPa	8	C9	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
1760	CORROSIVE LIQUID, N.O.S. vp50 ≤ 12.5 kPa	8	C9	II	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
1760	CORROSIVE LIQUID, N.O.S. vp50 > 12.5 kPa	8	C9	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1760	CORROSIVE LIQUID, N.O.S.	8	C9	III	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
1764	DICHLOROACETIC ACID	8	C3	II	8+N1	N	3	3			97	1.56	2	yes	T1 **(12)**	II A	yes	PP, EP, EX, A	0	6:+13°C; 17
1778	FLUOROSILICIC ACID	8	C1	II	8+N3	N	2	3		10	97		3	yes			no	PP, EP	0	34
1779	FORMIC ACID with more than 85% acid by mass	8	CF1	II	8+3+N3	N	2	3		10	97	1.22	3	yes	T1 **(12)**	II A	yes	PP, EP, EX, A	1	6:+12°C; 17; 34
1780	FUMARYL CHLORIDE	8	C3	II	8+N3	N	2	3		10	97	1.41	3	yes			no	PP, EP	0	8; 34
1783	HEXAMETHYLENEDIAMINE SOLUTION	8	C7	II	8+N3	N	3	2	2		97		3	yes	T4 **(3)**	II A	yes	PP, EP, EX, A	0	7; 17; 34
1783	HEXAMETHYLENEDIAMINE SOLUTION	8	C7	III	8+N3	N	3	2	2		97		3	yes	T3	II A	yes	PP, EP, EX, A	0	7; 17; 34
1789	HYDROCHLORIC ACID	8	C1	II	8	N	2	3		10	97		3	yes			no	PP, EP	0	34
1789	HYDROCHLORIC ACID	8	C1	III	8	N	4	3			97		3	yes			no	PP, EP	0	34
1805	PHOSPHORIC ACID, SOLUTION, WITH MORE THAN 80% (VOLUME) ACID	8	C1	III	8	N	4	3	2		95	> 1.6	3	yes			no	PP, EP	0	7; 17; 22; 34
1805	PHOSPHORIC ACID, SOLUTION, WITH 80% (VOLUME) ACID, OR LESS	8	C1	III	8	N	4	3			97	1.00 - 1.6	3	yes			no	PP, EP	0	22; 34
1814	POTASSIUM HYDROXIDE SOLUTION	8	C5	II	8+N3	N	4	2			97		3	yes			no	PP, EP	0	30; 34
1814	POTASSIUM HYDROXIDE SOLUTION	8	C5	III	8+N3	N	4	2			97		3	yes			no	PP, EP	0	30; 34
1823	SODIUM HYDROXIDE, SOLID	8	C6	II	8+N3	N	4	1	4		95	2.13	3	yes			no	PP, EP	0	7; 17; 34
1824	SODIUM HYDROXIDE SOLUTION	8	C5	II	8+N3	N	4	2			97		3	yes			no	PP, EP	0	30; 34
1824	SODIUM HYDROXIDE SOLUTION	8	C5	III	8+N3	N	4	2			97		3	yes			no	PP, EP	0	30; 34
1830	SULPHURIC ACID with more than 51% acid	8	C1	II	8+N3	N	4	3			97	1.4 - 1.84	3	yes			no	PP, EP	0	8; 22; 30; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1831	SULPHURIC ACID, FUMING	8	CT1	I	8+6.1	C	2	2		50	95	1.94	1	no			no	PP, EP, TOX, A	2	8
1832	SULPHURIC ACID, SPENT	8	C1	II	8	N	4	3			97		3	yes			no	PP, EP	0	8; 30; 34
1846	CARBON TETRACHLORIDE	6.1	T1	II	6.1+N2+S	C	2	2	3	50	95	1.59	2	no			no	PP, EP, TOX, A	2	23
1848	PROPIONIC ACID with not less than 10% and less than 90% acid by mass	8	C3	III	8+N3	N	3	3			97	0.99	3	yes			no	PP, EP	0	34
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	43
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	23; 38
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	43; 44

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 38; 44
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1863	FUEL, AVIATION, TURBINE ENGINE WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+F+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with vp50 < 110 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 <175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with vp50 < 110 kPa	3	F1	I	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 <175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point < 23°C with vp50 < 110 kPa	3	F1	II	3+(N1, N2, N3, CMR, F)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1863	FUEL, AVIATION, TURBINE ENGINE Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 44
1888	CHLOROFORM	6.1	T1	III	6.1+N2+CMR	C	2	2	3	50	95	1.48	2	no			no	PP, EP, TOX, A	0	23
1897	TETRACHLOROETHYLENE	6.1	T1	III	6.1+N2+S	C	2	2		50	95	1.62	2	no			no	PP, EP, TOX, A	0	
1912	METHYL CHLORIDE AND METHYLENE CHLORIDE MIXTURE	2	2F		2.1	G	1	1			91		1	no	T1 **(12)**	II A **(7)**	yes	PP, EX, A	1	2; 31

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1915	CYCLOHEXANONE	3	F1	III	3	N	3	2			97	0.95	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
1917	ETHYL ACRYLATE, STABILIZED	3	F1	II	3+unst.+N3	C	2	2		40	95	0.92	1	yes	T2 **(12)**	II B	yes	PP, EX, A	1	3; 5
1918	ISOPROPYLBENZENE (cumene)	3	F1	III	3+N2	N	3	3			97	0.86	3	yes	T2 **(12)**	II A **(7)**	yes	PP, EX, A	0	
1919	METHYL ACRYLATE, STABILIZED	3	F1	II	3+unst.+N3	C	2	2	3	50	95	0.95	1	yes	T2 **(12)**	II B	yes	PP, EX, A	1	3; 5; 23
1920	NONANES	3	F1	III	3+N2+F	N	3	3			97	0.70 - 0.75	3	yes	T3	II A	yes	PP, EX, A	0	
1922	PYRROLIDINE	3	FC	II	3+8	C	2	2		50	95	0.86	2	yes	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, A	1	
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE A)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE A0)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE A01)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE A02)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE A1)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE B)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE B1)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE B2)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., (MIXTURE C)	2	2F		2.1	G	1	1			91		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S.	2	3F		2.1 + CMR	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A, EP, TOX	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE A)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE A0)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE A01)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE A02)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE A1)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE B)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE B1)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE B2)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31
1965	HYDROCARBON GAS MIXTURE, REFRIGERATED, N.O.S., (MIXTURE C)	2	3F		2.1	G	2	4	1; 3		95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	2; 31

