TÜRK LOYDU

Chapter 19 – Inland Vessels

January 2020

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR No.29 is on or after 1st of January 2020. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

If there is a difference between the rules in English and in Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version. Once downloaded, this document will become UNCONTROLLED. Please check the website below for the valid version.

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Inland Vessels

AMENDMENTS

Revision	RCS No.	EIF Date*
Section 13	05/2022	01.01.2023
Section 12	03/2021	01.07.2021

* Entry into Force (EIF) Date is provided for general guidance only, EIF dates given in Rule Change Summary (RCS) are considered valid. In addition to the above stated changes, editorial corrections may have been made.

SECTION 1

CLASSIFICATION

A. General

1. Scope, prerequisites

1.1 Purpose of the Rules

1.1.1 The Rules for Classification and surveys of inland navigation vessels cover the Classification of inland navigation vessels as defined in 1.2.5.

1.1.2 The Rules published by **TL** give the requirements for the assignment and the maintenance of Class for inland navigation vessels.

1.1.3 Class assigned to a vessel reflects the discretionary opinion of **TL** 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.

1.1.4 General Terms and Conditions valid at the time of signing of the contract with the party ordering the classification apply.

1.2 General definitions

1.2.1 The following general definitions are used in these Rules.

1.2.2 TL Head Office

TL Head Office means the head office or designated head office department in charge of dealing with Rules and Classification particulars.

1.2.3 Rules

Rules means these Rules for the Classification of inland navigation vessels and documents issued by **TL** serving the same purpose.

1.2.4 Inland navigation vessel

An inland navigation vessel is a vessel designed and operated for inland navigation and related activities.

1.2.5 Classification

Classification means essentially:

- Review/approval of design documents, construction plans and material specifications in comparison with the applicable Rules, Guidelines and Regulations according to Sections 4-17 or other applicable Rules of **TL**.

- Supervision of construction of newbuildings or conversions

- Supervision of vessels in service by surveys required by **TL**'s Rules in order to ascertain that a condition is maintained, which complies with Class requirements

1.2.6 Class designation

The Class designation consists in:

- The Character of Classification, i.e. a sequence of abbreviations indicating the extent of compliance with the applicable Rules and the duration of the Class period

- Notations such as type and service Notations, additional Class Notations as well as range of navigation Notations affixed to the Character of Classification, indicating particular features capability, service restrictions or special equipment and installations, which are included in the Classification

1.2.7 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.

1.2.8 Surveyor

Surveyor means technical staff acting on behalf of **TL** to perform tasks in relation to Classification and survey duties.

1.2.9 Survey

Survey means an intervention by the Surveyor for assignment or maintenance of Class as defined in Section 3, or interventions by Surveyor within the limits of the tasks delegated by the Administrations.

1.2.10 Administration / Authorities

Administration/Authorities means the Government of the state in which the vessel is registered or the state under whose authority the vessel is operating in the specific case.

1.2.11 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.

1.2.12 TL's contractual partner

TL's contractual partner means the party ordering the classification services, which usually is the building yard, a supplier, the owner or operator of the vessel.

1.2.13 Owner

Owner means the Registered Owner or the Disponent Owner or the Manager or any other party responsible for the definition 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 laid down in Section 3.

1.2.14 Review/Approval

Review/Approval means the examination and acceptance by **TL** of documents, procedures or other items related to Classification, verifying solely their compliance with the relevant Rules requirements, or other referentials where requested.

1.2.15 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 **TL** as representative of continuous production.

1.2.16 Building Yard

The Building Yard is the contractual partner of **TL** ordering the newbuilding classification.

1.2.17 Building specification

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

1.2.18 Classification specification

The Classification specification is part of the Classification contract between the Building Yard and **TL** during construction and between the vessel Owner and **TL** after delivery. It specifies the Rules, Guidelines and Regulations forming the technical basis of the Classification as well as scope and necessary details of the Classification and survey procedures and refers to the building specification as far as necessary.

1.2.19 Sister vessels

Sister vessels are vessels built to the same reviewed/ approved plans for Classification purposes. Sister vessels may have minor design alterations provided such alterations do not affect matters related to Classification.

1.2.20 Conditions of Class and Memoranda

Conditions of Class

Any defect and/or deficiency affecting the class and to be dealt with within a specific period of time is indicated as a Condition of Class. Condition of Class is pending until it is cleared. Where it is not cleared by its limit date, the Condition of Class is overdue.

Memoranda

Any defect and/or deficiency, not affecting the maintenance of class, or any other information deemed noteworthy is indicated as a memorandum. Memoranda are not to be regarded as Conditions of Class.

1.3 Meaning of Classification and limits

1.3.1 The following shall apply unless otherwise specified.

1.3.2 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 and the Building Yard. This date is normally to be declared to **TL** by the ordering client applying for the assignment of Class to a newbuilding, see also D.

Special consideration may be given to applying new or modified Rule requirements which entered into force subsequent to the date of the contract, at the discretion of **TL** 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

Requests for interventions by **TL**, 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 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 Terms and Conditions of **TL**.

1.3.3 The date of "contract for construction" of a series of sister 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 and the Building Yard.
The optional vessels will be considered part of the same series of sister vessels if the option is exercised not later than one year after the contract to build the series was signed.

1.3.4 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 and the Building Yard. The amendment to the contract is to be considered as a "new contract" to which 1.3.2 and 1.3.3 apply.

1.3.5 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.

1.3.6 The Rules, surveys performed, reports, Certificates and other documents issued by **TL**, 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. **TL** cannot therefore assume the obligations arising from these functions, even when **TL** is consulted to answer inquiries concerning matters not covered by its Rules, or other documents.

1.3.7 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 of vessel or additional Class Notation assigned.

1.3.8 The Classification-related services and documents performed and issued by **TL** do not relieve the parties concerned of their responsibilities or other contractual obligations expressed or implied or of any liability whatsoever, nor do they create any right or claim in relation to **TL** with regard to such responsibilities, obligations and liabilities. In particular, **TL** does not declare the acceptance or commissioning of a vessel or any part of it, this being the exclusive responsibility of the Owner.

1.3.9 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.

Note:

Refer to 3.2 *as regards the Owner's responsibility for maintenance and operation of the vessel in relation to the maintenance of Class.*

1.3.10 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.

1.3.11 In any case the General Terms and Conditions of **TL** shall be observed.

1.4 Scope of Classification

1.4.1 Classification covers the vessel's hull and machinery including electrical installations as well as special equipment and installations as far as agreed in the respective classification contract. Classification aims primarily at ensuring reliability of the hull structure and machinery systems on board resulting in an adequate level of safety of personnel and environmental protection.
However, Classification is not intended to ensure the effectiveness of the intended missions.

1.4.2 Structures, machinery and equipment determining the type of vessel are subject to examination within the scope of Classification, in accordance with the Character of Classification and affixed Class Notations.
Other systems and components may be included in the Classification and/or certification procedure upon agreement with **TL**'s contractual partner and the Building Yard.

1.4.3 It is assumed that all parties involved in the planning and design, materials and components production and installation have the professional qualifications required and/or suitable facilities/equipment for fabrication. This will normally be established or confirmed by means of a certified quality assurance anagement system in accordance with ISO 9000, or equivalent.

1.5 Statutory Rules and Regulations

International and national Rules and Regulations as, for instance, adopted by the respective Flag State will, as a matter of principle, not be affected by the Rules for Classification and Surveys. However, various requirements stipulated by international conventions are taken into account in **TL**'s Rules. (See also 2.4.1).

2. Application

2.1 General

2.1.1 These Rules apply to all inland navigation vessels intended for inland navigation activities.

2.1.2 Classification according to these Rules applies primarily to new buildings constructed under surveillance of **TL**. Classification may also be applied to existing vessels by a survey for Admission to Class/Classification after construction, if sufficient documentation is available and found acceptable after examination by plan approval division, see D.1.2.

2.2 Interpretation

The interpretation of the Rules is the sole responsibility and at the sole discretion of **TL.**

2.3 Disagreement and appeal

2.3.1 Any technical disagreement with the Surveyor in connection with the performance of his duties should be raised by **TL**'s contractual partner as soon as possible.

2.3.2 **TL**'s contractual partner may appeal in writing to **TL** HO, who will subsequently consider the matter and announce its decision according to its established procedure.

2.4 Duties of TL's contractual partner

2.4.1 International and national Regulations

The Classification of a vessel does not absolve the Owner, Building Yard or any other party responsible for the vessel or parts thereof from compliance with any requirements issued by Administrations. When authorised by the Administration concerned, **TL** will act on its behalf within the limits of such authorisation. In this respect, **TL** will take into account the relevant requirements, survey the vessel, report and issue or contribute to the issue of the corresponding Certificates.

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 conflict between the provisions of the applicable international and national Regulations and those of the Rules, normally, the former take precedence. However, **TL** reserves the right to call for the necessary adaptation to preserve the intention of the Rules.

2.4.2 Surveyor's intervention

For the purpose of verifying compliance with the rules, **TL**'s contractual partner is to provide the **TL**'s surveyors with the free access to vessels and/or to their premises.

The clients are to take the necessary measures for the surveyor's inspections and testing to be carried out safely. The surveyor is to be constantly accompanied during surveys by personnel of the client.

3. Rules, Guidelines and Regulations

3.1 Rules

3.1.1 **TL**'s Rules for the Classification of inland navigation vessels (see Table 1.1) will be applied for structural elements of the hull and for components of the machinery and electrical installations of inland navigation vessels, subject to agreement between the Prospective vessel Owner and the Building Yard for the Classification order to **TL**.

Table 1.1 Rules for the Classification of inland navigation vessels

Section	Title
1-3	Classification and Surveys
4-11	Hull Design and Construction
12-13	Machinery, Systems and Electricity
14-17	Additional Requirements for Notations

3.1.2 When applicable for inland navigation vessels, other **TL**'s Rules, e.g. Rules for high speed craft, Rules for Materials and Welding, Rules for vessels in fibre reinforced plastics, wood, etc., may be used at **TL**'s discretion.

3.1.3 Vessels, not in compliance with 3.1.1 and 3.1.2 may be classed, provided that their structural elements or any installations are found to be equivalent for the respective Character of Classification including Class Notations regarding design, function and structural safety of the vessel.

3.2 Other construction Rules and Regulations

3.2.1 The appraisal of design and construction particulars by **TL** will be exclusively based on Rules and Guidelines, agreed upon in the specification of the Classification contract between the Prospective vessel Owner or the Building Yard and **TL**.

3.2.2 In addition, statutory construction Rules for inland navigation vessels, may be applied upon agreement with the relevant Authority and if defined in the specification of the Classification contract between the Prospective vessel Owner or the Building Yard and **TL**.

3.2.3 The compliance to statutory Regulations of the respective Authority is left to the responsibility of the Prospective vessel Owner and the Building Yard.

3.2.4 International Conventions, Resolutions, Codes, etc., may be applicable in certain cases and/or for certain aspects, e.g. pollution prevention. Details shall be clarified and laid down in the Classification specification in the particular case.

3.3 Industry Codes, Standards, etc.

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, TS.

B. Assignment of Class

1. General

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 **TL** Rules, see A.3.

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 recognised Classification Societies, or
- A specific Admission to Class Survey, in cases where a vessel is classed with a non-recognised Classification Society or is not classed at all

2. New Building Procedure

2.1 Vessel surveyed by TL during construction

2.1.1 When a vessel is surveyed by **TL** 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 A.2.1.

2.1.2 TL:

- Reviews/approves the plans and documentation submitted as required by the Rules, see D.
- 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/approved drawings
- Attends tests and trials provided for in the Rules
- Assigns the Character of Classification, refer to Section 2, A.3.

2.1.3 TL 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.

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 Use of materials, machinery, appliances and items

2.2.1 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 **TL** during construction are to be new and, tested by **TL**.

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

2.2.2 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/approved plans. In particular, the testing of products manufactured according to quality assurance procedures approved by **TL** or judged equivalent by **TL** and the approval of such procedures are governed by the requirements of **TL**.

2.3 Defects or deficiencies and their repairs

2.3.1 TL 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.

2.3.2 All repairs are subject to the preliminary agreement of **TL**. 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.

2.3.3 It is the duty of the Owner and Building Yard to notify **TL** 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.

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

2.4 Equivalence of Rule testing under certain conditions

Notwithstanding the provisions of 2.1.2, **TL** 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 Under Construction

3.1 Vessels built under supervision of a recognized Classification Society

In this case, vessels will be admitted to **TL**'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 reference is to be made to D.

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.

For the documentation to be supplied, see D.1.3.

3.2 Other vessels

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

4. Vessels Classed After Construction

4.1 General

4.1.1 When an Owner requests to **TL** 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 a recognised Classification Society, or

- Not classed with a recognised Society.

4.1.2 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.

4.1.3 For installations or equipment covered by additional Class Notations, **TL** will determine the documentation to be submitted.

4.1.4 In addition, **TL** 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 **TL** in individual cases.

4.2 Vessels classed with a recognised Classification Society

4.2.1 In this case, vessels will be admitted to **TL**'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 reference is to be made to D.2.

4.2.2 Surveys to be carried out are based on the age of the vessel and the updated current Class status of the previous recognised Classification Society, as provided by the Owner.

4.3 Vessels not classed with a recognised Classification Society

4.3.1 In this case, the Class of the vessel will be assigned upon a preliminary review/approval of the documentation listed in D.2.1.3 and subsequent satisfactory completion of the surveys.

4.3.2 The extent and scope of the Admission to Class Survey is 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 type and service Notations and/or additional Class Notations and/or special installations the vessel is provided with.

5. Date of Classification - definitions

5.1 Date of build

For a new building the date of build is the year and month on which the new construction survey process is completed.

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 indicated on the Classification Certificate

- Survey requirements are based on the date of build associated with each major portion of the vessel

5.2 Date of Classification for new buildings

In principle, the initial period of Class is assigned from the day on which the new building has been completed and enters in service. 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.

5.3 Date of Classification for existing vessels

In principle, for existing vessels the date of Classification is the date of completion of the Admission to Class Survey.

6. Period and validity of Class

6.1 Period of Class

The hull, the machinery as well as special equipment and installations classed have, in principle, the same period of Class; see also Section 2, A.3.3.

6.2 Prerequisites for validity of Class

6.2.1 The Class assigned by **TL** is only valid under the provision that the operating conditions are complied with as stated in the Class Certificate, the operation manual and/or as additionally agreed between the vessel Owner and **TL**.

6.2.2 The Classification 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.

6.2.3 In particular, it will be assumed that the draught of the vessel in operating conditions 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.

6.3 Validity of Class

6.3.1 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 Section 3 and that any repairs required as a consequence of such a survey are carried out to the satisfaction of **TL**.

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.

6.3.2 **TL**'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 **TL** 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.

6.3.3 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.

6.3.4 Where defects are found further to an inspection by an Administration, Owners are to:

- Immediately report the outcome of this inspection to **TL**, and

- Ask **TL** to perform a survey in order to verify the deficiencies, when related to the Class of the vessel

6.3.5 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 **TL**

- Reviewed/approved 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.

6.3.6 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 **TL** in due course. This applies particularly to cases, where system changes lead to structural conversions or important changes in the machinery and electrical installation.

6.3.7 **TL** 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.

6.4 Repairs, conversions

6.4.1 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 noncompliance with the Rule requirements are reported to the Surveyor during his survey.

6.4.2 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 **TL** 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 **TL** 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 **TL**'s Head Office.

6.4.3 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 D.

6.4.4 If following major conversions a new Character of Classification and/or new Notations are assigned so that the Class Certificate has to be reissued, commencement of a new period of Class may be agreed upon.

6.5 Change of ownership

6.5.1 In the case of change of ownership, the vessel retains its current Class with **TL** provided that:

- **TL** 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 **TL**'s General Terms and Conditions and Rules. This request covers inter alia the condition of the vessel when changing ownership

6.5.2 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 **TL** has not been advised by the former or, as the case may be, new Owner.

C. 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 **TL**, this fact will 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, **TL** will have to be informed accordingly. **TL** 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 period of more than 3 months.

2. Suspension of Class

2.1 General

2.1.1 The Class may be suspended either automatically or following the decision of **TL**. 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 more draft than that assigned, or has the draft marks placed on the sides in a position higher than that assigned, or, in cases of vessels where draft marks are not assigned

- When the Owner fails to inform **TL** 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 **TL** 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, **TL** 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 **TL**'s Surveyors with a view to completion prior to resuming trading

- When the Intermediate Survey has not been completed by the end of the corresponding survey time window (see Section 3, B.)

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 **TL**:

- 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 **TL**

- When one or more surveys are not held by their limit dates or the dates stipulated by **TL** also taking into account any extensions granted in accordance with the provisions of Section 2, A.3.3

- When, due to reported defects, **TL** 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 **TL** will consider on their merits, e.g. in the event of non-payment of fees

2.1.5 Suspension of Class decided by **TL** 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 **TL** 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

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

3.1.3 When the withdrawal of Class of a vessel comes into effect, **TL** will:

- Forward the Owner written notice

- Delete the vessel from the Register

4. Withdrawal/Suspension 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.

4.1.2 The same procedure may apply to type and service Notations of vessels which are assigned with more than one type and service Notation.

4.1.3 The suspension or withdrawal of a type and service Notation (where a vessel is assigned with more than one type and service Notation) or of an additional Class Notation generally does not affect the Class.

5. Reassignment/Readmission to Class

5.1 General

5.1.1 At the request of the Owner, a vessel which was previously classed with **TL**, subsequently withdrawn from Class and has not been classed since that time, 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 **TL**.

5.1.2 Where, after suspension or withdrawal of Class, the repairs required by **TL** 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, see Section 3.

5.1.3 Depending on the duration of the interruption period, parts of the machinery installation may have to be dismantled and navigation 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.

6. Lay-up and Recommissioning of Laidup Vessels

6.1 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.