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1969	ISOBUTANE (contains less than 0.1% 1.3-butadiene)	2	2F		2.1	G	1	1			91		1	no	T2 **(1)** **(12)**	II A **(6)**	yes	PP, EX, A	1	2; 31
1969	ISOBUTANE (with 0.1% or more 1.3-butadiene)	2	2F		2.1+CMR	G	1	1			91		1	no	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	1	2; 31
1972	METHANE REFRIGERATED LIQUID or NATURAL GAS, REFRIGERATED LIQUEFIED, with high methane content	2	3F		2.1	G	1	1	1		95		1	no	T1 **(12)**	II A	yes	PP, EX; A	1	2; 31; 42
1972	METHANE, REFRIGERATED or NATURAL GAS, REFRIGERATED, with high methane content	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EX; A	1	2; 31; 42
1978	PROPANE	2	2F		2.1	G	1	1			91		1	no	T1 **(12)**	II A	yes	PP, EX, A	1	2; 31
1978	PROPANE, REFRIGERATED	2	3F		2.1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EX; A	1	2; 31
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. Initial boiling point ≤ 60°C	3	FT1	I	3+6.1+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 115°C < Initial boiling point	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 23; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 115°C < Initial boiling point	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 27
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. Initial boiling point ≤ 60°C	3	FT1	I	3+6.1+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 115°C < Initial boiling point	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 23; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 27; 44
1986	ALCOHOLS, FLAMMABLE, TOXIC, N.O.S. 115°C < Initial boiling point	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1987	ALCOHOLS, N.O.S. (tert-BUTANOL 90% (MASS)/METHANOL 10% (MASS) MIXTURE)	3	F1	II	3	N	2	2		10	97		3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
1987	ALCOHOLS, N.O.S. (CYCLOHEXANOL)	3	F1	III	3+N3+F	N	3	3	2		95	0.95	3	yes	T3	II A	yes	PP, EX, A	0	7; 17
1987	ALCOHOLS, N.O.S. (CYCLOHEXANOL)	3	F1	III	3+N3+F	N	3	3	4		95	0.95	3	yes			no	PP	0	7; 17; 20:+46°C
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	14; 22; 27
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1987	ALCOHOLS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1987	ALCOHOLS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1987	ALCOHOLS, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	14; 22; 27; 44
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	14; 22; 27
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1989	ALDEHYDES, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1989	ALDEHYDES, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1989	ALDEHYDES, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	14; 22; 27; 44
1991	CHLOROPRENE, STABILIZED	3	FT1	I	3+6.1+unst.+CMR	C	2	2	3	50	95	0.96	1	no	T2 **(12)**	II B (II B3)	yes	PP, EP, EX, TOX, A	2	3; 5; 23
1992	FLAMMABLE LIQUID, TOXIC, N.O.S Initial boiling point ≤ 60°C	3	FT1	I	3+6.1+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 60°C <Initial boiling point ≤ 85°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 85°C <Initial boiling point ≤ 115°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 115°C <Initial boiling point	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 60°C <Initial boiling point ≤ 85°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 23; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 85°C <Initial boiling point ≤ 115°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 115°C <Initial boiling point	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 27
1992	FLAMMABLE LIQUID, TOXIC, N.O.S Initial boiling point ≤ 60°C	3	FT1	I	3+6.1+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 60°C <Initial boiling point ≤ 85°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 85°C <Initial boiling point ≤ 115°C	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 115°C <Initial boiling point	3	FT1	II	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 60°C <Initial boiling point ≤ 85°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 23; 27; 44
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 85°C <Initial boiling point ≤ 115°C	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1992	FLAMMABLE LIQUID, TOXIC, N.O.S 115°C <Initial boiling point	3	FT1	III	3+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+(N1, N2, N3, CMR, F)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+(N1, N2, N3, CMR, F)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	23; 27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+(N1, N2, N3 CMR, F)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+(N1, N2, N3 CMR, F)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	23; 27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	27
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL INITIAL BOILING POINT > 115°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1993	FLAMMABLE LIQUID, N.O.S. (CYCLOHEXANONE/ CYCLOHEXANOL MIXTURE)	3	F1	III	3+F	N	3	3			97	0.95	3	yes	T3	II A	yes	PP, EX, A	0	
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22;27
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
1993	FLAMMABLE LIQUID, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+(N1, N2, N3, CMR, F)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+(N1, N2, N3, CMR, F)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+(N1, N2, N3 CMR, F)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+(N1, N2, N3 CMR, F)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	23; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	27; 44
1993	FLAMMABLE LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL INITIAL BOILING POINT > 115°C	3	F1	III	3+(N1, N2, N3 CMR, F)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	27; 44