6.2 Upon expiry of the Class, a survey substituting the Class Renewal Survey will have to be performed.
An entry on the Class renewal will be made in the Class Certificate, with the Notation **Laid-up** and indicated in the Register

6.3 A vessel put out of commission may be subject to specific requirements for maintenance of Class, as specified below, provided that the Owner notifies **TL** of the fact.

6.4 If the Owner does not notify **TL** 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 Section 3.

6.5 The lay-up maintenance program provides for a "laying- 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 to be agreed with **TL**. The other periodical surveys which become overdue during the lay-up period may be postponed until the recommissioning of the vessel.

6.6 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 6.5.

6.7 The periodical surveys carried out during the lay-up period may be credited, either wholly or in part, at the discretion of **TL**, 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.

6.8 When a vessel is recommissioned, the Owner is to notify **TL** and make provisions for the vessel to be submitted to the following surveys:

- A survey prior to recommissioning, the scope of which depends on the duration of the lay-up period. Depending on the duration of the lay-up period, a navigation trial and/or recommissioning trials of specific installations and/or components will have to be carried out.

- All periodical surveys which have been postponed in accordance with 6.2, taking into account the provisions of 6.4.

6.9 Where the previous period of Class expired before the recommissioning and was extended as stated in 6.3, in addition to the provisions of 6.5 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.

D. 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 **TL**, if needed, by the Building Yard or by the Prospective vessel Owner, using the form provided by **TL**. It should be clearly agreed between the parties concerned, e.g. in the building contract, which party will be responsible for compliance with **TL**'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, **TL** will have to be advised accordingly indicating the scope of the subcontract. The Building Yard and Prospective Owner are responsible for observance of the Rules, Guidelines and Regulations by subcontractors.

1.1.3 When particulars already approved by **TL** for previous inland navigation vessels built under supervision of **TL** 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/approval such as construction plans, calculations, details on materials, type designation of standard equipment, etc. are to be submitted to **TL** at least in triplicate or in electronic format in English or other language agreed upon with **TL** in due time prior to commencement of construction/manufacturing.

The particulars submitted shall contain all details required to verify compliance with the construction Rules. **TL** 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 **TL**, the documents subject to review/approval will be returned in electronic format or one hard copy with a mark/stamp of review/approval. 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 **TL**'s inspection office(s) in charge of construction supervision.

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

1.3 Documentation

1.3.1 The design data, calculations and plans to be submitted for review/approval are listed in applicable requirements of Section 4-17.

1.3.2 The documentation submitted to **TL** is examined in relation to the Class requested in the order for Classification.

1.3.3 Should the Building Yard or Prospective Owner subsequently wish to have the Class, in particular the type and 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/ approved plans regarding items covered by Classification are to be submitted for review/approval.

1.3.5 The plans and design data to be submitted to **TL** 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 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 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 Building Yard or Prospective Owner to ascertain that drawings used for the procurement, construction and other works are in accordance with the reviewed/approved plans.

1.4 Supervision of construction and trials

1.4.1 **TL** will assess the production facilities and procedures of the Building Yard, subcontractors and other manufacturers, to determine whether they meet the requirements of **TL**'s Rules and any additional requirements of the 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 **TL**'s Surveyors, unless otherwise provided as a result of special arrangements agreed upon with **TL**.

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

1.4.3 In order to enable the Surveyor to fulfil 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.

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

- Parts for hull, machinery and electrical installations or special equipment subject to review/approval have been constructed in compliance with the reviewed/approved 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 **TL**'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 **TL**'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 construction Rules.

Where the machinery, electrical installations or special equipment and installations are of novel design or have not yet sufficiently proved their efficiency and reliability under actual service conditions on board, **TL** may require performance of trials under specified severe conditions.

1.5.2 Use of measuring equipment and of service suppliers

Firms providing services on behalf of the Owner or Building Yard, 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 **TL**, as deemed necessary.

The equipment used during tests and inspections in workshops, Building Yard 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. Such equipment is to be individually identified and calibrated to a recognised national or international standard.

1.5.3 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.

1.5.4 Measuring equipment on board

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 machinery and/or equipment installed on board the vessel based either on calibration records or comparison of readings with multiple instruments.

1.5.5 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.

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 to ensure that any deficiencies found, for instance during the navigation trials, have been eliminated.

1.6.2 Reports, Certificates, documentation

Testing of materials, components, machinery, etc. at subcontractor's works will be certified by the Surveyor and/or the local **TL**'s representation.

1.6.3 Upon completion of the construction and the trials on board, the Surveyor will prepare survey reports and a Class Certificate.

1.6.4 The Classification data of each vessel will be included in **TL**'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 **TL** may be classed subsequently following the procedures described in the following.

The vessel's Owner should contact **TL** for the necessary arrangements. **TL** is to be informed about the previous Class status and period, as well as about any conditions of Class imposed by the previous Classification Society. The written order for Admission to Class of existing vessels or special equipment including the required documents shall be formally addressed to **TL**'s Head Office in triplicate, if needed, using the form provided by **TL**.

2.1.2 The following documents updated to present status shall be submitted for examination where applicable. Information shall be provided about any additional Regulations to be observed.

2.1.3 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 vessels less than two years old

- Drawings for flexible couplings and/or torque limiting shafting devices in the propulsion line or manufacturer, make, model and rating information for vessels with the additional Class Notation **Ice**

- 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 **TL** 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/ approved.

2.2.2 Where sufficiently detailed documentation required for review/approval 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 recognized Classification Society, and if sufficient proof has been furnished regarding the present Class status, **TL** 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 Section 3 is to be carried out.

2.3 Reports, certificates, documentation

2.3.1 Upon 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 **TL**, the Rules in force for surveys as well as procedures applicable to vessels constructed under supervision of **TL** will apply.

3. Documentation to be Carried on Board

3.1 General

To allow quick action in case of surveys, special operation and especially in case of damage, the following documentation shall 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 **TL** 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 2

CLASS DESIGNATION

A. General

1. Definitions

1.1 The Class of an inland navigation vessel complying with the **TL** Rules is expressed by the "Character of Classification", assigned for hull and machinery including electrical installations.

1.2 Details about hull, machinery including electrical installations as well as special equipment and installations included in the Classification procedure are indicated by type and service Notations and additional Class Notations affixed to the Character of Classification, see Table 2.2 and Table 2.3.

1.3 The Character of Classification and the 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 Character of Classification and Notations are assigned according to the type, service and range of navigation of the vessel and other criteria which have been provided by the owner or building yard when requesting for Classification.

1.4 **TL** may change the Character of Classification or the 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.

1.5 The Character of Classification and Notations assigned to a vessel are indicated on the Certificate of Classification, as well as in the Register published by **TL**. It will be the decision of the owner or building yard to have the Notations, together with the whole Class designation, included in the published Register of **TL** or not.

1.6 The Character of Classification and Notations applicable to existing vessels conform to the Rules of **TL** in force at the date of assignment of Class, as indicated in 3.1. However, the Character of Classification and Notations of existing vessels may be updated according to the current Rules, as far as applicable.

2. Class Designation

Table 2.1 shows an example of a Class designation for hull and machinery of an inland navigation vessel.

Table 2.1 Example of Class designation

Example of Class designation
+ 1 A5 I (0,6) Z **Double hull Tanker / DP = 57,5kPa / TP = 65kPa** **+ M**

3. Characters of Classification

3.1 Characters of construction for hull and machinery installations

3.1.1 The character **+** heading the Class designation indicates that hull, machinery as well as special equipment and installations included in the Classification have been constructed:

- Under the supervision of and in accordance with the Rules of **TL** at the Building Yard and/or at subcontractors supplying construction components/ hull sections, as applicable

- With certification of **TL** of components and materials requiring inspection subject to **TL** construction Rules.

3.1.2 The character **[+]** will be assigned if the vessel has been designed and constructed in accordance with the Rules and under supervision of another recognized Classification Society and is subsequently - or at a later date - classed with **TL**, see Table 2.2.

3.1.3 The character **(+)** will be assigned to the relevant part of the vessel, where the procedure for the assignment of Classification is other than those detailed in 3.1.1 and 3.1.2, but however deemed acceptable, see Table 2.2.

3.1.4 In the event of Admission to Class (change of Class) from a Society or institution which is not recognized, prior examination of drawings and existing Certificates of the hull structure, the machinery and electrical installations is conditional.

Table 2.2 Characters of classification for hull and machinery

Component	Character	Rule requirements	Example
Hull	**+**	Vessels built under the supervision of **TL** and with certification of components and materials in accordance with the Rules.	**+ 1A5**
	[+]	Vessels built under the supervision of another recognized Classification Society and which have been assigned a class equivalent to **TL**'s Rules of Classification	**[+]1A5**
	(+)	Vessels built under the supervision of **TL** in accordance with the Rules, but , e.g. without certification of components and materials which, however, deemed to be acceptable. It is the responsibility of the Building Yard to ascertain that the materials and equipment used in the vessel's construction satisfactorily meet the Rules requirements	**(+)1A5**
		In the event of Admission to Class or Classification after construction from a Society or institution which is not recognized.	**1A5**
Machinery	**+,** etc.	Same characters followed by **M**	**+ M**

Table 2.3 Characters for compliance with rules

Character	Description
1A5	For vessels that fully meet the construction and scantling requirements.
Z	Where the vessel's anchors and chain cables meet the applicable requirements of the Rules.
(Z)	The character **Z** is replaced by **(Z)**, if the vessel's equipment does not meet the Rule requirements in full, but, however, it is deemed to be acceptable for the intended service.
(-)	Where **TL** considers that it is not called upon to form an opinion on the equipment with regard to particular conditions.

3.1.5 Under the same conditions, one of the characters defined in 3.1.1 to 3.1.3 is assigned, followed by the character **M** to the classed machinery installation.

3.1.6 Generally, one of the construction characters above is assigned, under the same conditions and followed by the appropriate character, to any special equipment for which a Classification Certificate is issued.

3.2 Characters of Class and compliance with Rules

If the vessel's hull fully complies with **TL** Rules - or another recognized Classification Society or other Rules considered to be equivalent, the Character of Classification will be: **1A5**

3.3 Class period

The duration of the class period is 5 years.

3.4 Range of navigation character

The character **I** indicates a vessel on inland navigation waters. Inland navigation waters comprise:

- All inland waterways
- All semi-maritime stretches of water up to wave height of 2 m
- Other waters showing comparable conditions

Note :

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 an inland navigation Notation or one of the navigation Notations listed in the Rules for seagoing vessels.

The character **I** is completed, between brackets, with the significant wave height for which the vessel has been calculated. See also B.10.

3.5 Equipment Character

3.5.1 The character **Z**, placed after the range of navigation, indicates that the vessel's equipment on anchors and chain cables meet the applicable requirements of the Rules.

3.5.2 Where the vessel's equipment does not meet the Rule requirements, but is deemed by **TL** to be acceptable for the intended service, the character **Z** is replaced by **(Z)**.

3.5.3 Where **TL** considers that it is not called upon to form an opinion on the anchor equipment, with regard to particular conditions, the character **Z** is replaced by **(-)**.

B. Classification Notations

1. General

1.1 There are different kinds of Notations, such as type and service Notations, describing particular features, capabilities, service restrictions or special equipment and installations included in the Classification, as defined in the following.

1.2 The Notations to be affixed to the Character of Classification related to the type and service of the vessel are optional and may be elected by the owner or building yard. The chosen scope of Notations has to be defined in the Classification specification as well as in the building specification.

2. Notations

2.1 General

2.1.1 Generally, the Notations will be assigned according to the indications or suggestions of the prospective vessel owner or building yard.

2.1.2 A Notation indicating the type and service of the vessel will be added to the Class designation, such as:

Cargo vessel, **Tanker**, etc.

2.1.3 The Notations, which have been considered for Classification, define the type and service of the vessel according to the request for Classification signed by the prospective owner or building yard. The assignment of any Notation to a new vessel is subject to compliance with the general Rule requirements laid down in **TL** Rules for Inland Navigation Vessels.

2.1.4 The Notations applicable to existing vessels conform to the Rules of **TL** in force at the date of assignment of Class. However, the Notations of existing vessels may be updated according to the current Rules, as far as applicable, at the request of the owner.

2.1.5 A Notation may be completed by one or more additional Class Notations, giving further precision regarding the type or service of the vessel, for some of which specific Rule requirements are applied.

2.1.6 The various type and service Notations which may be assigned to a vessel are listed in alphabetical order in Table 2.4. The additional Class Notations to the type and service Notations are listed in Table 2.5.

2.1.7 Where the intended duties of the vessel include support functions, they may be described by 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 of or in addition to the Notations referred to, when the applicable Rule requirements are met, e.g.:

- **HSC** for high speed craft
- **PATROL BOAT**
- **SUPPLY VESSEL**

2.1.8 **TL** reserves the right to grant other type and service Notations or additional Class Notations.

3. Notations for Vessels Carrying Dry Cargoes

3.1 Type and service Notations

3.1.1 Cargo vessel

The type and service Notation **Cargo vessel** applies to vessels intended for the carriage of solid cargo and/or bulk complying with the Section 14, A. or B., as applicable.

3.1.2 Container vessel

The type and service Notation **Container vessel** applies to vessels specially intended for the carriage of containers complying with Section 15, B.

3.1.3 Barge

The type and service Notation **Barge** applies to vessels without propulsion intended for the carriage of solid cargo and/or bulk complying with Section 14, A. or B., as applicable.

Table 2.4 **List of type and service notations**

Type and service notation	Reference for definition	Applicable rules
Barge	3.1.3	Section 14, A. or B. as applicable
Cargo vessel	3.1.1	Section 14, A. or B. as applicable
Container vessel	3.1.2	Section 15, B
Dredger (1)	6.1.1	Section 15,G
Excursion boat	5.1.3	Section 15, D
Hopper barge	6.1.3	Section 15,G
Hopper dredger (1)	6.1.2	Section 15,G
Hotel ship	5.1.2	Section 15,D
Launch	7.1.3	Section 15,H
Passenger vessel	5.1.1	Section 15,D
Pontoon (2)	7.1.4	Section 15,F
Pushed barge	3.1.4	Section 14, A. or B. as applicable
Pusher	7.1.2	Section 15,E
Restaurant ship	5.1.4	Section 15,D
Ro-Ro vessel	3.1.5	Section 15,C
Special service (3)	8.1.1	**TL** Rules
Split hopper barge	6.1.4	**TL** Rules
Tanker	4.1.1	Section 15,A
Tug	7.1.1	Section 15,E

(1) *This Notation may be completed by the type of the dredger, e.g.* **Hopper suction dredger**.
(2) *This Notation may be completed by the type of installations on deck of the pontoon, e.g.* **Pontoon /Crane**.
(3) *This Notation may be completed by the type of vessel, e.g.* **Floating dock.** *This type of vessel is considered on a case by case basis by **TL**, according to its type and service.*

3.1.4 Pushed barge

The type and service Notation **Pushed barge** applies to vessels without propulsion as part of a pushed convoy intended for the carriage of solid cargo and/or bulk complying with Section 14, A. or B., as applicable.

3.1.5 Ro-Ro vessel

The type and service Notation **Ro-Ro vessel** applies to vessels specially intended to carry vehicles, trains and loads on wheeled beds, complying with Section 15, C.

3.2 Additional class notations

3.2.1 Equipped for transport of containers

The type and service Notation **Cargo vessel** may be completed with the additional Class Notation **Equipped for transport of containers**, where the vessel complies with the Rule requirements stated under Section 17, C.

3.2.2 Equipped for transport of wheeled vehicles

The type and service Notation **Cargo vessel** may also be completed with the additional Class Notation **Equipped for transport of wheeled vehicles**, where the vessel

complies with the Rule requirements stated under Section 17, D.

3.2.3 DG

The type and service Notation **Cargo vessel** will be completed by the additional Class Notation **DG** when the cargo vessel is designed to carry dry dangerous goods in compliance with Section 16.

3.2.4 1R

The type and service Notation **Cargo vessel** will be completed by the additional Class Notation **1R**, when the cargo vessel's structure is designed for loading and unloading in one run.

3.2.5 2R

The type and service Notation **Cargo vessel** will be completed by the additional Class Notation **2R**, when the vessel’s structure is designed for loading and unloading in two runs.

3.2.6 Heavy cargo

The type and service Notation **Cargo vessel** will be completed by the additional Class Notation **Heavy cargo [AREA1, x_1 kN/m^2 - AREA2, x_2 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 values x_1 indicate the maximum allowable local pressures on the various zones AREA$_i$ where the cargo is intended to be stowed. The requirements for the assignment of this additional Class Notation are given in Section 17, B.

3.2.7 Nonhomload

The type and service Notation **Cargo vessel** will be completed by the additional Class Notation **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 Class Notation can be completed with the indication of the different maximum loads allowed in each hold and which holds may be empty, if appropriate.

3.2.8 Grabloading

The Notation **Grabloading** may be assigned to vessels with hold tank tops specially reinforced for loading/ unloading cargoes by means of grabs or buckets. The requirements for the assignment of this Notation are given in Section 17, A.3.

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

This Notation may only be assigned to vessels with the type and service Notation **Cargo vessel**.

Table 2.5 List of additional class notations

Additional class notation	Reference for definition	Applicable Rules
Notations related to type of construction **(1)**		
Double hull	9.2.2	Section 8, B. and C.
Single hull	9.2.2	Section 8, B. and C
With double bottom	9.2.2	Section 8, B.
With double sides	9.2.2	Section 8, C.
Notations related to hull materials **(1)**		
HS	9.2.1	
AL	9.2.1	
C	9.2.1	
W	9.2.1	
Other notations **(1)**		
Ice	9.3.1	
Ind	9.2.3	Section 17,A.2
No-propulsion	9.2.4	
FS	9.4.2	Section 17,F
Max. density	9.2.5	
Max. t°C	9.2.5	
Additional to cargo vessels		
1R	3.2.4	
2R	3.2.5	
Grabloading	3.2.8	Section 17,A.3
Heavy cargo [AREA1,x_1 kN/m^2 - AREA2,x_2 kN/m^2]	3.2.6	Section 17,B
Nonhomload	3.2.7	
Equipped for transport of containers	3.2.1	Section 17,C
Equipped fot transport of wheeled vehicles	3.2.2	Section 17,D
DG	3.2.3	Section 16
Additional to passenger vessels		
Ferry	5.2.1	Section 17,E
Additional to tankers		
TP= x kPa	4.2.1	
DP=x kPa	4.2.1	
Type G	4.2.2	Section 16
Type C	4.2.3	Section 16
Type N closed	4.2.4	Section 16
Type N open with flame arresters	4.2.5	Section 16
Type N open	4.2.6	Section 16
Type N open - Bunkerboat	4.2.7	Section 16
Type N open - Bilgesboat	4.2.8	Section 16
Flash point > 60°C	4.2.9	Section 16
Notation related to class		
Laid-up	Section 1, C.6.1.2	
(1) *Additional to all veseels*		

4. Notations for vessels carrying liquids or gazeous cargo in bulk

4.1 Type and service Notations

4.1.1 Tanker

The type and service Notation **Tanker** applies to vessels specially intended to carry liquid or gazeous cargo in bulk, in compliance with requirements stated under Section 15, A.

The list of cargoes the tanker is allowed to carry will be issued by **TL**, in the case of transport of dangerous goods (see Section 16.).

4.2 Additional Class Notations

4.2.1 TP and DP

In addition to the type and service Notation **Tanker**, the test pressure **TP** and the design pressure **DP** of the cargo tanks, expressed in kPa, are added as additional Class Notations.

4.2.2 Type G

Type G, applies to a tanker built and equipped in compliance with the applicable requirements of Section 16.

4.2.3 Type C

Type C, applies to a tanker built and equipped in compliance with the applicable requirements of Section 16.

4.2.4 Type N closed

Type N closed, applies to a tanker built and equipped in compliance with the applicable requirements of Section 16.

4.2.5 Type N open with flame arresters

Type N open with flame arresters, applies to a tanker built and equipped in compliance with the applicable requirements of Section 16.

4.2.6 Type N open

Type N open, applies to a tanker built and equipped in compliance with the applicable requirements of Section16, B.

4.2.7 Type N open - Bunkerboat

Type N open- Bunkerboat, applies to a tanker built and equipped in compliance with the applicable requirements of Section 16.

4.2.8 Type N open - Bilgesboat

Type N open- Bilgesboat, applies to a tanker built and equipped in compliance with the applicable requirements of, Section 16.

4.2.9 Flash point > 60 °C

The type and service Notation may be completed by the additional Class Notation **Flash point > 60 °C**, where the tanker is intended to carry only such type of products, under certain conditions.

5. Notations for vessels carrying passengers

5.1 Type and service Notation

5.1.1 Passenger vessel

The type and service Notation **Passenger vessel**, applies to vessels specially intended to carry passengers complying with the Section 15, D.

5.1.2 Hotel ship

Type and service notation **Hotel ship** for vessels complying with Section 15, D. for passenger vessels, excluding the requirements for vessel arrangement, fire protection, fire detection and extinguishing, electrical installations, buoyancy and stability (para. 3. to 6.).

The requirements (para. 3. to 6.) are outside the scope of Classification however evidence is to be provided that for these items, alternative arrangements in accordance with flag state requirements are in place.

This type of vessel sails in national service only.

5.1.3 Excursion boat

Type and service notation **Excursion boat** for vessels complying with, Section 15, D. for passenger vessels, excluding the requirements for vessel arrangement, fire protection, fire detection and extinguishing, electrical installations, buoyancy and stability (para. 3 to 6).

The requirements (para. 3. to 6.) are outside the scope of Classification however evidence is to be provided that for these items, alternative arrangements in accordance with flag state requirements are in place.

This type of vessel sails in national service only.

5.1.4 Restaurant ship

Type and service notation **Restaurant ship** for vessels complying with, Section 15, D. for passenger vessels, excluding the requirements for vessel arrangement, fire protection, fire detection and extinguishing, electrical installations, buoyancy and stability (Para 3. to 6).

The requirements (para. 3. to 6.) are outside the scope of Classification however evidence is to be provided that for these items, alternative arrangements in accordance with flag state requirements are in place.

This type of vessel sails in national service only.

5.2 Additional Class Notations

5.2.1 Ferry

The type and service Notation **Passenger vessel**, may be completed by the additional Class Notation **Ferry**, for vessels specially equipped to load wheeled vehicles, complying with Section 17, E.

6. Notations for vessels for dredging activities

6.1 Type and service Notations

6.1.1 Dredger

The type and service Notation **Dredger**, applies to vessels specially equipped only for dredging activities (excluding carrying dredged material), complying with, Section 15, G.

6.1.2 Hopper dredger

The type and service Notation **Hopper dredger**, applies to vessels specially equipped for dredging activities and carrying spoils or dredged material, complying with the applicable requirements of Section 15, G.

6.1.3 Hopper barge

The type and service Notation **Hopper barge**, applies to vessels specially equipped for carrying spoils or dredged material only, complying with the applicable requirements of Section 15, G.

6.1.4 Split hopper barge

The type and service Notation **Split hopper barge**, applies to vessels specially equipped for carrying spoils or dredged material only, and which open longitudinally around hinges in compliance with **TL** Rules.

7. Notations for working units

7.1 Type and service Notations

7.1.1 Tug

The type and service Notation **Tug**, applies to vessels specially equipped for towing, complying with applicable requirements of Section 15, E.

7.1.2 Pusher

The type and service Notation **Pusher**, applies to vessels specially equipped for pushing, complying with applicable requirements of Section 15, E..

7.1.3 Pontoon

The type and service Notation **Pontoon** is assigned to units intended to carry cargo and/or equipment on deck only, complying with Section 15, F.

When a crane is permanently fitted on board, the type and service Notation **Pontoon** is completed with **"Crane"** for information only.

8. Notations for miscellaneous units

8.1 Type and service Notations

8.1.1 Special service

The type and service Notation **Special service** is assigned to vessels which, due to the peculiar characteristics of their activity, are not covered by any of the type and service Notations mentioned above. The Classification requirements of such units are considered by **TL** on a case by case basis.

This type and 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.

An additional service Notation may be specified after the type and service Notation, e.g. **Special service/ Floating dock**, 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.

9. Other additional Class Notations

9.1 General

9.1.1 Other additional Class Notations express the Classification of additional equipment or specific arrangement, which has been requested by the Owner or Building Yard.

9.1.2 The assignment of these additional Class Notations is subject to the compliance with applicable additional Rule requirements.

9.2 Special considerations for hull structures

9.2.1 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
- **AL** for aluminium
- **C** for composite materials such as FRP
- **W** for wood

Material selection, design, dimensioning and manufacturing of hull structures made of composite materials, such as fibre reinforced plastics (**C**), or wood (**W**) are to be agreed upon case by case with **TL**

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9.2.2 Type of construction

Based on the different types of construction of the hull of each vessel or unit, the following additional Notations are added as prefix to the type and service Notation:

- **Single hull**, to vessels and units the hull of which is completely built with a single hull structure, as per applicable requirements of the Rules

- **Double hull**, to vessels and units the hull of which is completely built with a double hull structure, as per applicable Rules requirements

- **With double bottom**, to single hull vessels and units of which the hull is built with a double bottom only, as per applicable Rules requirements

- **With double sides**, to single hull vessels and units of which the hull is built with double sides only, as per applicable Rules requirements

9.2.3 Independent cargo tank

A vessel carrying substances in independent cargo tanks which meet the requirements of the Rules, in particular those concerning parallelepipedic cargo tanks, or cylindrical pressure tanks, will be assigned the Notation **Ind** placed after the type and service Notation.

9.2.4 No-propulsion

Each non-propelled vessel or unit will be assigned the additional Class Notation **No-propulsion**, to be added to its type and service Notation, e.g. **Dredger/ No-propulsion**.

9.2.5 Max. density - Max. t°

When applicable, the maximum allowed density, **Max. density** and/or temperature, **Max. t°** of the cargo or the liquids carried can be added to the type and service Notation as an additional Class Notation.

9.3 Navigation in ice

9.3.1 Ice

The additional Class Notation **Ice** is assigned to vessels the hull and machinery installation of which are designed such as to comply with the Rules requirements for navigation in drift ice in compliance with the applicable requirements of Section 17, A.

9.4 Stability notations

9.4.1 Damage stability

The additional Class Notation **FS** can be assigned to vessels for which a damage stability calculation have been examined by **TL** and found to comply with specific requirements Section 17,F.

The Certificate/attestation 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.

9.4.2 The Certificates/attestations 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 **TL** is not available on board

- The Classification Certificate is not valid

The above mentioned validity is also applicable for other Class Notations considering damage stability calculations.

9.5 Miscellaneous additional Class Notations

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

9.5.2 Procedures as developed by IMO such as LLC 66/88 and other Codes for seagoing ships may be adopted, as far as practicable, if no equivalent adequate Regulations are available.

10. Range of Navigation

10.1 General

10.1.1 The assignment of one of these Notations does not absolve the owner 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 Section 1, A.3.2.

10.1.2 Upon request of the prospective owner for a particular navigation condition, **TL** can calculate the vessel's scantlings for any wave height between 1,2 m and 2 m, based on the provisions in the construction Rules, to be defined by **TL**. In such cases, the range of navigation Notation will be assigned accordingly.

10.1.3 The range of navigation which **TL** 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 navigation Notation assigned by **TL** and a navigation zone or category as defined by national or international Regulations.

For vessels trading in defined river systems or waters only, deviations from the Rules requirements for the equipment may be either admitted or required by the Authorities. In such cases, the range of navigation character will be supplemented by indication of the respective area or river system, e.g. **KEBAN** or **DANUBE.**

10.2 Range of navigation I (0)

The range of navigation **I (0)** is assigned to a vessel having a structure with scantlings deemed suitable to navigate on still and smooth stretches of water.

10.3 Range of navigation I (0,6)

The range of navigation **I (0,6)** 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 maximum significant wave height of 0,6 m can develop.

10.4 Range of navigation I (1,2)

The range of navigation **I (1,2)** is assigned to a vessel having a structure with scantlings deemed suitable to navigate on semi-maritime stretches of water or lakes on which a maximum significant wave height of 1,2 m can develop. See also 10.1.2.

10.5 Range of navigation I (2)

The range of navigation **I (2)** is assigned to a vessel having a structure with scantlings deemed suitable to navigate on semi-maritime stretches of water or lakes on which a maximum significant wave height of 2 m can develop. See also 10.1.2.

SECTION 3

SURVEYS

A. General

1. Surveys for Maintenance of Class

1.1 For maintenance of Class, the regular periodical and non-periodical surveys of hull and machinery, including electrical installations as well as special equipment and installations agreed to be in the scope of Classification have to be performed as detailed in the following, see also Section 1, B.6.2.

The periodical surveys include:

- The Class Renewal Survey, see C.
- The Intermediate Survey, see B.
- The bottom survey, see E.
- The propeller shaft survey, see C.10.
- The boiler survey, see F.

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.

Where there are no specific survey requirements for additional Class Notations assigned to a vessel, the 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.

The surveys are to be carried out in accordance with the relevant requirements in order to confirm that the hull, machinery, including electrical installations, equipment and appliances comply with the applicable Rules and will remain in satisfactory condition.

Where the conditions for the maintenance of type and service Notations and additional Class Notations are not complied with, the type and service notation and/or the additional Class Notations as appropriate will be suspended and/or withdrawn in accordance with the applicable Rules given in Section 1, C.

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

Unless specified otherwise, any survey other than bottom, propeller shaft or boiler survey may be effected by carrying out partial surveys or splitting of surveys, e.g. continuous survey hull and machinery, at different times to be agreed upon with **TL**, provided that such a survey procedure is adequately extensive. The splitting of a survey is to be such as not to impair its effectiveness.

1.2 In addition to the above periodical surveys, vessels are to be submitted to non-periodical surveys such as occasional surveys whenever the circumstances so require.

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 and port of registration
- Damage or suspected damage
- Repair or replacement work
- Alterations or conversion
- Extraordinary surveys as parts of **TL**'s quality assurance system
- Postponement of surveys or of conditions of Class/recommendations

TL 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 following applies:

- In the case of a Class Renewal Survey, **TL** 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 **TL** is satisfied that there is justification for such an extension. In the case of Intermediate Surveys, no postponement is granted. The survey is to be completed within their prescribed windows.

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

1.3 General procedure of survey

1.3.1 The general procedure of survey consists in:

- An overall examination of the parts of the vessel covered by the Rule requirements

- At random checking of selected items covered by the Rule requirements

- Attending tests and trials where applicable and deemed necessary by the Surveyor

1.3.2 When a survey results in the identification of 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 are to be implemented before the vessel continues in service.

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

1.4 Definitions and procedures related to surveys

1.4.1 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.

1.4.2 Conditions of Class/recommendations

Any defect and/or deficiency affecting the Class, and which has to be dealt with within a limited period of time is indicated as a condition of Class/recommendation.

A condition of Class/recommendation is pending until it is settled. Where it is not settled by its limit date, the condition of Class/recommendation is overdue.

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1.5 Preparations and conditions for surveys

1.5.1 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 **TL**’s Head Office or the local **TL** representations in due time, so that the measures envisaged may be assessed and supervised as required.

1.5.2 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 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.

1.5.3 In special cases, e.g. where damages require immediate inspection and decisions, a survey may be conducted while the vessel is not in harbour. The prerequisites, procedure and specific conditions to be met, e.g. weather, will be fixed case by case. The decision as to feasibility of the survey may only be taken in agreement with the Surveyor.

1.5.4 **TL** 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, see Section 1, B.

1.5.5 Upon request **TL** may agree to testing, monitoring and analysis procedures as a supplement to or equivalent substitute for conventional survey methods.

1.5.6 **TL** 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, **TL** reserves the right to demand surveys to be held between the due dates of regular periodical surveys.

2. Selection of Surveyors

2.1 General

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

3. Documentation of Surveys, Confirmation of Class

3.1 General

3.1.1 The records of each survey, as well as any requirements upon which maintenance of Class has been made conditional, will be entered into the respective Survey Statement/Certificate.

By his signature in the certificate and other documents the Surveyor certifies what he himself has seen and checked during the particular survey.

3.1.2 In the Register the dates of the surveys will be indicated.

3.1.3 On request, the Class status may be confirmed in writing by a separate certificate/attestation issued by **TL**.

3.1.4 Where defects are repaired provisionally only, or where the Surveyor does not consider immediate repair or replacement necessary, the vessel's Class may be confirmed for a limited period. Cancellation of such limitations will have to be indicated in the Survey Statement/Certificate.

4. Surveys in Accordance With Regulations of the Authority

4.1 General

All activities outlined in 4.2 and 4.3 and, where applicable, issuance of relevant certificates/attestations is likewise subject to the respective latest edition of Society's General Terms and Conditions.

4.2 TL's intervention

Where surveys are requested by the Owner on account of international conventions, **TL** 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.

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

4.3 Validity of Certificates/attestations

If for some reason a vessel's Class has expired or has been withdrawn by **TL**, all Certificates/attestations issued by **TL** will automatically become void. If subsequently the Class is renewed or reassigned, the validity of these Certificates/attestations may be revived within the scope of their original period of validity, provided that all surveys meanwhile having fallen due have been carried out to the satisfaction of the Surveyor.

5. External Service Suppliers

5.1 General

Personnel or firms engaged in services affecting Classification and statutory work are subject to approval by **TL**.

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.

6. Periodical Surveys

6.1 General

6.1.1 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 inland navigation vessel.

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.

6.1.2 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.

7. Surveys Relative to Class Notations from other TL’s Rules

7.1 General

The surveys requested for granting of Class Notations defined in **TL**'s Rules but not in inland navigation Rules have to be performed according to corresponding requirements for maintenance of Class.

8. Class Extension Surveys

8.1 General

On owner’s special request and following surveys of hull and machinery afloat, **TL** may within two periods of Class, extend the Class by no more than 12 months in total, provided that the surveys show that hull and machinery are in unobjectionable condition.

In that case, the last survey in dry-dock shall not date back more than 5 years, counting from the date of the respective Class renewal survey.

With ships of over 20 years of age or the hull structural elements of which are riveted, the last survey in dry-dock shall not date back more than 3 years.

B. Intermediate Surveys

1. General

The Intermediate Survey becomes due 2,5 years after the commencement of the period of class and has to be carried out between six month before to six month after this date.

2. Surveys performance

2.1 General

2.1.1 Intermediate Surveys shall include all the inspections and checks required for eventual annual surveys. Additionally, the following requirements shall be observed.

Note :

More extensive Regulations of the country, where the vessel is registered, are to be observed.

2.1.2 The requirements apply to inland navigation vessels in general. Additional requirements may have to be observed for particular vessel types, due to request of the Owner or in connection with manufacturer's recommendations for special equipment.

3. Hull Structure

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 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 G.2.10), 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 case of a repair. The whole working procedure including the surface preparation has to be documented.

3.1.5 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.

3.1.6 Hatches and covers, bow, side and stern doors

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.

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

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.

3.2 Dry dock survey

When the vessel is granted with the range of navigation **I (1,2)** to **I (2)**, a dry dock survey has to be carried out. 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.

For performance of dry dock surveys, see E.

4. Machinery

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 F.
- Inspection and checking of the remote control, quickclosing/ 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

4.1.2 Fire extinguishing systems

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

4.1.3 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.

4.1.4 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 shall be subjected to a visual check. All hose assemblies made of synthetic rubber shall 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 recognised specialized companies.

4.1.5 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.

4.1.6 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 of the Owner regarding other inspection intervals/performance of the tests should be observed.

4.1.7 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)
- Axial thrust bearing clearance of main and auxiliary gas turbine rotors (where applicable)
- Insulation resistance of generators and electrical motors, including cabling and switch gear.