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22;27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1993	FLAMMABLE LIQUID, N.O.S. Flash point ≥ 23°C but ≤60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
1999	TARS, LIQUID, including road oils, and cutback bitumens	3	F1	III	3+S	N	4	3	2		97		3	yes	T3	II A **(6)**	yes	PP, EX, A	0	
2014	HYDROGEN PEROXIDE, AQUEOUS SOLUTION with not less than 20% but not more than 60% hydrogen peroxide (stabilized as necessary)	5.1	OC 1	II	5.1+8+unst.	C	2	2		35	95	1.2	2	yes			no	PP, EP	0	3; 33
2021	CHLOROPHENOLS, LIQUID (2-CHLO-ROPHENOL)	6.1	T1	III	6.1+N2	C	2	2		25	95	1.23	2	no	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	0	6:+10°C; 17
2022	CRESYLIC ACID	6.1	TC1	II	6.1+8+3+S	C	2	2		25	95	1.03	2	no	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	2	6:+16°C; 17
2023	EPICHLORHYDRINE	6.1	TF1	II	6.1+3+N3	C	2	2		35	95	1.18	2	no	T2 **(12)**	II B	yes	PP, EP, EX, TOX, A	2	5
2031	NITRIC ACID, other than red fuming, with more than 70% acid	8	CO 1	I	8+5.1+N3	N	2	3		10	97	1.41 - 1.48	3	yes			no	PP, EP	0	34
2031	NITRIC ACID, other than red fuming with at le 65% but not more than 70% acid	8	CO 1	II	8+5.1+N3	N	2	3		10	97	1.39 - 1.41	3	yes			no	PP, EP	0	34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2031	NITRIC ACID, other than red fuming, with less than 65% acid	8	CO1	II	8+N3	N	2	3		10	97	1.02 - 1.39	3	yes			no	PP, EP	0	34
2032	NITRIC ACID, RED FUMING	8	COT	I	8+5.1+6.1+N3	C	2	2		50	95	1.48 - 1.51	1	no			no	PP, EP, TOX, A	2	
2045	ISOBUTYRALDEHYDE (ISOBUTYL ALDEHYDE)	3	F1	II	3+N3	C	2	2	3	50	95	0.79	2	yes	T4	II A **(6)**	yes	PP, EX, A	1	15; 23
2046	CYMENES	3	F1	III	3+N2+F	N	3	3			97	0.88	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	0	
2047	DICHLOROPROPENES (2,3- DICHLOROPROP-1-ENE)	3	F1	II	3+N2+CMR	C	2	2		45	95	1.2	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	1	
2047	DICHLOROPROPENES (MIXTURES of 2,3- DICHLOROPROP-1-ENE and 1,3-DICHLOROPROPENE)	3	F1	II	3+N1+CMR	C	2	2		45	95	1.23	2	yes	T2 **(1)** **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	1	
2047	DICHLOROPROPENES (MIXTURES of 2,3- DICHLOROPROP-1-ENE and 1,3-DICHLOROPROPENE)	3	F1	III	3+N1+CMR	C	2	2		45	95	1.23	2	yes	T2 **(1)** **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	0	
2047	DICHLOROPROPENES (1,3-DICHLOROPROPENE)	3	F1	III	3+N1+CMR	C	2	2		40	95	1.23	2	yes	T2 **(1)** **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	0	
2048	DICYCLOPENTADIENE	3	F1	III	3+N2+F	N	3	3	2		95	0.94	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	7; 17
2050	DIISOBUTYLENE, ISOMERIC COMPOUNDS	3	F1	II	3+N2+F	N	2	3		10	97	0.72	3	yes	T3 **(2)**	II A **(6)**	yes	PP, EX, A	1	
2051	2-DIMETHYLAMINO ETHANOL	8	CF1	II	8+3+N3	N	3	2			97	0.89	3	yes	T3	II A **(6)**	yes	PP, EP, EX, A	1	34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2053	METHYL ISOBUTYL CARBINOL	3	F1	III	3	N	3	2			97	0.81	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
2054	MORPHOLINE	8	CF1	I	8+3+N3	N	3	2			97	1	3	yes	T3	II A	yes	PP, EP, EX, A	1	34
2055	STYRENE MONOMER, STABILIZED	3	F1	III	3+unst.+N3	N	3	2			97	0.91	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	3; 5; 16
2056	TETRAHYDROFURAN	3	F1	II	3	N	2	2		10	97	0.89	3	yes	T3	II B	yes	PP, EX, A	1	
2057	TRIPROPYLÈNE	3	F1	II	3+N1	C	2	2		35	95	0.744	2	yes	T3	II A	yes	PP, EX, A	1	
2057	TRIPROPYLENE	3	F1	III	3+N1	C	2	2		35	95	0.73	2	yes	T3	II A	yes	PP, EX, A	0	
2078	TOLUENE DIISOCYANATE (and isomeric mixtures) (2,4- TOLUENE DIISOCYANATE)	6.1	T1	II	6.1+N2+S	C	2	2	2	25	95	1.22	2	no	T1 **(12)**	II B (II B3 **(11)**)	yes	PP, EP, EX, TOX, A	2	2; 7; 8; 17
2078	TOLUENE DIISOCYANATE (and isomeric mixtures) (2,4- TOLUENE DIISOCYANATE)	6.1	T1	II	6.1+N2+S	C	2	1	4	25	95	1.22	2	no			no	PP, EP, TOX, A	2	2; 7; 8; 17; 20:+112°C; 26
2079	DIETHYLENETRIAMINE	8	C7	II	8+N3	N	4	2			97	0.96	3	yes			no	PP, EP	0	34
2187	CARBON DIOXIDE, REFRIGERATED LIQUID	2	3A		2.2	G	1	1	1		95		1	yes			no	PP	0	31; 39
2205	ADIPONITRILE	6.1	T1	III	6.1	C	2	2		25	95	0.96	2	no	T4	II B (II B3 **(11)**)	yes	PP, EP, EX, TOX, A	0	6: 6°C; 17
2206	ISOCYANATES, TOXIC, N.O.S. (4-CHLOROPHENYL ISOCYANATE)	6.1	T1	II	6.1+S	C	2	2	4	25	95	1.25	2	no			no	PP, EP, TOX, A	2	7; 17
2209	FORMALDEHYDE SOLUTION with not less than 25% formaldehyde	8	C9	III	8+N3	N	4	2			97	1.09	3	yes			no	PP, EP	0	15; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2215	MALEIC ANHYDRIDE, MOLTEN	8	C3	III	8+N3	N	3	3	2		95	0.93	3	yes	T2 **(12)**	II B **(4)**	yes	PP, EP, EX, A	0	7; 17; 25; 34
2215	MALEIC ANHYDRIDE, MOLTEN	8	C3	III	8+N3	N	3	1	4		95	0.93	3	yes			no	PP, EP	0	7; 17; 20:+88°C; 25; 34
2218	ACRYLIC ACID, STABILIZED	8	CF1	II	8+3+unst.+N1	C	2	2	4	30	95	1.05	1	yes	T2 **(12)**	II B	yes	PP, EP, EX, A	1	3; 4; 5; 17
2227	n-BUTYL METHACRYLATE, STABILIZED	3	F1	III	3+unst.+N3+F	C	2	2		25	95	0.9	1	yes	T3	II A	yes	PP, EX, A	0	3; 5
2238	CHLOROTOLUENES (m-CHLOROTOL-UENE)	3	F1	III	3+N2+S	C	2	2		30	95	1.08	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	0	
2238	CHLOROTOLUENES (o-CHLOROTOLU-ENE)	3	F1	III	3+N2+S	C	2	2		30	95	1.08	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	0	
2238	CHLOROTOLUENES (p-CHLOROTOLU-ENE)	3	F1	III	3+N2+S	C	2	2		30	95	1.07	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	0	6:+11°C; 17
2241	CYCLOHEPTANE	3	F1	II	3+N2	N	2	3		10	97	0.81	3	yes	T4 **(3)**	II A **(6)**	yes	PP, EX, A	1	
2247	n-DECANE	3	F1	III	3+F	C	2	2		30	95	0.73	2	yes	T4	II A	yes	PP, EX, A	0	
2248	DI-n-BUTYLAMINE	8	CF1	II	8+3+N3	N	3	2			97	0.76	3	yes	T3	II A **(6)**	yes	PP, EP, EX, A	1	34
2259	TRIETHYLENETETRAMINE	8	C7	II	8+N2	N	3	3			97	0.98	3	yes	T2 **(12)**	II B (II B3 **(11)**)	yes	PP, EP, EX, A	0	6: 16°C ; 17; 34
2263	DIMETHYLCYCLOHEXANES (cis-1,4-DIMETHYL- CYCLOHEXANE)	3	F1	II	3	C	2	2		35	95	0.78	2	yes	T4 **(3)**	II A **(6)**	yes	PP, EX, A	1	
2263	DIMETHYLCYCLOHEXANES (trans-1,4-DIMETHYL- CYCLOHEXANE)	3	F1	II	3	C	2	2		35	95	0.76	2	yes	T4 **(3)**	II A **(6)**	yes	PP, EX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2264	N,N-DIMETHYL- CYCLOHEXYLAMINE	8	CF1	II	8+3+N2	N	3	3			97	0.85	3	yes	T3	II B **(4)**	yes	PP, EP, EX, A	1	34
2265	N,N-DIMETHYLFORMAMIDE	3	F1	III	3+CMR	N	2	3	3	10	97	0.95	3	yes	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	0	
2266	DIMETHYL-N-PROPYLAMINE	3	FC	II	3+8	C	2	2	3	50	95	0.72	2	yes	T4	II A **(6)**	yes	PP, EP, EX, A	1	23
2276	2-ETHYLHEXYLAMINE	3	FC	III	3+8+N3	N	3	2			97	0.79	3	yes	T3	II A **(6)**	yes	PP, EP, EX, A	0	34
2278	n-HEPTENE	3	F1	II	3+N3	N	2	2		10	97	0.7	3	yes	T3	II B **(4)**	yes	PP, EX, A	1	
2280	HEXAMETHYLENEDIAMINE, SOLID, MOLTEN	8	C8	III	8+N3	N	3	3	2		95	0.83	3	yes	T3	II B (II B3 **(11)**)	yes	PP, EP, EX, A	0	7; 17; 34
2280	HEXAMETHYLENEDIAMINE, SOLID, MOLTEN	8	C8	III	8+N3	N	3	3	4		95	0.83	3	yes			no	PP, EP	0	7; 17; 20:+66°C; 34
2282	HEXANOLS	3	F1	III	3+N3	N	3	2			97	0.83	3	yes	T3	II A	yes	PP, EX, A	0	
2286	PENTAMETHYLHEPTANE	3	F1	III	3+F	N	3	3			97	0.75	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	0	
2288	ISOHEXENES	3	F1	II	3+unst.+N3	C	2	2	3	50	95	0.735	2	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	3; 23
2289	ISOPHORONEDIAMINE	8	C7	III	8+N2	N	3	3			97	0.92	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, A	0	6: 14°C; 17; 34
2302	5-METHYLHEXAN-2-ONE	3	F1	III	3	N	3	2			97	0.81	3	yes	T1 **(12)**	II A	yes	PP, EX, A	0	
2303	ISOPROPENYLBENZENE	3	F1	III	3+N2+F	N	3	3			97	0.91	3	yes	T2 **(12)**	II B	yes	PP, EX, A	0	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2309	OCTADIENE (1,7-OCTADIENE)	3	F1	II	3+N2	N	2	3		10	97	0.75	3	yes	T3	II B (II B3)	yes	PP, EX, A	1	
2311	PHENETIDINES	6.1	T1	III	6.1	C	2	2		25	95	1.07	2	no			no	PP, EP, TOX, A	0	6:+7°C; 17
2312	PHENOL, MOLTEN	6.1	T1	II	6.1+N3+S	C	2	2	4	25	95	1.07	2	no	T1 **(12)**	II A **(7)**	yes	PP, EP, EX, TOX, A	2	7; 17
2312	PHENOL, MOLTEN	6.1	T1	II	6.1+N3+S	C	2	2	4	25	95	1.07	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+67°C
2320	TETRAETHYLENEPENTAMINE	8	C7	III	8+N2	N	4	3			97	1	3	yes			no	PP, EP	0	34
2321	TRICHLOROBENZENES, LIQUID (1,2,4-TRICHLOROBENZENE)	6.1	T1	III	6.1+N1+S	C	2	2	2	25	95	1.45	2	no	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	0	7; 17
2321	TRICHLOROBENZENES, LIQUID (1,2,4-TRICHLOROBENZENE)	6.1	T1	III	6.1+N1+S	C	2	1	4	25	95	1.45	2	no			no	PP, EP, TOX, A	0	7; 17; 20:+95°C; 26
2323	TRIETHYL PHOSPHITE	3	F1	III	3	N	3	2			97	0.8	3	yes	T3	II B **(4)**	yes	PP, EX, A	0	
2324	TRIISOBUTYLENE	3	F1	III	3+N1+F	C	2	2		35	95	0.76	2	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	0	
2325	1,3,5-TRIMETHYLBENZENE	3	F1	III	3+N1	C	2	2		35	95	0.87	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	0	
2333	ALLYL ACETATE	3	FT1	II	3+6.1	C	2	2		40	95	0.93	2	no	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	2	
2348	BUTYL ACRYLATES, STABILIZED (n-BUTYL ACRYLATE, STABILIZED)	3	F1	III	3+unst.+N3	C	2	2		30	95	0.9	1	yes	T3	II B	yes	PP, EX, A	0	3; 5
2350	BUTYL METHYL ETHER	3	F1	II	3	N	2	2		10	97	0.74	3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2356	2-CHLOROPROPANE	3	F1	I	3	C	2	2	3	50	95	0.86	2	yes	T1 **(12)**	II A	yes	PP, EX, A	1	23
2357	CYCLOHEXYLAMINE	8	CF1	II	8+3+N3	N	3	2			97	0.86	3	yes	T3	II A	yes	PP, EP, EX, A	1	34
2362	1,1-DICHLOROETHANE	3	F1	II	3+N2	C	2	2	3	50	95	1.17	2	yes	T2 **(12)**	II A	yes	PP, EX, A	1	23
2370	1-HEXENE	3	F1	II	3+N3	N	2	2		10	97	0.67	3	yes	T3	II B **(4)**	yes	PP, EX, A	1	
2381	DIMÉTHYL DISULPHIDE	3	FT1	II	3+6.1	C	2	2		40	95	1.063	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	
2382	DIMETHYLHYDRAZINE, SYMMETRICAL	6.1	TF1	I	6.1+3+CMR	C	2	2		50	95	0.83	1	no	T4 **(3)**	II C **(5)**	yes	PP, EP, EX, TOX, A	2	
2383	DIPROPYLAMINE	3	FC	II	3+8+N3	C	2	2		35	95	0.74	2	yes	T3	II A	yes	PP, EP, EX, A	1	
2397	3-METHYLBUTAN-2-ONE	3	F1	II	3	N	2	2		10	97	0.81	3	yes	T1 **(12)**	II A **(6)**	yes	PP, EX, A	1	
2398	METHYL tert-BUTYL ETHER	3	F1	II	3	N	2	2		10	97	0.74	3	yes	T1 **(12)**	II A	yes	PP, EX, A	1	
2404	PROPIONITRILE	3	FT1	II	3+6.1	C	2	2		45	95	0.78	2	no	T1 **(8)** **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	2	
2414	THIOPHENE	3	F1	II	3+N3+S	N	2	3		10	97	1.06	3	yes	T2 **(12)**	II A	yes	PP, EX, A	1	
2430	ALKYLPHENOLS, SOLID, N.O.S. (NONYLPHENOL, ISOMERIC MIXTURE, MOLTEN)	8	C4	II	8+N1+F	N	3	1	2		95	0.95	2	yes	T2 **(12)**	II A **(6)**	yes	PP, EP, EX, A	0	7; 17