4.1.8 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

4.1.9 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.

4.1.10 Machinery installations and safety systems on tankers

On tankers the following installations and equipment are to be checked:

- Electrical equipment, in particular electrical installations in areas of explosion hazard, in which ignitable gas mixtures or water vapours may accumulate
- 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

On gas tankers, the following additional surveys are to be carried out:

- Venting system of cargo tanks and holds spaces
- All gastight bulkhead penetrations including gastight shaft sealing, if provided
- Cargo handling control and safety systems, if practicable, such as:
  - Emergency shut down valves at shore connections and tanks
  - Control, alarm and safety sytems 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
- Gas detection equipment including indicators and alarms in operation
- Ventilation systems of all spaces in cargo area
- Inert gas or dry air installations in operation, including the means for preventing backflow of cargo vapour to gas safe areas
- Gastightness of wheelhouse doors and windows
- Sealing arrangement 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.

5. Installations Under Pressure

For steam boiler installations, thermal oil plants and pressure vessels, see F.

C. Class Renewal Surveys

1. General

1.1 Scope

1.1.1 Class Renewal Surveys - also called special surveys - are to be carried out at the intervals p indicated by the Character of Class period.

1.1.2 Upon request, in exceptional cases extension of the Class period may be granted by **TL**, see A.8.1.

1.1.3 Class renewals for hull are numbered in the sequence I, II, III, etc. Regarding their scope, see 2.

1.1.4 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 1.1.2, the total survey period of the Class Renewal Survey shall not exceed 12 months, except under special circumstances and by prior agreement from **TL**.

1.1.5 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 extension period expires

- 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.

1.2 Class Renewal Survey performance

1.2.1 In addition to the inspections and checks to be carried out on occasion of the Intermediate Surveys, for class Renewal the following requirements shall be observed.

1.2.2 The Class Renewal Survey is in principle to be held 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 1.1.4 and E.

2. Hull and Hull Equipment

2.1 Class Renewal I

2.1.1 Class Renewal I will have to be performed at the end of the first Class period p. For definition see Section 1, A.1.2.7.

2.1.2 Conditions for surveys

When examination of associated structure is required, insulation of compartments intended for refrigerated cargoes is to be removed over the necessary extent for examination by the Surveyor of the condition of the structure, unless constructional arrangements make such inspections possible without removing the insulation.

If deemed necessary by the Surveyor, defective cement and asphalt covering are to be removed. The steel work is to be examined before painting or before the cement or other coverings are renewed.

2.1.3 Equipment for surveys

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

- Radiography (X or gamma rays)

- Ultrasonic test

- Magnetic particle test

- Dye penetrant test

2.1.4 Hull, general

At the Surveyor's discretion, the survey on principle covers the whole hull structure, particularly those areas which from experience are known to be exposed to fatigue and corrosion, such as openings in the shell and in the deck including doors and hatch coamings and covers, tanks, engine foundations and ends of superstructures. As a matter of principle, all machinery spaces, dry spaces, store rooms, pipe tunnels, cofferdams and void spaces are to be examined, including the piping systems.

2.1.5 Tank surveys

The ballast tanks are to be inspected at the Surveyor's discretion, the procedure as outlined in 2.3.3 shall be followed.

Fuel oil, lubricating oil and fresh water tanks need not to be emptied, if their tightness can be verified by an external examination while they are completely filled and there is no reason for doubt as to their unobjectionable condition. However, fore and after peak are in any case subject to internal examinations at each Class Renewal Survey.

2.1.6 Tightness and pressure tests

Each compartment of the double bottom, cofferdams and all tanks, the boundary plating of which forms part of the vessel's main structure, are to be subjected to pressure tests. Fuel oil, lubricating oil and fresh water tanks may be tested by filling with the respective liquid.

The test pressure applied is to correspond to a head ofwater up to the top of the overflow/air pipe or up to the hatch of a tank, where applicable, whichever is higher. For oil, lubricating oil tanks, the test pressure applied is to correspond to a head of liquid up to the top of the tank.

The tightness of pipe tunnels outside the inner bottom, and of void spaces, may be tested by air pressure. Air pressure testing of other spaces is to be agreed with the Surveyor from case to case. The overpressure shall not exceed 0,2 bar and not be less than 0,1 bar.

2.1.7 Thickness measurements

If the Surveyor has reason to suspect inadmissible corrosion, he may require the rust to be removed from parts of the structure and thickness measurements to be carried out, see G.

2.1.8 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, 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.

2.1.9 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.
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

2.1.10 Tankers

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 2.1.6.

During each Class renewal, the cofferdams of tankers are to be hydrostatically tested to the test pressure as defined in Section 5, D. and Section 11, C.

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 2.1.6. Where substances are carried which cause corrosion in connection with water, the kind of testing is to be specified.

At each Class renewal, 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 Section 5, D., depends on the density of the cargo.

2.1.11 Gas tankers

In addition to the requirements given under 2.1.10, the renewal survey of these vessels consists of the following examinations, measurements and testing:

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 **TL**.

- 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 tankplates, 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 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, penetraing 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.

2.1.12 Tankers, piping systems

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.

Note :
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.

2.2 Class Renewal II

2.2.1 The requirements for the second Class Renewal include those for Class Renewal I. Additionally the following investigations are to be carried out.

2.2.2 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 2.3.2.

2.2.3 In principle, all tanks and cargo tanks are to be examined internally. The fuel oil, lubricating oil and fresh water tanks are to be at least examined at random, as required by the Surveyor. If applicable, in vessels aged 2p years and over, during the Class Renewal Survey, all ballast tanks are to be examined for damages to the hull structural elements and to the coating. If applicable the procedure as outlined in B.3.1.4 shall be followed.
Peak tanks see 2.1.5.

2.2.4 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.

2.2.5 For thickness measurements, see G.

2.3 Class Renewal III and subsequent ones

2.3.1 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.

2.3.2 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.

2.3.3 All tanks and cargo tanks are to be examined internally. The fuel oil, lubricating oil and fresh water tanks are to be examined internally and tested in accordance with the requirements, at the Surveyor's discretion, see also 2.2.3. In the case of ballast tanks the procedure as outlined in B.3.1.4 shall be followed, if applicable.

Peak tanks see 2.1.5.

2.3.4 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.

2.3.5 The weight of the anchors is to be checked.

3. Machinery

3.1 General

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. If the continuous Class Renewal system is applied, the indications according to **TL** are to be observed.

The Class Renewal Survey includes the surveys and checks in B.4.

3.2 Surveys requiring dry docking

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 9.

3.3 Propulsion system and auxiliaries

3.3.1 General

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 3.3.2.

Spring elements made of rubber ring clutches with or without plies of fabric and under shear load, and other rubber or fibre reinforced plastic couplings are to be renewed, if required on account of negative inspection results.

3.3.2 Main propulsion diesel engines

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 b

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.

3.3.3 Auxiliary engines

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.

3.4 Auxiliary machinery, equipment and piping, survey performance

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.

3.5 Gas tankers

3.5.1 Cargo handling installation

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.

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.

3.5.2 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 :

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. Electrical Installations

4.1 Propulsion machinery

If the vessel is propelled by electrical machinery, the propulsion motors, the propulsion generators and exciters, particularly the windings of these machines, and their ventilating systems are to be examined and tested. Checking of the electric switch gear for operability is to cover also the protective, safety and interlocking devices.

The electric cables and their connections are to be inspected.

The insulation resistance of all electric machinery and equipment is to be tested.

4.2 Dynamic positioning systems

Dynamic positioning systems, if any, including control systems, are to be subjected to operational tests.

4.3 Auxiliary machinery and systems

The electrical machinery and equipment, including the generators, the motors of the essential services, the switch gear including its protective and interlocking devices, as well as the cable network are to be inspected externally. The remote stopping system, navigation lights, alarms, etc. are to be examined for proper operation. For vessels carrying dangerous goods, the condition of safety electrical equipment in relation to explosive atmospheres especially in cargo area has to be checked.

The insulation resistance is to be measured.

4.4 Explosion protection

Electrical installations and equipment located in spaces in which there is a risk of inflammable gas or vapour/air mixtures accumulating, are to be checked as to the explosion protection provided.

5. Pipes in Tanks

5.1 General

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.

6. Fire Extinguishing and Fire Alarm Systems

6.1 General

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 shall 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 recognised company. Reports of these inspections have to be provided to the Surveyor.

Emergency exits/escapes are to be inspected.

7. Spare Parts

7.1 General

If needed and in order to be able to restore machinery operation and manoeuvring capability of the vessel in case of damage, spare parts for the main propulsion and the essential equipment shall be available on board, documented and maintained in a corresponding list.

8. Trials

8.1 General

Upon completion of the surveys for Class renewal, the Surveyor shall be satisfied that the entire machinery installation including electrical installations and steering gear, as well as special equipment and installations are operable without any restrictions. In case of doubt, trials and/or operational tests may be necessary.

9. Periodical Surveys of Propeller Shafts and Tube Shafts, Propellers and Other Systems

9.1 General

For maintenance of the Class, periodical surveys and tests of propeller shafts and tube shafts, propellers and other systems of vessels are to be carried out. The scope of surveys and tests unless specifically restricted is defined in 10.

The following surveys are applicable for propeller shafts and tube shafts:

- Normal survey
- Modified survey
- Partial shaft survey

9.2 Normal survey for propeller shafts and tube shafts

9.2.1 Where the propeller shafts and tube shafts are:

- Fitted with continuous liners, or
- Protected against corrosion, or
- Mechanically grease-lubricated, or
- Fitted with approved oil sealing glands, or
- Made of corrosion resistant materials, or
- Of increased corrosion allowance to **TL** satisfaction

the interval of survey is to be 5 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, or
- The propeller is fitted keyless to the shaft taper, or

- The propeller is fitted to a solid flange coupling at the aft end of the shaft, the design details of which are approved

A non-destructive examination is to be made at each survey by an approved crack-detection method 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 and of the area of keyway for keyed propellers, or of the forward part of the aft shaft taper for keyless propellers, or of the aft fillet flange area of the shaft for solid flange coupling propellers.

In all other cases, the nominal interval of survey may be shorter. The scope and extent of survey is to be agreed with **TL**.

9.2.2 Propeller shafts and tube shafts are to be sufficiently drawn to permit entire examination. For further details see 10.2.2.

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 as described in 9.2.1 are examined by an approved crackdetection method without drawing of the shaft, where:

- The clearances and wear down of the bearings

- The records of lubricating oil analysis, oil consumption

- The visible shaft areas

are examined and found satisfactory. Lubricating oil controls are to be performed as specified in 9.3.2. For further details see 10.2.3. Where any doubt exists regarding the findings of the above, the shaft is to be sufficiently drawn to permit an entire examination.

9.2.3 Where the propeller is fitted on a solid flange coupling at the end of the shaft and in the case of proven designs and agreement of **TL**, the crack detection test of the aft coupling flange fillet area of the shaft may be dispensed with.

9.3 Modified survey for propeller shafts and tube shafts

9.3.1 For single and multi-shafting arrangements a modified survey may be accepted instead of the normal survey at alternate p, possibly in connection with the dry dock survey, at the most, subject to:

- The shaft is fitted with oil lubricated bearings and oil sealing glands, or it is mechanically grease-lubricated

- The shaft and its fittings are not exposed to corrosion

- New oil seals may be fitted without removal of the propeller (except in the case of keyed propeller)

- The design details are approved

- And provided that the clearances of the aft bearing are found in order and the lube oil and the oil sealing arrangements have proved effective in any of the following three cases:

- Where the propeller is keyed on the shaft taper and suitable crack-prevention measures are taken, or

- Where the propeller is fitted to a solid flange coupling at the end of the shaft, or

- Where the propeller is fitted keyless to the shaft taper

The maximum interval between two successive normal surveys is not to exceed 2 periods of Class.

9.3.2 The shaft is to be sufficiently drawn to permit examination of the aft bearing contact area of the shaft. For further details see 10.3.2.

Drawing of the shaft to expose the aft bearing contact area of the shaft may not be required where a lubricating oil analysis is carried out regularly at intervals not exceeding 6 months, and the oil consumption is recorded and considered to be within permissible limits. The documentation on lubricating oil analysis is to be available on board and be checked. Each analysis should include the minimum parameters:

- Water content
- Chloride content
- Content of bearing metal particles
- Oil aging (resistance to oxidation)

Oil samples should be taken under service conditions. For further details see 10.3.3. Where any doubt exists regarding the findings of the above, the shaft is to be sufficiently drawn to permit an examination according to 10.2.2.

9.4 Propellers

During normal or modified surveys of the propeller shafts and tube 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.

9.5 Other systems

Other systems for main propulsion purposes, such as rudder and steering propellers, pod propulsion systems, pump jet units, etc., are subject to the same survey intervals as propeller shafts and tube shafts.

The scope and extent of the surveys will be defined by **TL**.

10. Survey Performance of Propeller Shafts and Tube Shafts, Propellers and Other Systems

10.1 General

The periodical surveys and tests of propeller shafts and tube shafts, propellers and other systems (when applicable) are to be performed as follows.

10.2 Normal survey for propeller shafts and tube shafts

10.2.1 General

The prerequisites are defined in 9.2. It is distinguished between:

- Survey with drawing of the shaft
- Survey without drawing of the shaft

10.2.2 Survey with drawing of the shaft

The scope of normal survey consists in the following:

- Dismantling of propeller and key, where fitted, visual inspection of all parts of the shaft especially the cone, the keyway, the bearing contact areas of the shaft, the bearings, and the thread of the propeller nut, or the fillet of the flange, examination of the propeller fit
- 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, or the fillet of the flange in case of a solid flange coupling
- Examination of the bearing clearances and/or wear down before dismantling and after reassembling of the shaft with recording of the values measured
- Overhaul of the shaft sealing glands according to manufacturer's instructions (sealing rings, liners, etc.)

10.2.3 Survey without drawing of the shaft

Where the prerequisites as defined in 9.2.2 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 crackdetection 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 **TL**. See also 9.2.3.

10.3 Modified survey for propeller shafts and tube shafts

10.3.1 General

The prerequisites are defined in 9.3. It is distinguished between:

- Survey with exposing the aft bearing contact area of the shaft

- Survey without exposing the aft bearing contact area of the shaft

10.3.2 Survey with exposing the aft bearing contact area of the shaft

The scope of the modified survey consists in the following:

- Drawing the shaft to expose the aft bearing contact area of the shaft

- Examination of the forward bearing as far as possible and of all accessible parts of the shaft including the propeller connection to the shaft

- Examination and overhaul of the oil sealing glands according to manufacturer's instructions (sealing rings, liners, etc.)

- Examination of the bearing clearances and/or wear down of the shaft with recording of the values measured

- Examination of the lubricating oil analysis and consumption to be within permissible limits

- For keyed propellers, performing a nondestructive examination by an approved crack-detection method of about one third of the length of the taper from the large end, for which dismantling of the propeller is required, examination of the propeller fit.

Where doubts exist regarding the findings, the shaft is to be further dismantled, respectively drawn.

10.3.3 Survey without exposing the aft bearing contact area of the shaft

Where the prerequisites as defined in 9.3.2 apply, the scope of the modified survey without exposing the aft bearing contact area of the shaft consists in the following:

- Examination and overhaul of the oil sealing glands according to manufacturer's instructions (sealing rings, liners, etc.)

- Examination of the bearing clearances and/or wear down of the shaft with recording of the values measured

- For keyed propellers, performing a nondestructive examination by an approved crack-detection method of about one third of the length of the taper from the large end, for which dismantling of the propeller is required, examination of the propeller fit.

In addition to this, the survey shall include the following:

- 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 further dismantled, respectively drawn.

10.4 Propellers

10.4.1 Propellers are to be examined visually on the occasion of each propeller shaft or tube shaft survey.

10.4.2 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.

10.5 Other systems

As far as practicable, the gearing and control elements of rudder and steering propellers are to be examined through inspection openings. For other systems such as pod propulsion systems, pump jet units, etc., if applicable, the scope of survey is to be agreed with **TL**'s concerned departments. In any cases, a survey has to be carried out during Class Renewal Survey. The maintenance according to manufacturer's instructions is to be checked. A function test is to be carried out.

11. Inert Gas Systems

11.1 General

Inert gas installations of the cargo tank area of tankers are to be checked as to their operability in accordance with **TL**’s survey programme, at intervals of nominally 2,5 years, preferably on the occasion of each Class Renewal and intermediate survey.

12. Bottom Surveys

For bottom surveys, see E.

13. Installations Under Pressure

For steam boiler installations, thermal oil plants and pressure vessels, see F.

D. Non-Periodical Surveys

1. Damage and Repair Surveys

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 Section 1, B.6.3.2.

1.1 Damage and repair surveys performance

1.1.1 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 Section 1, B.6.3.2.

In the case of grounding, dry docking or, alternatively, an in-water survey is required.

1.1.2 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 **TL**'s Head Office or **TL**'s representative.

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

1.1.4 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.

1.1.5 Regarding the materials employed and certificates required, the requirements for newbuildings are applicable. See Section 1, B.6.4.

1.1.6 Regarding corrosion damages or excessive wastage beyond allowable limits that affect the vessel's Class, see G.

2. Voyage Repairs and Maintenance

Where repairs to hull, machinery or equipment, which affect or may affect Class are to be carried out by a riding crew during a voyage, a complete procedure is to be submitted to and agreed upon with **TL**.

Maintenance and overhaul to hull, machinery, as well as special equipment and installations in accordance with the recommended manufacturer's procedures and established practice and which does not require Society approval, are not included. However, any repair as a result of such maintenance and overhauls which affects or may affect Class is to be noted in the vessel's log and submitted to the attending Surveyor for use in determining further survey requirements.

3. Conversion Surveys

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, **TL**'s approval is to be requested as in the case of newbuildings and surveys are to be carried out, as described in Section 1, B.6.4.

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

4. Extraordinary Surveys

TL 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 **TL**'s quality assurance system.

5. Survey for Towage or Voyage Over Sea

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

E. Bottom Surveys

1. Dry Dock Surveys

1.1 Inland navigation 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.

1.2 Intermediate surveys have to be carried out in drydock 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 navigation range **I (x),** 1,2 ≤ × ≤ 2, when it sails regularly in salt or brackish waters

Moreover, for each bottom survey performed in addition to the bottom surveys stipulated by the Classification requirements a **TL**'s Surveyor shall be called to attend.

1.3 Performance of dry dock surveys

1.3.1 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.

1.3.2 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.

1.3.3 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.

1.3.4 Machinery and propulsion systems

For propeller(s), propeller shaft(s), stern tube(s), see C.9.

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.

2. In-Water Surveys

2.1 General

In particular circumstances, in-water survey, the extent of which is subject to preliminary agreement of **TL**, may be performed under the following conditions.

2.2 Approval

The diving firm assisting in in-water surveys shall be approved by **TL** for this purpose according **TL**'s procedures.

2.3 Performance of survey

2.3.1 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.

2.3.2 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 shall be free from fouling.

2.3.3 The underwater pictures on the surface monitor screen shall offer reliable technical information such as to enable the Surveyor to judge the parts and/ or the areas surveyed.

2.3.4 Documentation suited for video reproduction including voice is to be made available to **TL**.

2.4 Additional examinations

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.

F. Installations under Pressure

1. Steam Boiler Installations

1.1 General

Auxiliary steam generators/boilers, external and internal inspections are to be carried out at Intermediate Survey and at Class Renewal Survey.

1.2 External inspection performance

1.2.1 The operability and general condition of the entire boiler, including its valves and fittings, pumps, piping, insulation, foundation, control and regulating systems and its protective and safety equipment, are to be examined.

Note :
More extensive Regulations of the country, where the vessel is registered, are to be observed.

1.2.2 In detail, the following items are to be examined:

- The entire 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 recognised 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

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 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

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

For external inspection performance, the following items are to be examined in detail:

- The entire 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.

Note :
More extensive Regulations of the country, where the vessel is registered, are to be observed.

3. Pressure Vessels

3.1 General

3.1.1 Pressure vessels are to be inspected internally and externally every p years, 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 unobjectionable 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 that standards.

The test pressure shall in no case exceed the initial test pressure

3.1.3 Pressure vessels survey performance

Pressure vessels which are subject to survey by **TL** according to the construction Rules, 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 fireextinguishing 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 recognised 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:

$p \times l \geq 1000$ (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.

G. Performance and Scope of Thickness Measurements

1. Objectives of Thickness Measurements

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.

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

- Criteria on longitudinal 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.

1.1.3 The thickness of structural elements is checked by measurements, in order to assess whether or not the values stipulated in the construction 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, see Table 3.1 and Table 3.2.

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

Note :
*The specific guidelines of **TL** give details about the scope of authorization.*

1.1.5 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.

1.1.6 The scope of thickness measurement as well as the reporting shall be fixed in a survey planning meeting between the Surveyor, representatives of the vessel's Owners and the approved thickness measurement operator/firm well in advance of measurements and prior to commencing the survey.

1.1.7 Thickness measurements of structures in areas where close-up surveys are required shall be carried out simultaneously with the close-up survey.

2. Definitions

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 2.8.1.

2.2 Spaces

Spaces are separate compartments such as holds and tanks.

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.

2.4 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.

2.5 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.

2.6 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.

2.7 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 ships, if applicable, to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the vessel.

2.8 Substantial corrosion

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

2.9 Suspect areas

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

2.10 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

2.11 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.

2.12 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.

3. Scope and Extent of Measurements For Class Renewal Survey

3.1 General

The thickness measurements required by the Rules 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 2.9

- Additional measurements on areas determined as affected by substantial corrosion as defined in 2.8

3.2 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 Table 3.1 and Table 3.2, depending on the vessel's Class Renewal Survey number. Respective thickness measurements to determine the general level of corrosion are to be carried out.

3.3 Reduction of thickness measurement scope

The extent of thickness measurements may be reduced, in comparison with those stated in Table 3.1 and Table 3.2, provided during the close-up examination the Surveyor satisfies himself that there is no structural diminution and the protective coating, where applied, continues to be effective. When the structure is coated and the coating is found to be in good condition, as defined in 2.10, the Surveyor may, at his discretion, accept a reduced program of thickness measurements in the corresponding areas. Other effective protective arrangements may also be considered. The requirements for close-up survey of tank vessels are stated in Table 3.3.

3.4 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 2.8 the number of thickness measurements is to be increased to determine the extent of substantial corrosion.

3.5 Transverse sections

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

3.6 Ballast tanks

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

3.7 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.

3.8 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, approximatively 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 4.4.

4. Corrosion and Wear Tolerances

4.1 General

Where thickness measurements result in corrosion and wear values exceeding those stated in the following, the respective hull structural elements will have to be renewed.

4.2 Longitudinal and buckling strength

In general, the applicable criteria on longitudinal and buckling strength will be decided by **TL**, if needed, on a case by case basis.

4.3 Local strength and pitting

4.3.1 The following apply to vessels classed on the basis of these Rules.

4.3.2 Where applicable, the maximum permissible largesurface reduction of plate thickness and web thickness of profiles should not exceed the values of corrosion additions as stipulated in, Section 5, B.7.1.2 for steel and Section 5, B.7.1.3 for stainless steel or aluminium alloys.

4.3.3 Beyond the calculated corrosion additions t_C, and at the Surveyor's discretion, a maximum permissible locally limited reduction of thickness for isolated pits of 0,35, respectively of 0,2 times the as-built thickness for 50% scattered pits, may be accepted.

4.4 Anchor equipment

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

Maximum permissible reduction in weight of anchors: 10 %.

5. Reporting

5.1 General

Appropriate reporting forms recommended by **TL** are to be used for recording thickness measurements. The report is to provide the name of the vessel, the location of measurement, the thickness measured and the corresponding original thickness. Furthermore, the report is to include the date when the measurements were carried out, the type of measuring equipment, the names and the qualification of the operator and his signature.

The single measurement recorded is to represent the average of multiple measurements.

The report shall be verified and validated by the Surveyor.

Table 3.1 Requirements for thickness measurements at Class Renewal Survey
General cargo vessels and other vessels

Class renewal survey number			
Class renewal I	**Class renewal II**	**Class renewal III**	**Class renewal IV and subsequent**
Suspect areas	**Suspect areas**	**Suspect areas**	**Suspect areas**
	Within the cargo length area or 0,5L amidships: - selected deck plates - one transverse section - selected bottom/inner bottom plates - selected side shell plates - selected hatch covers and coamings **(1)**	Within the cargo length area or 0,5L amidships: - each exposed deck plate - two transverse sections - selected tank top plates - each bottom/inner bottom plates - all side shell plates - selected transverse and longitudinal cargo hold bulkheads **(1)** - all hatch covers and coamings **(1)**	Within the cargo length area or 0,5L amidships: - each deck plate - three transverse sections **(3)** - each bottom/inner bottom/tank top plate - all side shell plates - all transverse and longitudinal cargo hold bulkheads **(1)** - all hatch covers and coamings **(1)**
		Outside the cargo length area: - selected deck plates - selected side shell plates - selected bottom plates	Outside the cargo length area: - each deck plate - each side shell plate - each bottom plate
	Collision bulkhead, forward machinery space bulkhead, aft peak bulkhead **(1), (2)**		All transverse and longitudinal bulkheads outside cargo hold area **(1), (2)**
	In engine room **(2)** - river chests - river water manifold - duct keel or pipe tunnel plating and internals		
		Selected internal structure such as ballast tank, floors and longitudinals, transverse frames, web frames, deck beams, girders, etc. Measurements may be increased if the Surveyor deems it necessary	

(1) *Including plates and stiffeners.*
(2) *Measurements may be waived or reduced after satisfactory visual examination, when such bulkheads form the boundaries of dry void spaces or river chests, etc. are found in good condition.*
(3) *The number of transverse sections may be reduced at the Surveyor's discretion for vessels of length under 40 m.*

Table 3.2 Requirements for thickness measurements at Class Renewal Survey Tank vessels

<table>
<tr><th colspan="4">Class renewal survey number</th></tr>
<tr><th>Class renewal I</th><th>Class renewal II</th><th>Class renewal III</th><th>Class renewal IV and subsequent</th></tr>
<tr><th>Suspect areas</th><th>Suspect areas</th><th>Suspect areas</th><th>Suspect areas</th></tr>
<tr><td></td><td colspan="3">Measurement for general assessment and recording of corrosion pattern of those structural members subject to close-up survey according to Table 3.3</td></tr>
<tr><td></td><td>Within the cargo length area:
- selected deck plates
- one transverse section
- selected bottom/inner bottom plates
- selected side shell plates
- selected hatch covers and coamings (1)</td><td>Within the cargo length area:
- each deck plate
- two transverse sections in two different tanks
- each bottom/inner bottom plates
- all side shell plates
- selected transverse and longitudinal cargo tank bulkheads (1)
- all hatch covers and coamings (1)</td><td>Within the cargo length area:
- each deck plate
- three transverse sections in three different tanks (3)
- each bottom/inner bottom plate
- all side shell plates
- all transverse and longitudinal cargo tank bulkheads (1)
- all hatch covers and coamings (1)</td></tr>
<tr><td></td><td></td><td>Outside the cargo length area:
- selected deck plates
- selected side shell plates
- selected bottom plates</td><td>Outside the cargo length area:
- each deck plate
- each side shell plate
- each bottom plate</td></tr>
<tr><td></td><td colspan="2">Collision bulkhead, forward machinery space bulkhead, aft peak bulkhead (1), (2)</td><td>All transverse and longitudinal bulkheads outside cargo length area
(1), (2)</td></tr>
<tr><td></td><td colspan="3">In engine room (2)
- river chests
- river water manifold
- duct keel or pipe tunnel plating and internals</td></tr>
<tr><td></td><td></td><td colspan="2">Selected internal structure such as ballast tank, floors and longitudinals, transverse frames, web frames, deck beams, girders, etc.
Measurements may be increased if the Surveyor deems it necessary</td></tr>
<tr><td colspan="4">(1) Including plates and stiffeners.
(2) Measurements may be waived or reduced after satisfactory visual examination, when such bulkheads form the boundaries of dry void spaces or river chests, etc. are found in good condition.
(3) The number of transverse sections may be reduced at the Surveyor’s discretion for vessels of length under 40 m.</td></tr>
</table>

Table 3.3 Requirements for Close-up Survey at Class Renewal Survey of Tank vessels

Class renewal survey number			
Class renewal I	**Class renewal II**	**Class renewal III**	**Class renewal IV and subsequent**
	Within the cargo length area: - selected deck plates in one tank for survey from inside of the tank - selected deck longitunals/brackets in one tank **(1)** - one transverse section selected in one representative cargo tank	Within the cargo length area: - selected deck plates in two tanks for survey from inside of the tank - selected deck longitunals/brackets in two tanks **(1)** - selected bulkheads for survey of upper and lower parts **(1)** - two transverse sections selected in two representative cargo tank - selected plates and stiffeners in one representative ballast tank	Within the cargo length area: - selected deck plates in four tanks for survey from inside of the tank - selected deck longitunals/brackets in four tanks **(1)** - all bulkheads for survey of upper and lower parts **(1)** - three transverse sections selected in three representative cargo tanks, including all transverse sections in one representative cargo tank **(2)** - selected plates and stiffeners in all ballast tanks

(1) *Including plates and stiffeners.*
(2) *The number of transverse sections may be reduced at the Surveyor's discretion for vessels of length under 40 m.*

SECTION 4

HULL DESIGN and CONSTRUCTION - GENERAL

A. General

1. Symbols and Definitions

1.1 Symbols and units

1.1.1 Symbols

L = Rule length [m], defined in 1.2.1

B = Breadth [m], defined in 1.2.2

H = Depth [m], defined in 1.2.3

T = Draught [m], defined in 1.2.4

Δ = Displacement [t] at draught T

C_B = Block coefficient

$$= \frac{\Delta}{L \cdot B \cdot T}$$

1.1.2 Units

Unless otherwise specified, the units used in the Rules are as indicated in Table 4.1.

1.2 Definitions

1.2.1 Rule length

The Rule length L is the distance [m] measured on the load waterline from the forward side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post. L is to be not less than 96 % and need not exceed 97 % of the extreme length on the load waterline.

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-bycase basis.

1.2.2 Breadth

The breadth B is the greatest moulded breadth, measured amidships below the weather deck.

1.2.3 Depth

The depth H is the distance [m] measured vertically on the midship transverse section, from the base line to the top of the deck beam at side on the uppermost continuous deck.

Table 4.1 Units

Designation	Usual symbol	Units
Vessel's dimensions	See 1.1.1	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	kNm
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

1.2.4 Draught

The draught T is the distance [m] measured vertically on the midship transverse section, from the base line to the load waterline.

1.2.5 Ends of Rule length and midship

The fore end (FE) of the Rule length L, see Fig. 4.1, 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. 4.1, 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.

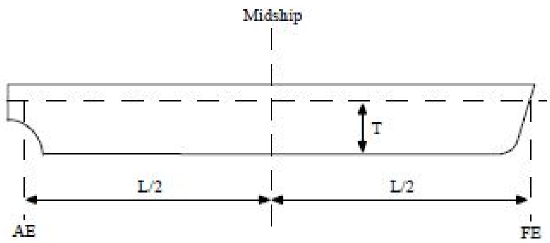


Figure 4.1 Ends and midship

1.2.6 Superstructure

A superstructure is a decked structure connected to the strength deck defined in 1.2.8, extending from side to side of the vessel or with the side plating not being inboard of the shell plating more than 0,04B.

1.2.7 Deckhouse

A deckhouse is a decked structure other than a superstructure, located on the strength deck defined in 1.2.8 or above.

1.2.8 Strength deck

The strength deck (main deck) is the uppermost continuous deck contributing to the hull girder longitudinal strength.

1.2.9 Weather deck

The weather deck is the uppermost continuous exposed deck.

1.2.10 Bulkhead deck

The bulkhead deck is the uppermost deck up to which the transverse watertight bulkheads and the shell are carried.

1.3 Vessel parts

1.3.1 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

1.3.2 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

1.3.3 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

1.3.4 Aft part

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

1.4 Reference co-ordinate system

1.4.1 The vessel's geometry and loads are defined with respect to the following right-hand co-ordinate system (see Fig. 4.2)

- 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

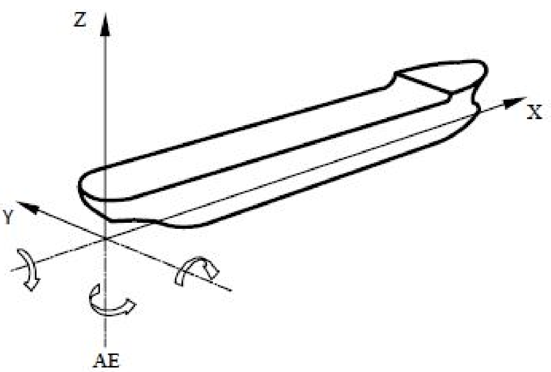


Figure 4.2 Reference co-ordinate system

1.4.2 Positive rotations are oriented in anticlockwise direction about the X, Y and Z axes.

2. Application

2.1 Structural requirements

2.1.1 These Rules contain the requirements for determination of the minimum scantlings, applicable to all types of inland waterway displacement vessels, up to 135 m in length, of normal form, speed and proportions, made in welded steel construction.

2.1.2 The requirements of these Rules apply also to those steel vessels in which parts of the hull, e.g. superstructures or movable decks, are built in aluminium alloys.

2.1.3 Vessels with length exceeding 135 m, vessels whose hull materials are different than those mentioned in 2.1.1 and 2.1.2 and vessels with novel features or unusual hull design are to be individually considered by TL, on the basis of the principles and criteria adopted in the Rules.

2.1.4 High speed craft is to comply with applicable TL Rules.

Where the vessel speed exceeds 40 km/h, the safety guidelines defined by Statutory Regulations are to be considered.

2.2 Limits of application to lifting appliances

2.2.1 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.

2.2.2 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.

2.3 Rules applicable to various vessel parts

The various Sections and Letters of the Rules are to be applied for the scantlings of vessel parts according to Table 4.2.

2.4 Rules applicable to other vessel items

The various Sections and Letters of the Rules are to be applied for the scantlings of other vessel items according to Table 4.3.

B. Documents for Approval

1. DocumentsSubmitted

1.1 Documents to be submitted for all vessels

1.1.1 The plans and documents to be submitted to **TL** for review/approval are listed in Table 4.4

The above plans and documents are to be supplemented by further documentation which depends on the type and service notation and, possibly, the additional Class Notation assigned to the vessel.

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.

Table 4.2 Rules applicable for the scantling of vessel parts

<table>
<tr><th rowspan="2">Part</th><th colspan="2">Applicable Section</th></tr>
<tr><th>General</th><th>Specific</th></tr>
<tr><td>Fore part</td><td rowspan="4">Section 5
Section 6
Section 11</td><td>Section 9,A</td></tr>
<tr><td>Central part
L ≥ 40 m</td><td>Section 7
Section 8
Sections 14-17</td></tr>
<tr><td>Central part
L < 40 m</td><td>Section 8,F
Sections 14-17</td></tr>
<tr><td>Aft part</td><td>Section 9,B</td></tr>
</table>

1.1.2 **TL** 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/approved drawings is subject to **TL**'s approval before work is commenced.

Table 4.3 Rules applicable for the scantling of other items

Item	Applicable Section
Machinery space	Section 9,B
Superstructure and deckhouse	Section 9,D
Hatch covers	Section 9,E
Movable decks and ramps	Section 9,F
Arrangement for hull and superstructure openings	Section 9,G
Rudders	Section 10,A
Other hull fittings	Section 10

1.1.4 Plans and documents to be submitted for İnformation

In addition to those in 1.1.1, the following plans and documents are to be submitted to TL 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 TL.