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2430	ALKYLPHENOLS, SOLID, N.O.S. (NONYLPHENOL, ISOMERIC MIXTURE, MOLTEN)	8	C4	II	8+N1+F	N	3	2	4		95	0.95	2	yes			no	PP, EP	0	7; 17; 20:+125°C
2432	N,N-DIETHYLANILINE	6.1	T1	III	6.1+N2	C	2	2		25	95	0.93	2	no			no	PP, EP, TOX, A	0	
2448	SULPHUR, MOLTEN	4.1	F3	III	4.1+S	N	4	1	4		95	2.07	3	yes			no	PP, EP, TOX*, A	0	* Toximeter for H2S; 7; 17 20:+150°C; 28; 32
2458	HEXADIENES	3	F1	II	3+N3	N	2	2		10	97	0.72	3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	
2477	METHYL ISOTHIOCYANATE	6.1	TF1	I	6.1+3+N1	C	2	2	2	35	95	1.07 **(10)**	1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	7; 17
2485	n-BUTYL ISOCYANATE	6.1	TF1	I	6.1+3	C	2	2		35	95	0.89	1	no	T2 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	
2486	ISOBUTYL ISOCYANATE	6.1	TF1	I	6.1+3	C	2	2		40	95		1	no	T4 **(3)**	II A	yes	PP, EP, EX, TOX, A	2	
2487	PHENYL ISOCYANATE	6.1	TF1	I	6.1+3	C	2	2		25	95	1.1	1	no	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	
2490	DICHLOROISOPROPYL ETHER	6.1	T1	II	6.1	C	2	2		25	95	1.11	2	no			no	PP, EP, TOX, A	2	
2491	ETHANOLAMINE or ETHANOLAMINE SOLUTION	8	C7	III	8+N3	N	3	2			97	1.02	3	yes	T2 **(12)**	II B **(4)**	yes	PP, EP, EX, A	0	6: 14°C; 17; 34
2493	HEXAMETHYLENEIMINE	3	FC	II	3+8+N3	N	3	2			97	0.88	3	yes	T3 **(2)**	II A	yes	PP, EP, EX, A	1	34
2496	PROPIONIC ANHYDRIDE	8	C3	III	8+N3	N	4	3			97	1.02	3	yes			no	PP, EP	0	34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2518	1,5,9-CYCLODODECATRIENE	6.1	T1	III	6.1+F	C	2	2		25	95	0.9	2	no			no	PP, EP, TOX, A	0	
2527	ISOBUTYL ACRYLATE, STABILIZED	3	F1	III	3+unst.	C	2	2		30	95	0.89	1	yes	T2 **(12)**	II B **(8)**	yes	PP, EX, A	0	3; 5
2528	ISOBUTYL ISOBUTYRATE	3	F1	III	3+N3	N	3	2			97	0.86	3	yes	T2 **(12)**	II A	yes	PP, EX, A	0	
2531	METHACRYLIC ACID, STABILIZED	8	C3	II	8+unst.+N3	C	2	2	4	25	95	1.02	1	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	0	3; 4; 5; 7; 17
2564	TRICHLOROACETIC ACID SOLUTION	8	C3	II	8+N1	C	2	2	2	25	95	1.62 **(10)**	2	yes	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, A	0	7; 17; 22
2564	TRICHLOROACETIC ACID SOLUTION	8	C3	III	8+N1	C	2	2		25	95	1.62 **(10)**	2	yes			no	PP, EP	0	22
2574	TRICRESYL PHOSPHATE with more than 3% ortho isomer	6.1	T1	II	6.1+N1+S	C	2	2		25	95	1.18	2	no			no	PP, EP, TOX, A	2	
2579	PIPERAZINE, MOLTEN	8	C8	III	8+N2	N	3	3	2		95	0.9	3	yes			no	PP, EP	0	7; 17; 34
2582	FERRIC CHLORIDE SOLUTION	8	C1	III	8	N	4	3			97	1.45	3	yes			no	PP, EP	0	22; 30; 34
2586	ALKYLSULPHONIC ACIDS, LIQUID or ARYLSULPHONIC ACIDS, LIQUID with not more than 5% free sulphuric acid	8	C3	III	8	N	4	3			97		3	yes			no	PP, EP	0	34
2608	NITROPROPANES	3	F1	III	3	N	3	2			97	1	3	yes	T2 **(12)**	II B **(6)**	yes	PP, EX, A	0	
2615	ETHYL PROPYL ETHER	3	F1	II	3	N	2	2		10	97	0.73	3	yes	T4 **(3)**	II A **(6)**	yes	PP, EX, A	1	
2618	VINYLTOLUENES, STABILIZED	3	F1	III	3+unst.+N2+F	C	2	2		25	95	0.92	1	yes	T1 **(12)**	II A	yes	PP, EX, A	0	3; 5
2651	4,4′-DIAMINO- DIPHENYLMETHANE	6.1	T2	III	6.1+N2+CMR+S	C	2	2	2	25	95	1	2	no			no	PP, EP, TOX, A	0	7; 17

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2672	AMMONIA SOLUTION, relative density between 0.880 and 0.957 at 15°C in water, with more than 10% but not more than 35% ammonia (more than 25% but not more than 35% ammonia)	8	C5	III	8+N1	C	2	2	1	50	95	0.88 **(9)** - 0.96 **(9)**	2	yes			no	PP, EP	0	
2672	AMMONIA SOLUTION relative density between 0.880 and 0.957 at 15°C in water, with more than 10% but not more than 35% ammonia (more than 25% ammonia)	8	C5	III	8+N3	N	2	2		10	95	0.88 **(9)** - 0.96 **(9)**	2	yes			no	PP, EP	0	34
2683	AMMONIUM SULPHIDE SOLUTION	8	CFT	II	8+3+6.1	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	15; 16
2693	BISULPHITES, AQUEOUS SOLUTION, N.O.S.	8	C1	III	8	N	4	3			97		3	yes			no	PP, EP	0	27; 34
2709	BUTYLBENZENES	3	F1	III	3+N1+F	N	2	3		35	97	0.87	2	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	0	41
2709	BUTYLBENZENES (n-BUTYLBENZENE)	3	F1	III	3+N1+F	N	3	3			97	0.87	2	yes	T2 **(12)**	II A	yes	PP, EX, A	0	41
2733	AMINES, FLAMMABLE, CORROSIVE, N.O.S. or POLYAMINES, FLAMMABLE, CORROSIVE, N.O.S. (2-AMINOBUTANE)	3	FC	II	3+8+N1	C	2	2	3	50	95	0.72	2	yes	T4 **(3)**	II A **(6)**	yes	PP, EP, EX, A	1	23
2735	AMINES, LIQUID, CORROSIVE, N.O.S. or POLYAMINES, LIQUID, CORROSIVE, N.O.S. vp50≤12.5kPa	8	C7	I	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
2735	AMINES, LIQUID, CORROSIVE, N.O.S. or POLYAMINES, LIQUID, CORROSIVE, N.O.S. vp50 > 12.5 kPa	8	C7	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2735	AMINES, LIQUID, CORROSIVE, N.O.S. or POLYAMINES, LIQUID, CORROSIVE, N.O.S. vp50 ≤ 12.5 kPa	8	C7	II	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
2735	AMINES, LIQUID, CORROSIVE, N.O.S. or POLYAMINES, LIQUID, CORROSIVE, N.O.S. vp50 > 12.5 kPa	8	C7	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
2735	AMINES, LIQUID, CORROSIVE, N.O.S. or POLYAMINES, LIQUID, CORROSIVE, N.O.S.	8	C7	III	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
2754	N-ETHYLTOLUIDINES (N-ETHYL-o-TOLUIDINE)	6.1	T1	II	6.1+F	C	2	2		25	95	0.94	2	no			no	PP, EP, TOX, A	2	
2754	N-ETHYLTOLUIDINES (N-ETHYL-m-TOLUIDINE)	6.1	T1	II	6.1+F	C	2	2		25	95	0.94	2	no			no	PP, EP, TOX, A	2	
2754	N-ETHYLTOLUIDINES (N-ETHYL-o-TOLUIDINE and N-ETHYL-m-TOLUIDINE MIXTURES)	6.1	T1	II	6.1+F	C	2	2		25	95	0.94	2	no			no	PP, EP, TOX, A	2	
2754	N-ETHYLTOLUIDINES (N-ETHYL-p-TOLUIDINE)	6.1	T1	II	6.1+F	C	2	2	2	25	95	0.94	2	no			no	PP, EP, TOX, A	2	7; 17
2785	4-THIAPENTANAL (3-METHYLMERCAPTO- PROPIONALDEHYDE)	6.1	T1	III	6.1	C	2	2		25	95	1.04	2	no			no	PP, EP, TOX, A	0	
2789	ACETIC ACID, GLACIAL or ACETIC ACID SOLUTION, more than 80% acid, by mass	8	CF1	II	8+3	N	2	3	2	10	95	1.05 with 100 % acid	3	yes	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, A	1	7; 17; 34
2790	ACETIC ACID SOLUTION, not less than 50% but not more than 80% acid, by mass	8	C3	II	8	N	2	3		10	97		3	yes			no	PP, EP	0	34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2790	ACETIC ACID SOLUTION, more than 10% and less than 50% acid, by mass	8	C3	III	8	N	2	3		10	97		3	yes			no	PP, EP	0	34
2796	BATTERY FLUID, ACID	8	C1	II	8+N3	N	4	3			97	1.00 - 1.84	3	yes			no	PP, EP	0	8; 22; 30; 34
2796	SULPHURIC ACID with not more than 51% acid	8	C1	II	8+N3	N	4	3			97	1.00 - 1.41	3	yes			no	PP, EP	0	8; 22; 30; 34
2797	BATTERY FLUID, ALKALI	8	C5	II	8+N3	N	4	3			97	1.00 - 2.13	3	yes			no	PP, EP	0	22; 30; 34
2810	TOXIC LIQUID, ORGANIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	6.1	T1	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no			no	PP, EP, TOX, A	2	22; 23; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	6.1	T1	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no			no	PP, EP, TOX, A	2	22; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 115°C < Initial boiling point	6.1	T1	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no			no	PP, EP, TOX, A	2	22; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	6.1	T1	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	2	22; 23; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	6.1	T1	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	2	22; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 115°C < Initial boiling point	6.1	T1	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	2	22; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	6.1	T1	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	0	22; 23; 27
2810	TOXIC LIQUID, ORGANIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	6.1	T1	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	0	22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2810	TOXIC LIQUID, ORGANIC, N.O.S. 115°C < Initial boiling point	6.1	T1	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	0	22; 27
2811	TOXIC SOLID, ORGANIC, N.O.S. (1,2,3-TRICHLOROBENZENE, MOLTEN)	6.1	T2	III	6.1+S	C	2	2	2	25	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	7; 17; 22
2811	TOXIC SOLID, ORGANIC, N.O.S. (1,2,3-TRICHLOROBENZENE, MOLTEN)	6.1	T2	III	6.1+S	C	2	1	4	25	95		2	no			no	PP, EP, TOX, A	0	7; 17; 20:+92°C; 22; 26
2811	TOXIC SOLID, ORGANIC, N.O.S. (1,3,5-TRICHLOROBENZENE, MOLTEN)	6.1	T2	III	6.1+S	C	2	2	2	25	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	7; 17; 22
2811	TOXIC SOLID, ORGANIC, N.O.S. (1,3,5-TRICHLOROBENZENE, MOLTEN)	6.1	T2	III	6.1+S	C	2	1	4	25	95		2	no			no	PP, EP, TOX, A	0	7; 17; 20:+92°C; 22; 26
2815	N-AMINOETHYL PIPERAZINE	8	C7	III	8+N2	N	4	3			97	0.98	3	yes			no	PP, EP	0	34
2820	BUTYRIC ACID	8	C3	III	8+N3	N	2	3		10	97	0.96	3	yes			no	PP, EP	0	34
2829	CAPROIC ACID	8	C3	III	8+N3	N	4	3			97	0.92	3	yes			no	PP, EP	0	34
2831	1,1,1-TRICHLOROETHANE	6.1	T1	III	6.1+N2	C	2	2	3	50	95	1.34	2	no			no	PP, EP, TOX, A	0	23
2850	PROPYLENE TETRAMER	3	F1	III	3+N1+F	N	4	3			97	0.76	2	yes	T3		no	PP	0	
2874	FURFURYL ALCOHOL	6.1	T1	III	6.1+N3	C	2	2		25	95	1.13	2	no			no	PP, EP, TOX, A	0	
2904	PHENOLATES, LIQUID	8	C9	III	8	N	4	2			97	1.13 - 1.18	3	yes			no	PP, EP	0	34
2920	CORROSIVE LIQUID, FLAMMABLE, N.O.S. (2- PROPANOL AND DODECYLDIMETHYL- AMMONIUM CHLORIDE, AQUEOUS SOLUTION)	8	CF1	II	8+3+F	N	3	3			97	0.95	3	yes	T3	II A	yes	PP, EP, EX, A	1	34