Table 4.4 Plans and documents to be submitted for review/approval 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	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 Steel grades Location and height of air vent outlets of various compartments Corrosion protection Openings in decks and shell and relevant compensations Boundaries of flat areas in bottom and sides Details of structural reinforcements and/or discontinuities 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
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 themain deck and superstructure deck
Rudder 1	Maximum ahead service speed
Sternframe or sternpost, sterntube Propeller shaft boss and brackets (1)	
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
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.*	

SECTION 5

HULL DESIGN and CONSTRUCTION - MATERIALS and DESIGN PRINCIPLES

A. Materials

1. General

1.1 Usable materials

1.1.1 The characteristics of the materials to be used in the construction of inland navigation vessels are to comply with the applicable **TL** Rules for Material.

Only base materials from manufacturers which are approved by **TL** in the applicable relevant base material grades shall be used.

1.1.2 Aluminium alloys

The use of aluminium alloys is to comply with the requirements of 3.

1.2 Manufacturing processes of materials

The following requirements presume that cold or hot manufacturing processes are carried out in compliance with current sound working practice and the applicable requirements of **TL** Rules for Material.

2. Steels for Hull Structure

2.1 Application

2.1.1 Table 5.1 gives the mechanical characteristics of steels currently used in the construction of inland navigation vessels.

2.1.2 When steels with a minimum yield stress R_{eH} greater than 235 N/mm^2 are used, hull scantlings are to be determined by taking into account the material factor k defined in 2.4.

Table 5.1 Mechanical properties of hull steels

Steel grades ($t \le 100$ mm)	Minimum yield stress R_{eH} [N/mm^2]	Ultimate minimum tensile strength R_m [N/mm^2]
A-B-D	235	400-520
A32-D32	315	440-570
A36-D36	355	490-630
A40-D40 **(1)**	390	510-660
(1) $t \le 50\ mm$		

2.1.3 When no other information is available, the minimum guaranteed 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:

$$R_{eH} = R_{eH0} \cdot \left(1.04 - \frac{0.75}{1000} \cdot \theta\right) \quad \left[N/mm^2\right]$$

$$E = E_0 \cdot \left(1.03 - \frac{0.5}{1000} \cdot \theta\right) \quad \left[N/mm^2\right]$$

R_{eH0} = Value of the minimum guaranteed yield stress at ambient temperature

E_0 = Value of the Young's modulus at ambient temperature

θ = Service temperature [°C]

2.2 Information to be kept on board

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 Table 5.1 are used, their mechanical and chemical properties, as well as any workmanship requirements or recommendations, are to be available on board together with the above plan.

2.3 Dimensional tolerances

2.3.1 Plates and wide flats

For plates and wide flats, an under thickness tolerance of 0,3 mm is permitted.

2.3.2 Sections and bars

For sections and bars, the under thickness tolerance is to be in accordance with the requirements of a recognised international or national standard.

2.4 Material factor k

Unless otherwise specified, the material factor k is defined in Table 5.2, as a function of the minimum yield stress R_{eH}.

For higher strength hull structural steel with other nominal yield stresses up to 390 N/mm^2, the material factor k may be determined by the following formula:

$$k = \frac{295}{R_{eH} + 60}$$

Steels with a yield stress lower than 235 N/mm^2 or greater than 390 N/mm^2 are considered by **TL** on a case-by-case basis.

Table 5.2 Material factor k

R_{eH} [N/mm^2]	k
235	1
315	0,78
355	0,72
390	0,66

2.5 Grades of steel

2.5.1 Mild steel grades A, B and D

The distribution of the steel grades used in the different regions of the vessel is indicated in Table 5.3.

Steel of grade D may be required for members consisting in plates more than 20 mm thick in areas liable to important static or dynamic stress concentrations.

2.5.2 High tensile strength structural steel grades AH and DH

In Table 5.4 the grades of the higher strength hull structural steels are marked by the letter "H".

The distribution of the steel grades used in the midship, holds or tanks regions is given in Table 5.4.

Outside these regions, the thickness of high tensile strength steel shall be kept unchanged until the region where the thickness of ordinary steel is the same for the vessel considered.

Table 5.3 Distribution of steel grades in midship and holds or tank regions

	$t \leq 15$	$15 < t \leq 20$	$t > 20$
Bilge, sheerstrake, stringer plate	A	B	D
Side shell	A	A	A
Deck and bottom	A	A	A
Deck plates at the corners of hatches	A	B	D

Table 5.4 Distribution of steel grades in midship and holds or tank regions

	$t \leq 20$	$t > 20$
Bilge, sheerstrake, stringer plate	AH	DH
Side shell	AH	AH
Deck and bottom	AH	AH
Deck plates at the corners of long hatches	AH	DH

2.5.3 For strength members not mentioned in these tables, grade A/AH may generally be used.

2.5.4 Where structural members are completely or partly made from higher strength hull structural steel, a suitable notation will be entered into the ship's certificate.

2.5.5 In the drawings submitted for approval, it is to be shown which structural members are made of higher strength hull structural steel. These drawings are to be placed on board in case any repairs are to be carried out.

2.5.6 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 **TL**.

2.6 Grades of steel for structures exposed to low temperatures

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 **TL** Rules for Material.

2.7 Connections with higher strength steel

2.7.1 Outside the higher strength steel area, scantlings of longitudinal elements in normal strength steel are to be calculated assuming that the midship area is made in normal strength steel.

2.7.2 Regarding welding of higher strength hull structural steel, see **TL** Rules for Welding.

2.8 Connections between steel and aluminium

2.8.1 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).

2.8.2 Any heterogeneous jointing system is considered by **TL** on a case by case basis.

2.8.3 The use of transition joints made of aluminium/ steel clad plates or profiles is considered by **TL** on a case-by-case basis (see also 3.3).

3. Aluminium Alloy Structures

3.1 Application

3.1.1 The use of aluminium alloys is normally authorized, instead of steel, provided that equivalent strength is maintained.

The arrangements adopted are to comply, where applicable, with the requirements of the International Conventions and National Regulations.

3.1.2 Use of aluminium alloys on tankers

The use of aluminium alloys is authorized for wheelhouses located aft of aft cofferdam or forward of fore cofferdam.

3.1.3 Influence of welding on mechanical characteristics

Welding heat lowers locally the mechanical strength of aluminium alloys hardened by work hardening. Consequently, where necessary, a drop in the mechanical characteristics of welded structures with respect to those of the parent material is to be considered in the heat-affected zone.

3.2 Material factor

3.2.1 The material factor for aluminium alloys is to be obtained from the following formula:

$$k = \frac{235}{R_{p0.2} \cdot \eta_1}$$

$R_{p0,2}$ = Minimum yield stress [N/mm^2] of the parent material in delivery condition.

η_1 = Joint coefficient given in Table 5.5.

3.2.2 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.

3.3 Transition joints

3.3.1 General

The aluminium material is to comply with **TL** Rules for Material and the steel is to be of an appropriate grade complying with the requirements of these Rules.

Table 5.5 Joint coefficent for aluminium alloys

Aluminium alloys	η_1
Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1
Alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$R'_{p0,2} / R_{p0,2}$
Alloys hardened by heat treatment (series 6000) **(1)**	$R'_{p0,2} / R_{p0,2}$

$R'_{p0,2}$ = minimum yield stress [N/mm^2] of metal in welded condition.

(1) *When no information is available, coefficient η_1 is to be taken equal to the metallurgical efficiency coefficient β defined in Table 5.6.*

Table 5.6 Aluminium alloy: Metallurgical efficiency coefficient β

Aluminium alloy	Temper condition	Thickness [mm]	β
6005 A (open sections)	T5 or T6	t ≤ 6	0,45
		t > 6	0,40
6005A (closed sections)	T5 or T6	all	0,50
6061 (sections)	T6	all	0,53
6082 (sections)	T6	all	0,45

3.3.2 Explosion transition joints

Explosion bonded composite aluminium/steel transition joints used for the connection of aluminium structures to steel plating are to comply with **TL** Rules for Material.

3.3.3 Rolled transition joints

The use of rolled bonded composite aluminium/steel transition joints will be examined by **TL** on a case-by-case basis.

4. Other Materials

4.1 General

4.1.1 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 **TL** Rules for Materials.

4.1.2 The use of plastics, wood or other special materials not covered by these Rules is to be considered by **TL** on a case-by-case basis.

In such a case, **TL** states the requirements for the acceptance of the materials concerned.

4.1.3 Materials used in welding processes are to comply with the applicable **TL** Rules for Welding.

B. Strength Principles

1. Symbols

w = Section modulus [cm^3] of an ordinary stiffeneror primary supporting member, as the case may be, with an attached plating of width b_p

h_w = Web height [mm] of an ordinary stiffener or a primary supporting member, as the case may be

t_w = Web thickness [mm] of an ordinary stiffener or a primary supporting member, as the case may be

b_f = Face plate width [mm] of an ordinary stiffener or a primary supporting member, as the case may be

t_f = Face plate thickness [mm] of an ordinary stiffener or a primary supporting member, as the case may be

t_p = Thickness [mm] of the plating attached to an ordinary stiffener or a primary supporting member, as the case may be

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of an ordinary stiffener or a primary supporting member, as the case may be, measured between the supporting members

ℓ_b = Length [m] of brackets

I = Moment of inertia [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 [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 paralel to the plating, calculated at mid-length of the bracket

k = Material factor defined in A.2.4 and A.3.2

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 Attention is to be paid to the structural continuity:

- in way of changes in the framing system
- at the connections of primary or ordinary stiffeners
- in way of the ends of the fore and aft parts, and machinery space
- in way of ends of superstructures

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

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

2.2 Rounding off of scantlings

2.2.1 Plate thicknesses

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

a) The net thickness (see 6.) is calculated in accordance with the rule requirements

b) Corrosion addition t_C (see 7.) is added to the calculated net thickness, and this gross thickness is rounded off to the nearest half-milimetre

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

2.2.2 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 %.

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 **TL** on a case-bycase 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 Doublers having width [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 Section 11, A.2.6.

3.1.3 When doublers fitted on the outer shell and strength deck within 0,5L amidships are accepted by **TL**, their width and thickness are to be such that slot welds are not necessary according to the requirements in 3.1.2. Outside this area, the possibility of fitting doublers requiring slot welds will be considered by **TL** on a case-by-case basis.

4. Ordinary Stiffeners

4.1 Stiffener not perpendicular to the attached plating

Where the angle between the section web and the attached plating is less than 70°, the actual section modulus may be obtained [cm^3] from the following formula:

$w = w_0 \cdot \sin \alpha$

w_0 = Actual section modulus [cm^3] of the stiffener assumed to be perpendicular to the plating

α = Angle between the stiffener web and the attached plating, to be measured at mid-span of the section.

4.2 Span of ordinary stiffeners

The span ℓ of ordinary stiffeners is to be measured as shown in Fig. 5.1 to Fig. 5.4.

Instead of the true length of curved frames, the length of the chord between the supporting points can be selected.

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 [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):

  $b_P = 0,5 \cdot s$

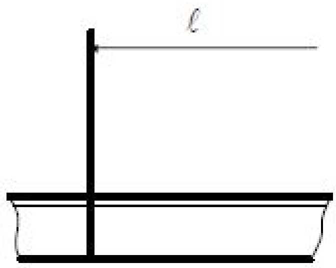


Fig. 5.1 Ordinary stiffener without brackets

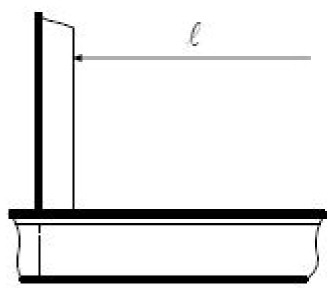


Fig. 5.2 Ordinary stiffener with a stiffener at one end

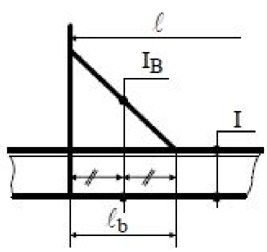


Fig. 5.3 Ordinary stiffener with end bracket

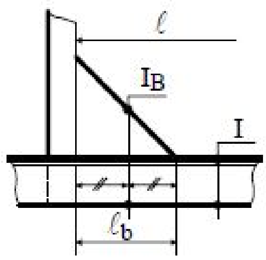


Fig. 5.4 Ordinary stiffener with a bracket and a stiffener at one end

4.3.2 Buckling check

The attached plating to be considered for the buckling check of ordinary stiffeners is defined in C.3.3.

4.4 Sections

The main characteristics of sections currently used are given in F.

4.5 Built sections

4.5.1 Geometric properties

The geometric properties of built sections as shown in Fig. 5.5 may be calculated as indicated in the following formulae.

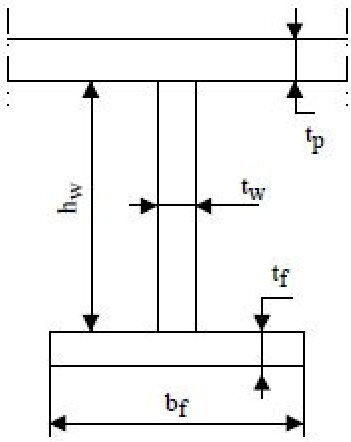


Fig. 5.5 Dimensions of a built section

The shear sectional area of a built section with attached plating is to be obtained [cm^2] from the following formula:

$$A_{sh} = \frac{h_w \cdot t_w}{100}$$

The section modulus of a built section with attached plating of sectional area A_a [mm^2] is to be obtained [cm^3] from the following formula:

$$w = \frac{h_w \cdot t_f \cdot b_f}{1000} + \frac{t_w \cdot h^2 \cdot w}{6000} \cdot \left(1 + \frac{A_a - t_f \cdot b_f}{A_a + \frac{t_w \cdot h_w}{2}}\right)$$

The distance from mid-plate thickness of face plate to neutral axis is to be obtained [cm] from the following formula:

$$v = \frac{h_w \cdot (A_a + 0.5 \cdot t_w \cdot h_w)}{10 \cdot (A_a + \cdot t_f \cdot b_f \cdot t_w \cdot h_w)}$$

The moment of inertia of a built section with attached plating is to be obtained [cm^4] from the following formula:

$$I = w \cdot v$$

These formulae are applicable provided that:

$A_a \geq t_f \,.\, b_f$

$$\frac{h_w}{t_p} \geq 10$$

$$\frac{h_w}{t_f} \geq 10$$

4.6 End connections

4.6.1 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. 5.6 to Fig. 5.9. In the case of high values for the design loads, additional stiffening is required.

Connection details other than those shown in Fig. 5.6 to Fig. 5.9 may be considered by **TL** on a case-by-case basis. In some cases, **TL** may require the details to be supported by direct calculations submitted for review.

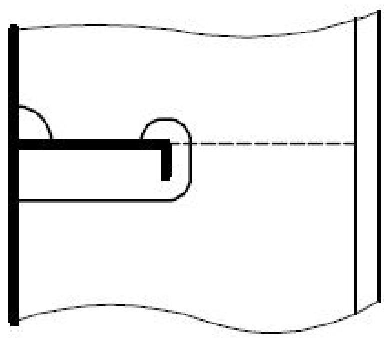


Fig. 5.6 End connection of ordinary stiffener without collar plate

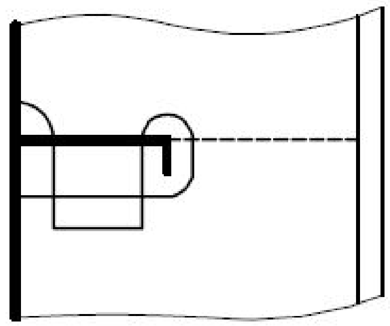


Fig. 5.7 End connection of ordinary stiffener with collar plate

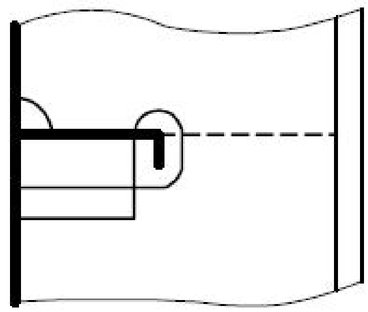


Fig. 5.8 End connection of ordinary stiffener with one large collar plate

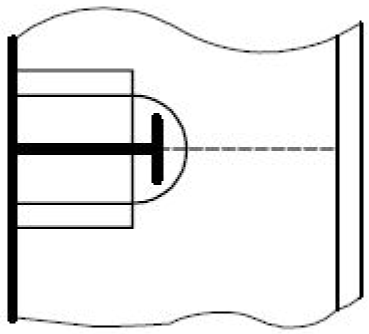


Fig. 5.9 8 End connection of ordinary stiffener with two large collar plates

4.6.2 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:

$$\frac{\ell_b}{t} > 60$$

ℓ_b = Length [mm] of the free edge of the bracket

t = Bracket net thickness [mm].

are to be flanged or stiffened by a welded face plate.

The sectional area [cm^2] of the flange or the face plate is to be not less than 0,01 · ℓ_b .

The width of the face plate is to be not less than 10 · t.

4.6.3 Bracketed ordinary stiffeners

4.6.3.1 For the scantlings of brackets the required section modulus of the section is decisive. Where sections of different section moduli are connected to each other, the scantlings of the brackets are generally governed by the smaller section.

4.6.3.2 The net thickness of brackets is not to be less than:

$$t = c \cdot \sqrt[3]{\frac{W}{k_1}}$$

c = 1,2 for non-flanged brackets

= 0,95 for flanged brackets

k_1 = Material factor k for the section according A. 2.4 and 3.2

W = Section modulus of smaller section [cm^3]

t_{min} = 5,0 mm

t_{max} = Web thickness of smaller section

4.6.3.3 The arm length of brackets is not to be less than:

$$\ell = 46{,}2\ \sqrt[3]{\frac{W}{k1}} \cdot \sqrt{k2}\ \cdot ct\ \ [mm]$$

ℓ = 100 mm

$$c_t = \sqrt{\frac{t}{t_a}}$$

ta = "as built" thickness of bracket [mm]

≥ t according 4.7.2

W = See 4.7.2

k_2 = Material factor k for the bracket according to A.2.4 and 3.2

The arm length ℓ is the length of the welded connection.

Note:

For deviating arm lengths, the thickness of brackets is to be estimated by direct calculations considering sufficient safety against buckling.

4.6.3.4 The throat thickness a of the welded connection is to be determined according to Section 11, A.4.8.

4.6.3.5 Where flanged brackets are used, the width of flange is to be determined according to the following formula:

$$b = 40 + \frac{W}{30} \quad [\text{mm}]$$

b is not to be taken less than 50 mm and need not be taken greater than 90 mm.

4.6.4 Sniped ends of stiffeners

Stiffeners may be sniped at the ends if the thickness of the plating supported by the stiffeners is not less than:

$$t = c \cdot \sqrt{\frac{p \cdot s\,(\ell - 0{,}5 \cdot s)}{R_{eH}}} \quad [\text{mm}]$$

p = Stiffener design load [kN/m^2]

c = Coefficient

= 15,8 for watertight bulkheads and for tank bulkheads

= 19,6 for all other components

5. Primary Supporting Members

5.1 Span of primary supporting members

The span of primary supporting members is to be determined in compliance with 4.2.

5.2 Width of attached plating

5.2.1 Girders

5.2.1.1 The effective breadth of plating em of frames and girders may be determined according to Table 5.7, considering the type of loading. Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

5.2.1.2 The effective cross sectional area of plates is not to be less than the cross sectional area of the face plate.

5.2.1.3 The effective width of stiffeners and girders subjected to compressive stresses may be determined according to C.2.2, but is in no case to be taken greater than the effective breadth determined by 5.2.1.1.

5.2.2 Cantilevers

Where cantilevers are fitted at every frame, the effective breadth of plating may be taken as the frame spacing. Where cantilevers are fitted at a greater spacing, the effective breadth of plating at the respective cross section may approximately be taken as the distance of the cross section from the point on which the load is acting, however, not greater than the spacing of the cantilevers.

Table 5.7 Effective breadth e_m of frames and girders

ℓ/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0,36	0,64	0,82	0,91	0,96	0,98	1,0	1,0
e_{m2}/e	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,9

e_{m1} is to be applied where girders are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.

e_{m2} is to be applied where girders are loaded by 3 or less single loads.

Intermediate values may be obtained by direct interpolation.

ℓ = length between zero-points of bending moment curve, i.e. unsupported span in case of simply supported girders and 0,6 × unsupported span in case of constraint of both ends of girder

e = width of plating supported, measured from centre to centre of the adjacent unsupported fields

5.2.3 Corrugated bulkheads

The width of attached plating of corrugated bulkhead primary supporting members is to be determined as follows:

- When primary supporting members are paralel to the corrugations and are welded to the corrugation flanges, the width of the attached plating is to be calculated in accordance with 5.2.2 and 5.2.3, 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.

5.3 Geometric properties

5.3.1 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 4.5.1, reducing the web height h_w by the depth of the cut-outs for the passage of the ordinary stiffeners, if any.

5.4 Bracketed end connections

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

The height of end brackets is to be not less than that of the weakest primary supporting member.

5.4.2 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.

5.4.3 The bracket web thickness is to be not less than that of the weakest primary supporting member.

5.4.4 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.

5.4.5 In addition to the above requirements, the scantlings of end brackets are to comply with the applicable requirements given in Section 8, B. to E.

5.5 Bracketless end connections

5.5.1 In the case of bracketless end connections between primary supporting members, the strength continuity is to be obtained as schematically shown in Fig. 5.10 or by any other method which **TL** may consider equivalent.

5.5.2 In general, the continuity of the face plates is to be ensured.

5.6 Cut-outs and holes

5.6.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the depth of cut-outs is to be not greater than 50 % of the depth of the primary supporting member. Other cases are to be covered by calculations submitted to **TL**.

5.6.2 Openings may not be fitted in way of toes of end brackets.

5.7 Stiffening arrangement

5.7.1 General

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

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

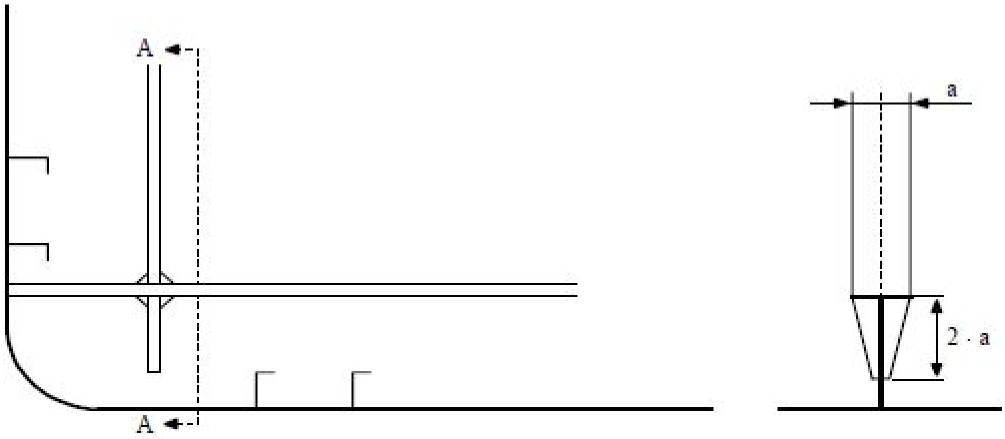


Fig. 5.10 Connection of two primary supporting members

5.7.2 Longitudinal framing system

In way of each longitudinal the transverses are to be stiffened. This stiffener is to extend between the longitudinal and the upper faceplate of the transverse, without any connection with that faceplate.

The stiffener is to be made of a flat, the width b and thickness t of which [mm] are not to be less than:

$$b = \frac{20}{3} \sqrt{w_\ell}$$

$$t = \frac{2}{3} \sqrt{w_\ell}$$

w_ℓ being the section modulus of the longitudinal [cm³].
However, on deck transverses, side shell transverses or longitudinal bulkhead transverses, stiffeners may be provided only every two longitudinal spacings.

TL may waive this rule where the transverse is a rolled section or where it is otherwise covered by calculations.
The sectional area of the connection of the transverse stiffener to the longitudinal and to the transverses is not to be less than the stiffener rule sectional area.

5.7.3 Tripping brackets (see Fig. 5.11) welded to the face plate are generally to be fitted:

- at intervals not exceeding 20 times the face plate width
- at the toe of end brackets
- at rounded face plates
- in way of cross ties
- in way of concentrated loads

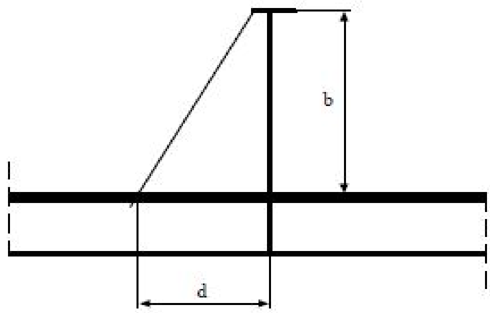


Fig. 5.11 Primary supporting member: web stiffener in way of ordinary stiffener

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.

5.7.4 The arm length of tripping brackets is to be not less than the greater of the following values [m]:

$$d = 0.38 \cdot b$$

$$= 0.85 \cdot b \cdot \sqrt{\frac{s_t}{t}}$$

b = Height [m] of tripping brackets, shown in Fig. 5.11

s_t = Spacing [m] of tripping brackets

t = Thickness [mm] of tripping brackets.

5.7.5 The thickness of the tripping brackets is not to be less than the web thickness of the primary supporting member.

6. Hull Scantling Principle

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 Section 4, A.1.4.

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

Unless otherwise specified, the loads are to be calculated at mid-span of the ordinary stiffener considered.

6.1.4 Primary supporting members

Unless otherwise specified, the loads are to be calculated at mid-span of the primary supporting member considered.

6.2 Bracket 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 bracket coefficients β_b and β_s, of ordinary stiffeners are to be obtained from Table 5.8.

Table 5.8 Bracket coefficients

Brackets at ends	β_b	β_s
0	1	1
1	0,90	0,95
2	0,81	0,90

6.2.2 Primary supporting members

Conventional parameters of end brackets are given in Fig. 5.12. Special consideration is to be given to conditions different from those shown.

The bracket coefficients β_b and β_s, of primary supporting members are to be determined using the following formulae, and are not to be less than the values given in Table 5.8:

$$\beta_b = \left(1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}\right)^2$$

$$\beta_s = 1 - \sum_{i=1}^{n} \frac{\ell_{bi}}{\ell}$$

ℓ = span [m] of primary supporting member, defined in 4.2

ℓ_{bi} = $\ell_b - 0{,}25 \cdot h_w$

ℓ_{bi} ≥ 0

ℓ_b = MIN (d; b)

d, b = Length [m] of brackets arms, defined in Fig. 5.12

h_w = Height [m] of the primary supporting member (see Fig. 5.12)

n = Number of end brackets

6.3 Coefficients for vertical structural members λ_b and λ_S

The coefficients λ_b and λ_S to be used for the scantlings of vertical structural members are to be determined as follows:

λ_S = $2 . \lambda_b - 1$

λ_b is the greater of:

$$= 1 + 0.2 \cdot \frac{p_{Sd} - p_{Su}}{p_{Sd} + p_{Su}}$$

$$= 1 - 0.2 \cdot \frac{p_{Sd} - p_{Su}}{p_{Sd} + p_{Su}}$$

p_{Su} = Still water pressure [kN/m^2] at the upper end of the structural member considered

p_{Sd} = Still water pressure [kN/m^2] at the lower end of the structural member considered.

6.4 Plate panels

6.4.1 Thickness

The required thickness of plating subjected to lateral pressures may be reduced according to the aspect ratio and curvature of the panel considered, according to the formula:

$$t = t_0 \cdot c_a \cdot c_r$$

t_0 = Plating thickness [mm] as required in terms of the lateral pressure

c_a = Aspect ratio defined in 6.4.2

c_r = Coefficient of curvature defined in 6.4.3.

6.4.2 Aspect ratio

The aspect ratio of a plate panel is given by following formula:

$$c_a = 1.21 \cdot \sqrt{1 + 0.33 \cdot \left(\frac{s}{\ell}\right) - 0.69 \cdot \frac{s}{\ell}} \leq 1$$

s = Length [m] of the shorter side of the plate panel

ℓ = Length [m] of the longer side of the plate panel

6.4.3 Curvature of plate panels

The coefficient of curvature of plate pane is given by the following formula:

$$c_r = 1 - 0.5 \cdot \frac{s}{r} \geq 0.75$$

r = Radius of curvature [m]

7. Net strength characteristic calculation

7.1 General

7.1.1 The scantlings 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 Section 10.

- Massive pieces made of steel forgings, steel castings or iron castings

7.1.2 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

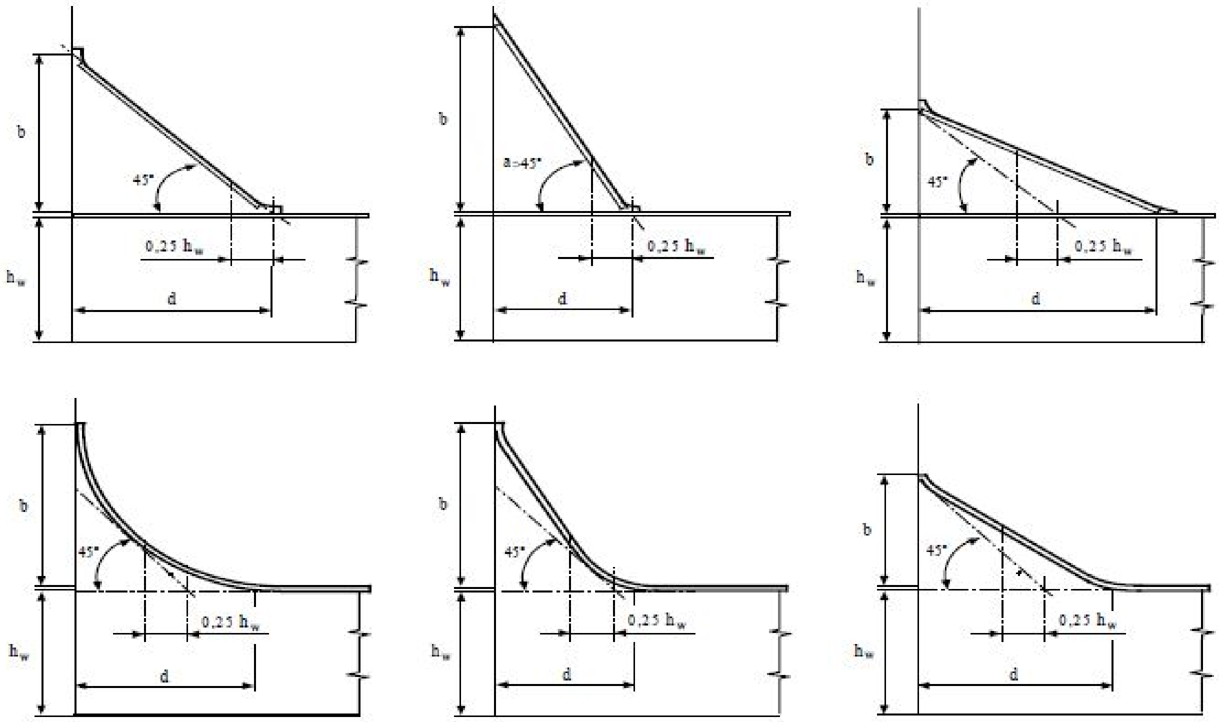


Fig. 5.12 Characteristics of primary supporting member brackets

7.1.3 The vessel is to be built at least with the gross scantlings obtained by reversing the procedure described in 7.2.

7.2 Designer's proposal based on gross scantlings

7.2.1 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 7.2.2 to 7.2.5.

7.2.2 Plating

The net thickness is to be obtained by deducting the corrosion addition t_C from the gross thickness.

7.2.3 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 may be obtained from the following formula:

$$w = w_G \cdot (1 - \alpha \cdot t_C) - \beta \cdot t_C$$

w_G = Wtiffener gross section modulus [cm^3]

α, β = Coefficients defined in Table 5.9.

Table 5.9 Coefficient α and β

Type of ordinary stiffeners		α	β
Flat bars	- w_G > 17 cm^3	0,066	1,6
Flanged profiles	- w_G > 17 cm^3	0,101	1,6
Bulb profiles	- w_G ≤ 200 cm^3	0,070	0,4
	- w_G > 200 cm^3	0,035	7,4

7.2.4 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.

7.2.5 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 7.2.2 to 7.2.4.

7.3 Designer's proposal based on net scantlings

7.3.1 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 8.

7.3.2 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.

8. Corrosion Additions

8.1 Values of corrosion additions

8.1.1 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 Section 11, B.1. The designer may define values of corrosion additions greater than those specified in 8.1.2.

8.1.2 Corrosion additions for steel other than stainless steel

The corrosion addition for each of the two sides of a structural member, t_{C1} or t_{C2}, is specified in Table 5.10.

- For plating with a net thickness greater than 8 mm, " the total corrosion addition t_C [mm] for both sides of the structural member is obtained by the following formula:

  $t_C = t_{C1} + t_{C2}$

- For plating with a net thickness less than or equal to 8 mm, the smallest of the following values:

  - 25 % of the net thickness of the plating
  - $t_C = t_{C1} + t_{C2}$

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

$t_C = 2 \cdot t_{C1}$

When a structural element is affected by more than one value of corrosion addition (e.g. plate in a dry bulk cargo hold extending in the double bottom), the scantling criteria are to be generally applied considering the severest value of corrosion addition applicable to the member.

8.1.3 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 5.10 Corrosion additions [mm] for one side exposure (t_{C1} or t_{C2})

Compartment type		General (1)
Ballast tank		1,00
Cargo tank and fuel ol tank	Plating of horizontal surfaces	0,75
	Plating of non-horizontal surfaces	0,50
	Ordinary stiffeners and primary supporting members	0,50
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 and primary supporting members	0,50
Hopper well of dredging vessels		2,00
Accommodation spaces		0,00
Compartments and areas other than those mentioned above		0,50
(1) *General: corrosion additions are applicable to all members of the considered item.*		

C. Proof of Buckling Strength

The calculation method is based on DIN Standard 18800.

1. Definitions

a = Length of single or partial plate field [mm]

b = Breadth of single plate field [mm]

α = Aspect ratio of single plate field

= a / b

n = Number of single plate field breadths within the partial or total plate field

t = Nominal plate thickness [mm]

= t_a - t_C [mm]

t_a = Plate thickness as built [mm]

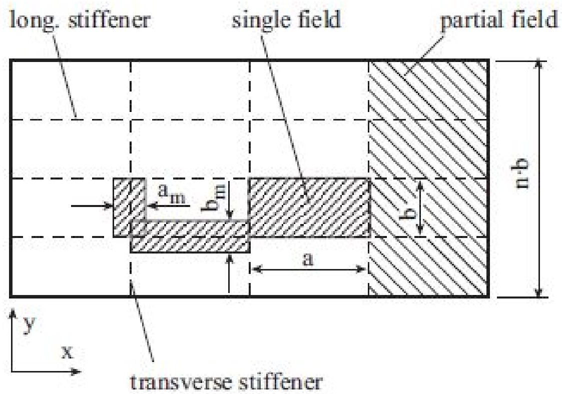
t_C = Corrosion addition according to K. [mm]

σ_x = Membrane stress in x-direction [N/mm^2]

σ_y = Membrane stress in y-direction [N/mm^2]

τ = Shear stress in the x-y plane [N/mm^2]

Compressive and shear stresses are to be taken positive, tension stresses are to be taken negative.