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2920	CORROSIVE LIQUID, FLAMMABLE, N.O.S. (AQUEOUS SOLUTION OF HEXADECYLTRIMETHYL- AMMONIUM CHLORIDE (50%) AND ETHANOL (35%))	8	CF1	II	8+3+F	N	2	3		10	95	0.9	3	yes	T2 **(12)**	II B	yes	PP, EP, EX, A	1	6:+7°C; 17; 34
2920	CORROSIVE LIQUID, FLAMMABLE, N.O.S. (AQUEOUS SOLUTION OF HEXADECYLTRIMETHYL- AMMONIUM CHLORIDE (50%) AND ETHANOL (35%))	8	CF1	II	8+3+F	N	2	3		10	95	0.9	3	yes	T2 **(12)**	II B (II B3)	yes	PP, EP, EX, A	1	6:+7°C; 17; 34; 44
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	8	CT1	I	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no			no	PP, EP, TOX, A	2	22; 23; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	8	CT1	I	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no			no	PP, EP, TOX, A	2	22; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 115°C < Initial boiling point	8	CT1	I	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no			no	PP, EP, TOX, A	2	22; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	8	CT1	II	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	2	22; 23; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	8	CT1	II	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	2	22; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 115°C < Initial boiling point	8	CT1	II	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	2	22; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	8	CT1	III	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	0	22; 23; 27
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	8	CT1	III	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	0	22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2922	CORROSIVE LIQUID, TOXIC, N.O.S. 115°C < Initial boiling point	8	CT1	III	8+6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	0	22; 27
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. (AQUEOUS SOLUTION OF DIALKYL-(C8-C18)- DIMETHYLAMMO-NIUM CHLORIDE AND 2-PROPANOL)	3	FC	II	3+8+F	C	2	2		50	95	0.88	2	yes	T2 **(12)**	II A	yes	PP, EP, EX, A	1	
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. Initial boiling point ≤ 60°C	3	FC	I	3+8+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, A	1	22; 27
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 60°C < Initial boiling point ≤ 85°C	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, A	1	22; 23; 27
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 85°C < Initial boiling point ≤ 115°C	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, A	1	22; 27
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 115°C < Initial boiling point	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, A	1	22; 27
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 23°C ≤ Flash point ≤ 60°C	3	FC	III	3+8+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, A	0	14; 22; 27; 34
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. Initial boiling point ≤ 60°C	3	FC	I	3+8+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, A	1	22; 27; 44
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 60°C < Initial boiling point ≤ 85°C	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, A	1	22; 23; 27; 44
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 85°C < Initial boiling point ≤ 115°C	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, A	1	22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 115°C < Initial boiling point	3	FC	II	3+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, A	1	22; 27; 44
2924	FLAMMABLE LIQUID, CORROSIVE, N.O.S. 23°C ≤ Flash point ≤ 60°C	3	FC	III	3+8+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, A	0	14; 22; 27; 34; 44
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 60°C < Initial boiling point ≤ 85°C	6.1	TC1	I	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no			no	PP, EP, TOX, A	2	22; 23; 27
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 85°C < Initial boiling point ≤ 115°C	6.1	TC1	I	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no			no	PP, EP, TOX, A	2	22; 27
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TC1	I	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no			no	PP, EP, TOX, A	2	22; 27
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	TC1	II	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	2	22; 23; 27
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	TC1	II	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	2	22; 27
2927	TOXIC LIQUID, CORROSIVE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TC1	II	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	2	22; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TF1	I	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
2929	TOXIC LIQUID, FLAMMABLE, ORGANIC, N.O.S. 115°C <Initial boiling point	6.1	TF1	II	6.1+3+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
2935	ETHYL-2-CHLORO-PROPIONATE	3	F1	III	3	C	2	2		30	95	1.08	2	yes	T4 **(3)**	II A	yes	PP, EX, A	0	
2947	ISOPROPYL CHLOROACETATE	3	F1	III	3	C	2	2		30	95	1.09	2	yes	T4 **(3)**	II A	yes	PP, EX, A	0	
2966	THIOGLYCOL	6.1	T1	II	6.1	C	2	2		25	95	1.12	2	no			no	PP, EP, TOX, A	2	
2983	ETHYLENE OXIDE AND PROPYLENE OXIDE MIXTURE, with not more than 30% ethylene oxide	3	FT1	I	3+6.1+unst.	C	1	1	3		95	0.85	1	no	T2 **(12)**	II B (II B3)	yes	PP, EP, EX, TOX, A	2	2; 3; 12; 31
2984	HYDROGEN PEROXIDE AQUEOUS SOLUTION with not less than 8%, but less than 20% hydrogen peroxide (stabilized as necessary)	5.1	O1	III	5.1+unst.	C	2	2		35	95	1.06	2	yes			no	PP	0	3; 33
3077	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S., MOLTEN, (ALKYLAMINE (C12 to C18))	9	M7	III	9+F	N	4	3	2		95	0.79	3	yes			no	PP	0	7; 17
3079	METHACRYLONITRILE, STABILIZED	6.1	TF1	I	6.1+3+unst.+N3	C	2	2		45	95	0.8	1	no	T1 **(12)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	3; 5
3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (BILGE WATER, FREE OF SLUDGE)	9	M6	III	9+N2+F	N	4	3			97		3	yes			no	PP	0	

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (heavy heating oil)	9	M6	III	9+CMR+ (N1, N2, F or S)	N	2	3		10	97		3	yes			no	PP	0	
3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.	9	M6	III	9+(N1, N2, CMR, F or S)	N	4	3			97		3	yes			no	PP	0	22; 27
3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (BILGE WATER, CONTAINS SLUDGE)	9	M6	III	9+CMR+N1	N	2	3		10	97		3	yes			no	PP, EP, TOX, A	0	45
3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (OIL SLUDGE)	9	M6	III	9+CMR+N1	N	2	3		10	97		3	yes			no	PP, EP, TOX, A	0	45
3092	1-METHOXY-2-PROPANOL	3	F1	III	3	N	3	2			97	0.92	3	yes	T3	II B	yes	PP, EX, A	0	
3145	ALKYLPHENOLS, LIQUID, N.O.S. (including C2-C12 homologues)	8	C3	II	8+N3	N	4	3			97	0.95	3	yes			no	PP, EP	0	27; 34
3145	ALKYLPHENOLS, LIQUID, N.O.S. (including C2-C12 homologues)	8	C3	III	8+N3	N	4	3			97	0.95	3	yes			no	PP, EP	0	27; 34
3175	SOLIDS CONTAINING FLAMMABLE LIQUID, N.O.S., MOLTEN, having a flash-point up to 60°C (2- PROPANOL AND DIALKYL-(C12 to C18)- DIMETH-YLAMMONIUM CHLORIDE)	4.1	F1	II	4.1	N	3	3	4		95	0.86	3	yes	T2 **(12)**	II A **(6)**	yes	PP, EX, A	1	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (CARBON BLACK REEDSTOCK) (PYROL-YSIS OIL)	3	F2	III	3+F	N	3	3	2		95		3	yes	T1 **(12)**	II B	yes	PP, EX, A	0	7; 17

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (PYROLYSIS OIL A)	3	F2	III	3+F	N	3	3	2		95		3	yes	T1 **(12)**	II B	yes	PP, EX, A	0	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (RESIDUAL OIL)	3	F2	III	3+F	N	3	3	2		95		3	yes	T1 **(12)**	II B	yes	PP, EX, A	0	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (MIXTURE OF CRUDE NAPHTHALINE)	3	F2	III	3+F	N	3	3	2		95		3	yes	T1 **(12)**	II B	yes	PP, EX, A	0	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (CREOSOTE OIL)	3	F2	III	3+N1+F	C	2	2	2	10	95		2	yes	T2 **(12)**	II B	yes	PP, EX, A	0	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (Low QI Pitch)	3	F2	III	3+N2+CMR+S	N	3	1	4		95	1.1 - 1.3	3	yes	T2 **(12)**	II B **(2)**	yes	PP, EP, EX, TOX, A	0	7; 17
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: T ≤ 80°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	2	4		95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	7; 17; 22; 27

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: 80°C < T ≤ 115°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	1	4		95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	7; 17; 22; 25; 27
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: T > 115°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	1	4		95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	7; 17; 22; 27
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: T ≤ 80°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	2	4		95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	7; 17; 22; 27; 44
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: 80°C < T ≤ 115°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	1	4		95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	7; 17; 22; 25; 27; 44
3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S. with flash-point above 60°C, at or above its flash-point (maximum transport temperature: T > 115°C)	3	F2	III	3+(N1, N2, N3, CMR, F or S)	N	3	1	4		95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	7; 17; 22; 27; 44
3257	ELEVATED TEMPERATURE LIQUID, N.O.S. at or above 100°C and below its flash-point (including molten metals, molten salts, etc.)	9	M9	III	9+(N1, N2, N3, CMR, F or S)	N	4	1	4		95		3	yes			no	PP	0	7; 17; 20: +115°C; 22; 24; 25; 27

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3257	ELEVATED TEMPERATURE LIQUID, N.O.S. at or above 100°C and below its flash-point (including molten metals, molten salts, etc.)	9	M9	III	9+(N1, N2, N3, CMR, F or S)	N	4	1	4		95		3	yes			no	PP	0	7; 17; 20: +225°C; 22; 24; 27
3259	AMINES, SOLID, CORROSIVE, N.O.S. (MONOALKYL-(C12 to C18)- AMINE ACETATE, MOLTEN)	8	C8	III	8	N	4	3	2		95	0.87	3	yes			no	PP, EP	0	7; 17; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (AQUEOUS SOLUTION OF PHOSPHORIC ACID AND CITRIC ACID)	8	C1	I	8	N	2	3		10	97		3	yes			no	PP, EP	0	34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (AQUEOUS SOLUTION OF PHOSPHORIC ACID AND CITRIC ACID)	8	C1	II	8	N	4	3			97		3	yes			no	PP, EP	0	34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (AQUEOUS SOLUTION OF PHOSPHORIC ACID AND CITRIC ACID)	8	C1	III	8	N	4	3			97		3	yes			no	PP, EP	0	34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. vp50 > 12.5 kPa	8	C1	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. vp50 ≤ 12.5 kPa	8	C1	I	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. vp50 ≤ 12.5 kPa	8	C1	II	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. vp50 > 12.5 kPa	8	C1	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. vp50 ≥ 6 kPa	8	C1	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. Corrosive to steel or aluminium corrosiveness ≥6.25 mm/year	8	C1	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3264	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. Melting point > 0°C and transported at elevated temperatures	8	C1	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34; 38
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. vp50>12.5kPa	8	C3	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. vp50≤12.5kPa	8	C3	I	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. vp50>12.5kPa	8	C3	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. vp50≤12.5kPa	8	C3	II	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. vp50≥6kPa	8	C3	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. Corrosive to steel or aluminium corrosiveness ≥6.25 mm/year	8	C3	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34
3265	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. Melting point > 0°C and transported at elevated temperatures	8	C3	III	8+(N1, N2, N3, CMR, F or S)	N	4	3			97		3	yes			no	PP, EP	0	22; 27; 34; 38
3266	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. vp50>12.5kPa	8	C5	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3266	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. vp50≤12.5kPa	8	C5	I	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3266	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. vp50>12.5kPa	8	C5	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3266	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. vp50≤12.5kPa	8	C5	II	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
3266	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S.	8	C5	III	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
3267	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. vp50>12.5kPa	8	C7	I	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3267	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. vp50≤12.5kPa	8	C7	I	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
3267	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. vp50>12.5kPa	8	C7	II	8+(N1, N2, N3, CMR, F or S)	N	2	3		10	97		3	yes			no	PP, EP	0	22; 27; 34
3267	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. vp50≤12.5kPa	8	C7	II	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
3267	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S.	8	C7	III	8+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP, EP	0	22; 27; 34
3271	ETHERS, N.O.S. (tert- AMYL- METHYL ETHER)	3	F1	II	3+N1	C	2	2	3	50	95	0.77	2	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	
3271	ETHERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3271	ETHERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3271	ETHERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3271	ETHERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3271	ETHERS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3271	ETHERS, N.O.S. Flash point ≥23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	14; 22; 27
3271	ETHERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3271	ETHERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3271	ETHERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3271	ETHERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3271	ETHERS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3271	ETHERS, N.O.S. Flash point ≥23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3272	ESTERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3272	ESTERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3272	ESTERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3272	ESTERS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T2 **(12)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3272	ESTERS, N.O.S. Flash point ≥23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	14; 22; 27
3272	ESTERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T2 **(12)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point < 23°C with 175kPa≤vp50<300kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T2 **(12)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<175kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T2 **(12)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point < 23°C with 110kPa≤vp50<150kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T2 **(12)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T2 **(12)**	II B **(4)** (II B3)	yes	PP, EX, A	1	14; 22; 27; 44
3272	ESTERS, N.O.S. Flash point ≥23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EX, A	0	14; 22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3276	NITRILES, TOXIC, LIQUID, N.O.S. (2-METHYLGLUTARONITRILE)	6.1	T1	II	6.1	C	2	2		10	95	0.95	2	no	T4 **(3)**		no	PP, EP, TOX, A	2	
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. Initial boiling point ≤ 60°C	3	FTC	I	3+6.1+8+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 115°C <Initial boiling point	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 115°C <Initial boiling point	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 27
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. Initial boiling point ≤ 60°C	3	FTC	I	3+6.1+8+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 115°C <Initial boiling point	3	FTC	I	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 60°C <Initial boiling point ≤ 85°C	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 27; 44
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 85°C <Initial boiling point ≤ 115°C	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
3286	FLAMMABLE LIQUID, TOXIC, CORROSIVE, N.O.S. 115°C <Initial boiling point	3	FTC	II	3+6.1+8+ (N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 27; 44
3287	TOXIC LIQUID, INORGANIC, N.O.S. (SODIUM DICHROMATE SOLUTION)	6.1	T4	III	6.1+CMR	C	2	2		30	95	1.68	2	no			no	PP, EP, TOX, A	0	
3287	TOXIC LIQUID, INORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	T4	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		1	no			no	PP, EP, TOX, A	2	22; 23; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	T4	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		1	no			no	PP, EP, TOX, A	2	22; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 115°C <Initial boiling point	6.1	T4	I	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no			no	PP, EP, TOX, A	2	22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3287	TOXIC LIQUID, INORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	T4	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	2	22; 23; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	T4	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	2	22; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 115°C <Initial boiling point	6.1	T4	II	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	2	22; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 60°C <Initial boiling point ≤ 85°C	6.1	T4	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2	3	50	95		2	no			no	PP, EP, TOX, A	0	22; 23; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 85°C <Initial boiling point ≤ 115°C	6.1	T4	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		50	95		2	no			no	PP, EP, TOX, A	0	22; 27
3287	TOXIC LIQUID, INORGANIC, N.O.S. 115°C <Initial boiling point	6.1	T4	III	6.1+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	0	22; 27
3289	TOXIC LIQUID, CORROSIVE, INORGANIC, N.O.S. BOILING POINT > 115°C	6.1	TC3	I	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		1	no			no	PP, EP, TOX, A	2	22; 27
3289	TOXIC LIQUID, CORROSIVE, INORGANIC, N.O.S. BOILING POINT > 115°C	6.1	TC3	II	6.1+8+(N1, N2, N3, CMR, F or S)	C	2	2		35	95		2	no			no	PP, EP, TOX, A	2	22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. CONTAINING ISOPRENE AND PENTADIENE, STABILIZED	3	F1	I	3+unst.+N2+CMR	C	2	2	3	50	95	0.678	1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	3
3295	HYDROCARBONS, LIQUID, N.O.S. (1-OCTEN)	3	F1	II	3+N2+F	N	2	3		10	97	0.71	3	yes	T3	II B **(4)**	yes	PP, EX, A	1	14
3295	HYDROCARBONS, LIQUID, N.O.S. (POLYCYCLIC AROMATIC HYDROCARBONS MIXTURE)	3	F1	III	3+CMR+F	N	2	3	3	10	97	1.08	3	yes	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	0	14

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(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	23; 27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	1	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	23; 27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	27
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	I	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	23; 27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	II	3+CMR+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT ≤ 60°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	1	1			95		1	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	1	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 60°C < INITIAL BOILING POINT ≤ 85°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2	3	50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	23; 27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE 85°C < INITIAL BOILING POINT ≤ 115°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2		50	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3295	HYDROCARBONS, LIQUID, N.O.S. WITH MORE THAN 10% BENZENE INITIAL BOILING POINT > 115°C	3	F1	III	3+CMR+ (N1, N2, N3)	C	2	2		35	95		2	yes	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	27; 44
3295	HYDROCARBONS, LIQUID, N.O.S. CONTAINING ISOPRENE AND PENTADIENE, STABILIZED	3	F1	I	3+unst.+N2+CMR	C	2	2	3	50	95	0.678	1	yes	T4 **(3)**	II B3	yes	PP, EX, A	1	3; 44
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with vp50 < 110 kPa	3	F1	I	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 175 kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	1	1			95		1	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 175kPa ≤ vp50 < 300 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	1	50	95		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 175 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		50	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with 110 kPa ≤ vp50 < 150 kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2	3	10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point < 23°C with vp50<110kPa	3	F1	II	3+(N1, N2, N3, CMR, F or S)	N	2	2		10	97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	1	14; 22; 27
3295	HYDROCARBONS, LIQUID, N.O.S. Flash point ≥ 23°C but ≤ 60°C	3	F1	III	3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	14; 22; 27
3412	FORMIC ACID with not less than 10% but not more than 85% acid by mass	8	C3	II	8+N3	N	2	3		10	97	1.22	3	yes	T1 **(12)**	II A	yes	PP, EP, EX, A	0	6:+12°C; 17; 34
3412	FORMIC ACID with not less than 5% but less than 10% acid by mass	8	C3	III	8	N	2	3		10	97	1.22	3	yes	T1 **(12)**	II A	yes	PP, EP, EX, A	0	6:+12°C; 17; 34
3426	ACRYLAMIDE, SOLUTION	6.1	T1	III	6.1	C	2	2		30	95	1.03	2	no			no	PP, EP, TOX, A	0	3; 5; 16
3429	CHLOROTOLUIDINES, LIQUID	6.1	T1	III	6.1+S	C	2	2		25	95	1.15	2	no	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, TOX, A	0	6:+6°C; 17
3446	NITROTOLUENES, SOLID, MOLTEN (p-NITROTOLUENE)	6.1	T2	II	6.1+N2+S	C	2	2	2	25	95	1.16	2	no	T2 **(12)**	II B (II B3 **(11)**)	yes	PP, EP, EX, TOX, A	2	7; 17
3446	NITROTOLUENES, SOLID, MOLTEN (p-NITROTOLUENE)	6.1	T2	II	6.1+N2+S	C	2	1	4	25	95	1.16	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+88°C; 26
3451	TOLUIDINES, SOLID, MOLTEN (p-TOLUIDINE)	6.1	T2	II	6.1+N1	C	2	2	2	25	95	1.05	2	no	T1 **(12)**	II A **(7)**	yes	PP, EP, EX, TOX, A	2	7; 17

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3451	TOLUIDINES, SOLID, MOLTEN (p-TOLUIDINE)	6.1	T2	II	6.1+N1	C	2	2	4	25	95	1.05	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+60°C
3455	CRESOLS, SOLID, MOLTEN	6.1	TC2	II	6.1+8+N3	C	2	2	2	25	95	1.03 - 1.05	2	no	T1 **(12)**	II A **(7)**	yes	PP, EP, EX, TOX, A	2	7; 17
3455	CRESOLS, SOLID, MOLTEN	6.1	TC2	II	6.1+8+N3	C	2	2	4	25	95	1.03 - 1.05	2	no			no	PP, EP, TOX, A	2	7; 17; 20:+66°C
3463	PROPIONIC ACID with not less than 90% acid by mass	8	CF1	II	8+3+N3	N	3	3			97	0.99	3	yes	T1 **(12)**	II A **(6)**	yes	PP, EP, EX, A	1	34
3475	ETHANOL AND GASOLINE MIXTURE or ETHANOL AND MOTOR SPIRIT MIXTURE or ETHANOL AND PETROL MIXTURE, with more than 10% but not more than 90% éthanol	3	F1	II	3+N2+CMR+F	N	2	3	3	10	97	0.69 - 0.78 **(9)**	3	yes	T3	IIA	yes	PP, EP, EX, TOX, A	1	
3475	ETHANOL AND GASOLINE MIXTURE or ETHANOL AND MOTOR SPIRIT MIXTURE or ETHANOL AND PETROL MIXTURE, with more than 90% éthanol	3	F1	II	3+N2+CMR+F	N	2	3	3	10	97	0.78 - 0.79 **(9)**	3	yes	T2 **(12)**	IIB (II B1)	yes	PP, EP, EX, TOX, A	1	
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	I	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22
3494	Petroleum, sour crude oil, flammable, toxic, 60°C < Initial boiling point ≤ 85°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22; 23

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3494	Petroleum, sour crude oil, flammable, toxic, 85°C < initial boiling point ≤ 115°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22
3494	Petroleum, sour crude oil, flammable, toxic, 115°C < Initial boiling point	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	2	22
3494	Petroleum, sour crude oil, flammable, toxic, 60°C < initial boiling point ≤ 85°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22; 23
3494	Petroleum, sour crude oil, flammable, toxic, 85°C < initial boiling point ≤ 115°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22
3494	Petroleum, sour crude oil, flammable, toxic, 115°C < initial boiling point	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)**	yes	PP, EP, EX, TOX, A	0	22
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	I	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 44
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 44
3494	Petroleum, sour crude oil, flammable, toxic, initial boiling point ≤ 60°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	1	1			95		1	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 44
3494	Petroleum, sour crude oil, flammable, toxic, 60°C < Initial boiling point ≤ 85°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 23; 44
3494	Petroleum, sour crude oil, flammable, toxic, 85°C < initial boiling point ≤ 115°C	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permited	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
3494	Petroleum, sour crude oil, flammable, toxic, 115°C < Initial boiling point	3	TF1	II	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	2	22; 44
3494	Petroleum, sour crude oil, flammable, toxic, 60°C < initial boiling point ≤ 85°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2	3	50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 23; 44
3494	Petroleum, sour crude oil, flammable, toxic, 85°C < initial boiling point ≤ 115°C	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		50	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 44
3494	Petroleum, sour crude oil, flammable, toxic, 115°C < initial boiling point	3	TF1	III	3+6.1+(N1, N2, N3, CMR, F)	C	2	2		35	95		2	no	T4 **(3)**	II B **(4)** (II B3)	yes	PP, EP, EX, TOX, A	0	22; 44
9000	AMMONIA, DEEPLY REFRIGERATED	2	3TC		2.1+2.3+8+N1	G	1	1	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	1; 2; 31
9000	AMMONIA, ANHYDROUS, DEEPLY REFRIGERATED	2	3TC		2.1+2.3+8+N1	G	2	4	1; 3		95		1	no	T1 **(12)**	II A	yes	PP, EP, EX, TOX, A	2	1; 2; 31
9001	SUBSTANCE WITH A FLASHPOINT ABOVE 60 °C, HEATED within a range of 15 K below the flashpoint	3	F4		3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B **(4)**	yes	PP, EX, A	0	22; 27
9001	SUBSTANCE WITH A FLASHPOINT ABOVE 60 °C, HEATED within a range of 15 K below the flashpoint	3	F4		3+(N1, N2, N3, CMR, F or S)	N	3	2			97		3	yes	T4 **(3)**	II B3	yes	PP, EX, A	0	22; 27; 44
9002	SUBSTANCES HAVING A SELF-IGNITION TEMPERATURE ≤ 200 °C, N.O.S.	3	F5		3+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	yes	T4	II B **(4)**	yes	PP, EX, A	0	22; 27
9002	SUBSTANCES HAVING A SELF-IGNITION TEMPERATURE ≤ 200 °C, N.O.S.	3	F5		3+(N1, N2, N3, CMR, F or S)	C	1	1			95		1	yes	T4	II B3	yes	PP, EX, A	0	22; 27; 44

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
9003	SUBSTANCES WITH A FLASH- POINT ABOVE 60°C BUT NOT MORE THAN 100°C or SUBSTANCES WHERE 60°C < flash- point ≤ 100°C, which are not affected to another class (ETHYLENE GLYCOL MONOBUTYL ETHER)	9	M12		9+N3+F	N	4	3			97	0.9	3	yes			no	PP	0	
9003	SUBSTANCES WITH A FLASH- POINT ABOVE 60°C BUT NOT MORE THAN 100°C or SUBSTANCES WHERE 60°C < flash- point ≤ 100°C, which are not affected to another class (2-ETHYLHEXYLACRYLATE)	9	M12		9+N3+F	N	4	3			97	0.89	3	yes			no	PP	0	3; 5; 16
9003	SUBSTANCES WITH A FLASH- POINT ABOVE 60°C BUT NOT MORE THAN 100°C or SUBSTANCES WHERE 60°C < flash- point ≤ 100°C, which are not affected to another class	9	M12		9+(N1, N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP	0	22; 27
9004	DIPHENYLMETHANE- 4.4'- DIISOCYANATE	9	M12		9+S	N	2	3	4	10	95	1.21 **(10)**	3	yes			no	PP	0	7; 8; 17; 19
9005	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S, MOLTEN (maximum transport temperature: T ≤ 80°C)	9	M12		9+(N2, N3, CMR, F or S)	N	4	2	4		95		3	yes			no	PP	0	7; 22; 27
9005	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S, MOLTEN (maximum transport temperature: 80°C < T ≤ 115°C)	9	M12		9+(N2, N3, CMR, F or S)	N	4	1	4		95		3	yes			no	PP	0	7; 22; 25; 27

UN No. or substance identification No.	Name and description	Class	Classification code	Packing group	Danger labels	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the pressure relief valve / high-velocity vent valve in kPa	Maximum degree of filling in %	Relative density at 20°C	Type of sampling device	Pump-room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements / Remarks
(1)	(2)	3(a)	3(b)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
9005	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S, MOLTEN (maximum transport temperature: T > 115°C)	9	M12		9+(N2, N3, CMR, F or S)	N	4	1	4		95		3	yes			no	PP	0	7; 22; 27
9006	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.	9	M12		9+(N2, N3, CMR, F or S)	N	4	2			97		3	yes			no	PP	0	22; 27

(1) The ignition temperature has not been determined in accordance with a standardized determination procedure therefore, provisional assignment has been made to temperature class T2 which is considered safe.

(2) The ignition temperature has not been determined in accordance with a standardized determination procedure therefore, provisional assignment has been made to temperature class T3 which is considered safe.

(3) The ignition temperature has not been determined in accordance with a standardized determination procedure therefore, provisional assignment has been made to temperature class T4 which is considered safe.

(4) The maximum experimental safe gap (MESG) has not been measured in accordance with a standardized determination procedure; therefore, assignment has been made to explosion group II B which is considered safe.

(5) The maximum experimental safe gap (MESG) has not been measured in accordance with a standardized determination procedure; therefore, assignment has been made to explosion group II C which is considered safe.

(6) The maximum experimental safe gap (MESG) has not been measured in accordance with a standardized determination procedure; therefore, assignment has been made to the explosion group that is considered safe.

(7) The maximum experimental safe gap (MESG) has not been measured in accordance with a standardized determination procedure; therefore, assignment has been made to the explosion group in compliance with IEC 60079-20-1."

(8) Assignment in accordance with IMO IBC Code (International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk) (IBC Code).

(9) Relative density at 15°C.

(10) Relative density at 25°C.

(11) No maximum experimental safe gap (MESG) has been determined in accordance with a standardized determination procedure; thus, the substance is provisionally assigned to explosion group II B3, which is considered to be safe.

(12) This temperature class does not apply for the selection of explosion protected installations and equipment. The surface temperature of explosion protected installations and equipment shall not exceed 200° C.

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