Longitudinal : stiffener in the direction of the length a
Transverse : stiffener in the direction of the breadth b

Fig. 5.13 Definition of plate fields subject to buckling

Note:

If the stresses in the x- and y-direction already contain the Poisson effect, the following modified stress values may be used:

Both stresses σ_x and σ_y* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:*

$$\sigma_x = (\sigma^*_x - 0,3 \cdot \sigma^*_y) / 0,91$$

$$\sigma_y = (\sigma^*_y - 0,3 \cdot \sigma^*_x) / 0,91$$

σ_x^*, σ_y^* = *Stresses containing the Poisson effect*

Where compressive stress fulfils the condition $\sigma_y^* < 0{,}3\ \sigma_x^*$, *then* $\sigma_y = 0$ *and* $\sigma_x = \sigma_x^*$.

Where compressive stress fulfils the condition $\sigma_x^* < 0{,}3\ \sigma_y^*$, *then* $\sigma_x = 0$ *and* $\sigma_y = \sigma_y^*$.

When at least σ_x^* *or* σ_y^* *is tension stress, then* $\sigma_x = \sigma_x^*$ *and* $\sigma_y = \sigma_y^*$.

ψ = Edge stress ratio according to Table 5.12

F1 = Correction factor for boundary condition at the long. stiffeners according to Table 5.11

Table 5.11 Correction factor F_1

1,0 for stiffeners sniped at both ends	
Guidance values where both ends are effectively connected to adjacent structures * :	
1,05	for flat bars
1,10	for bulb sections
1,20	for angle and tee-sections
1,30	for girders of high rigidity (e.g. bottom transverses)
** Exact values may be determined by direct calculations.*	

σ_e = Reference stress

$$\sigma_e = 0{,}9 \cdot E \left(\frac{t}{b}\right)^2 \quad [\text{N/mm}^2]$$

E = Young's modulus

= $2{,}06 \cdot 10^5$ N/mm² for steel

= $0{,}69 \cdot 10^5$ N/mm² for aluminium alloys

R_{eH} = Nominal yield point [N/mm²] for hull structural steels according to A.2.

= 0,2 % proof stress [N/mm²] for aluminium alloys

S = Safety factor

= 1,1 in general

= 1,2 for structures which are exclusively exposed to local loads

= 1,05 for combinations of statistically independent Loads

For constructions of aluminium alloys, the safety factors are to be increased in each case by 0,1.

λ = Reference degree of slenderness

$$\lambda = \sqrt{\frac{R_{eH}}{K \cdot \sigma_e}}$$

K = buckling factor according to Tables 5.12 and 5.13

In general, the ratio of plate field breadth to plate thickness shall not exceed b/t = 100.

2. Proof of single plate fields

2.1 Proof is to be provided that the following condition is complied with for the single plate field a.b:

$$\left(\frac{|\sigma_x| \cdot S}{\kappa_x \cdot R_{eH}}\right)^{e1} + \left(\frac{|\sigma_y| \cdot S}{\kappa_y \cdot R_{eH}}\right)^{e2} - F3\left(\frac{\sigma_x \cdot \sigma_y \cdot S^2}{R_{eH}^2}\right) + \left(\frac{|\tau| \cdot S \cdot \sqrt{3}}{\kappa_\tau \cdot R_{eH}}\right)^{e3} \le 1{,}0$$

Each term of the above condition shall not exceed 1,0.

The reduction factors κ_x, κ_y and κ_τ are given in Table 5.12 and/or 5.13.

Where $\sigma_x \le 0$ (tension stress), $\kappa_x = 1{,}0$.

Where $\sigma_y \le 0$ (tension stress), $\kappa_y = 1{,}0$.

The exponents e_1, e_2 and e_3 as well as the factor B are calculated or set respectively:

Exponents $e_1 \div e_3$ and factor B	Plate field	
	Plane	Curved
e_1	$1+\kappa_x^4$	1,25
e_2	$1+\kappa_y^4$	1,25
e_3	$1+\kappa_x \cdot \kappa_y \cdot \kappa_\tau^2$	2,0
B σ_x and σ_y positive (compression stress)	$(\kappa_x \cdot \kappa_y)^5$	0
B σ_x and σ_y negative (tension stress)	1	-

2.2 Effective width of plating

The effective width of plating may be determined by the following formulae:

$b_m = \kappa_x \cdot b$ for longitudinal stiffeners

$a_m = \kappa_y \cdot a$ for transverse stiffeners

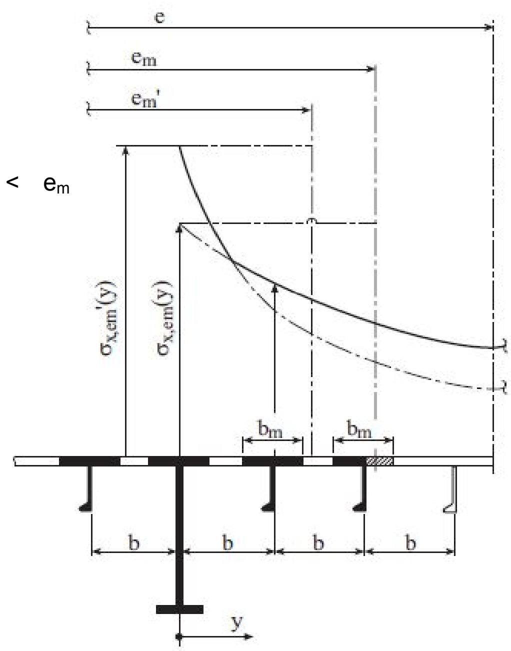
see also Fig. 5.13.

The effective width of plating is not to be taken greater than the effective breadth obtained from B.4.3 and B.5.2.

Note

The effective width e'_m of stiffened flange plates of girders may be determined as follows:

Stiffening parallel to web of girder:



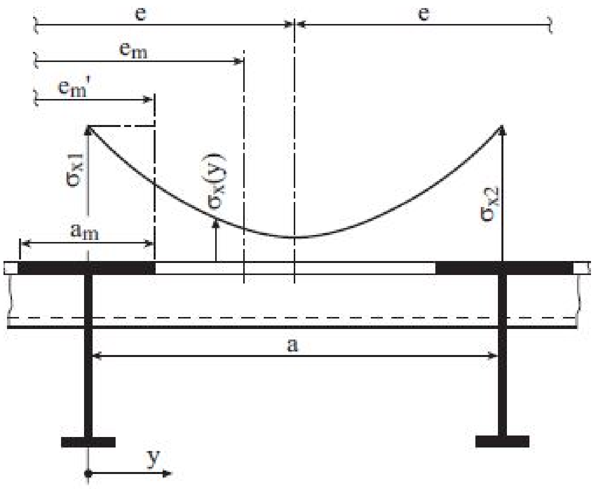
$b < e_m$

$e'_m = n \cdot b_m$

n = *Integer number of the stiffener spacing b inside the effective breadth e_m*

$$n = int\left(\frac{e_m}{b}\right)$$

Stiffening perpendicular to web of girder :



$a \geq e_m$

$e'_m = n \cdot a_m < e_m$

$$n = 2{,}7 \cdot \frac{e_m}{a} \leq 1$$

e = *width of plating supported according to B.4.3 and B.5.2*

For $b \geq e_m$ or $a < e_m$ respectively, b and a have to be exchanged.

a_m and b_m for flange plates are in general to be determined for $\psi = 1$.

Stress distribution between two girders:

$$\sigma_x(y) = \sigma_{x1} \cdot \left\{ 1 - \frac{y}{e}\left[3 + c_1 - 4 \cdot c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2) \right] \right\}$$

$$c_1 = \frac{\sigma_{x2}}{\sigma_{x1}} \qquad 0 \le c_1 \le 1$$

$$c_2 = \frac{1{,}5}{e} \cdot \left(e''_{m1} + e''_{m2} \right) - 0{,}5$$

$$e''_{m1} = \frac{e'_{m1}}{e_{m1}}$$

$$e''_{m2} = \frac{e'_{m2}}{e_{m2}}$$

σ_{x1}, σ_{x2} = *Normal stresses in flange plates of adjacent girder 1 and 2 with spacing e*

y = *Distance of considered location from girder 1*

Scantlings of plates and stiffeners are in general to be determined according to the maximum stresses σ_x(y) at girder webs and stiffeners respectively. For stiffeners under compression arranged parallel to the girder web with spacing b, no lesser value than 0,25 . R_{eH} shall be inserted for σ_x(y=b). Shear stress distribution in the flange plates may be assumed linearly.

2.3 Webs and flanges

For non-stiffened webs and flanges of sections and girders, proof of sufficient buckling strength is to be provided as for single plate fields according to 2.1.

Note

*Within 0,6 **L** amidships, the following guidance values are recommended for the ratio of web depth to web thickness and/or flange breadth to flange thickness:*

flat bars : $\frac{h_w}{t_w} \le 19{,}5\sqrt{k}$

angle, tee and bulb sections:

web : $\frac{h_w}{t_w} \le 60{,}0\sqrt{k}$

flange : $\frac{b_i}{t_f} \le 19{,}5\sqrt{k}$

b_i = *b_1 or b_2 according to Fig. 5.14, the larger value is to be taken.*

3. Proof of partial and total fields

3.1 Longitudinal and transverse stiffeners

Proof is to be provided that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in 3.2 and 3.3.

3.2 Lateral buckling

$$\frac{\sigma_a + \sigma_b}{R_{eH}} \cdot S \le 1$$

σ_a = Uniformly distributed compressive stress in the direction of the stiffener axis [N/mm²]

= σ_x for longitudinal stiffeners

= σ_y for transverse stiffeners

σ_b = Bending stress in the stiffeners

σ_b = $\frac{M_0 + M_1}{W_{st} \cdot 10^3}$ [N/mm²]

M_o = Bending moment due to deformation w of stiffener

M_o = $F_{Ki} \frac{p_z \cdot w}{c_f - p_z}$ [N . mm]

$(c_f - p_z) > 0$

M_1 = bending moment due to the lateral load p for continuous longitudinal stiffeners:

M_1 = $\frac{p \cdot b \cdot a^2}{24 \cdot 10^3}$ [N · mm]

for transverse stiffeners:

M_1 = $\frac{p \cdot a \cdot (n \cdot b)^2}{c_s \cdot 8 \cdot 10^3}$ [N · mm]

p = Lateral load [kN/m²] according to Section 6

F_{Ki} = Ideal buckling force of the stiffener [N]

$F_{Kix} = \frac{\pi^2}{a^2} \cdot E \cdot I_x \cdot 10^4$ for long. stiffeners

$F_{Kiy} = \frac{\pi^2}{(n \cdot b)^2} \cdot E \cdot I_y \cdot 10^4$ for transv. stiffeners

I_x, I_y = Moments of inertia of the longitudinal or transverse stiffener including effective width of plating according to 2.2 [cm^4]

$$I_x \geq \frac{b \cdot t^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{a \cdot t^3}{12 \cdot 10^4}$$

p_z = Nominal lateral load of the stiffener due to σ_x, σ_y and τ [N/mm$_2$]

for longitudinal stiffeners:

$$p_{zx} = \frac{ta}{a}\left(\cdot \sigma x l \left(\frac{\pi \cdot b}{a}\right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2}\, \tau_1 \right)$$

For transverse stiffeners :

$$p_{zy} = \frac{ta}{a}\left(2 \cdot c_x \cdot \sigma_{xl} + \sigma_y \left(\frac{\pi \cdot a}{n \cdot b}\right)^2 \left(1 + \frac{A_y}{a \cdot t_a}\right) + \sqrt{2}\, \tau_1 \right)$$

$$\sigma_{xl} = \sigma_x \left(1 + \frac{A_x}{b \cdot t_a}\right)$$

c_x, c_y = Factor 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 $0 \leq \Psi \leq 1$

$$c_x, c_y = \frac{0,5}{1 - \Psi} \text{ for } \Psi < 0$$

ψ = Edge stress ratio according to Table 6.3

Ax,Ay = Sectional area of the longitudinal or transverse Stiffener respectively [mm^2]

$$\tau_1 = \left[\tau - t \sqrt{ReH \cdot E \left(\frac{m_1}{a^2} + \frac{m_2}{b^2} \right)} \right] \geq 0$$

for longitudinal stiffeners: :

$$\frac{a}{b} \geq 2,0 \;:\; m_1 = 1,47 \quad m_2 = 0,49$$

$$\frac{a}{b} < 2,0 \;:\; m_1 = 1,96 \quad m_2 = 0,37$$

for transverse stiffeners :

$$\frac{a}{n \cdot b} \geq 0,5 \;:\; m_1 = 0,37 \quad m_2 = \frac{1,96}{n^2}$$

$$\frac{a}{n \cdot b} < 0,5 \;:\; m_1 = 0,49 \quad m_2 = \frac{1,47}{n^2}$$

w = wo + w_1

w_o = Assumed imperfection [mm]

$\frac{a}{250} \geq w_{ox} \leq \frac{b}{250}$ for long. stiffeners

$\frac{n \cdot b}{250} \geq w_{oy} \leq \frac{a}{250}$ for transv. stiffeners

however $w_o \leq 10$ mm.

Note

For stiffeners sniped at both ends, wo shall not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 = Deformation of stiffener due to lateral load p at midpoint of stiffener span [mm]

In case of uniformly distributed load, the following values for w_1 may be used:

for longitudinal stiffeners:

$$w_1 = \frac{p \cdot b \cdot a^4}{384 \cdot 10^7 \cdot E \cdot I_x}$$

For transverse stiffeners:

$$w_1 = \frac{5 \cdot a \cdot p \cdot (n \cdot b)^4}{384 \cdot 10^7 \cdot E \cdot I_y \cdot c_s^2}$$

Table 5.12 Plane plate fields

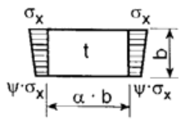
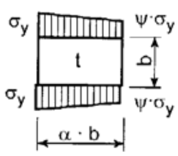
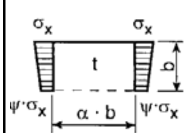
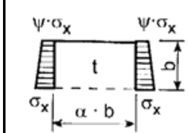
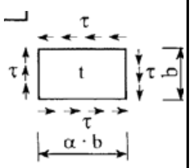
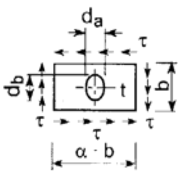
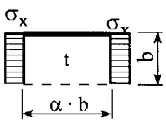
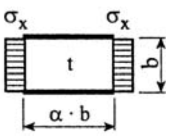
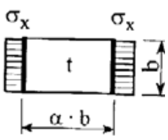
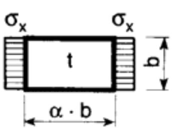
Load case		Edge stress ratio Ψ	Aspect ratio α	Buckling factor K	Reduction factor κ
1		$1 \geq \Psi \geq 0$	$\alpha > 1$	$K = \frac{8,4}{\Psi + 1,1}$	$\kappa_x = 1$ for $\lambda \leq \lambda_c$ $\kappa_x = c\left(\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right)$ for $\lambda > \lambda_c$ $c = (1,25 - 0,12\ \Psi) \leq 12,5$ $\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0,88}{c}}\right)$
		$0 > \Psi > -1$		$K = 7,63 - \Psi(6,26 - 10\Psi)$	
		$\Psi \leq -1$		$K = (1 - \Psi)^2 \cdot 5,975$	
2		$1 \geq \Psi \geq 0$	$\alpha \geq 1$	$K = F_1\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2,1}{(\psi + 1,1)}$	$\kappa_y = c\left(\frac{1}{\lambda} - \frac{R + F^2(H - R)}{\lambda^2}\right)$ $c = (1,25 - 0,12\ \Psi) \leq 12,5$ $R = \lambda\left(1 - \frac{\lambda}{c}\right)$ for $\lambda < \lambda_c$ $R = 0,22$ for $\lambda \geq \lambda_c$ $\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0,88}{c}}\right)$ $F = \left(1 - \frac{\frac{K}{0,91} - 1}{\lambda_p^2}\right) c_1 \geq 0$ $\lambda_p^2 = \lambda^2 - 0,5$ $1 \leq \lambda_p^2 \leq 3$ $c_1 = 0$ for σ_y due to direct loads $c_1 = 1 - \frac{F1}{\alpha} \geq 0$ for σ_y due to bending (in general) $c_1 = 0$ for σ_y due to bending in extreme load cases (e.g. w.t. bulkheads) $H = \lambda - \frac{2\lambda}{c \cdot (T + \sqrt{T^2 - 4})} \geq R$ $T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$
		$0 > \Psi > -1$	$1 \leq \alpha \leq 1,5$	$K = F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2,1}{1,1}(1 + \Psi) - \frac{\Psi}{\alpha^2}(13,9 - 10\Psi)\right]$	
			$\alpha > 1,5$	$K = F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2,1}{1,1}(1 + \Psi) - \frac{\Psi}{\alpha^2}\left(5,87 + 1,87\ \alpha^2 + \frac{8,6}{\alpha^2} - 10\Psi\right)\right]$	
		$\Psi \leq -1$	$1 \leq \alpha \leq (1 - \Psi)\frac{3}{4}$	$K = F_1\left(\frac{1 - \Psi}{\alpha}\right)^2 5,975$	
			$1 > (1 - \Psi)\frac{3}{4}$	$K = F_1\left[\left(\frac{1 - \Psi}{\alpha}\right)^2 3,9675 + 0,5375\left(\frac{1 - \Psi}{\alpha}\right)^4 + 1,87\right]$	
3		$1 \geq \Psi \geq 0$	$\alpha > 0$	$K = \frac{4\,(0,425 + 1/\alpha^2)}{3\Psi + 1}$	$\kappa_x = 1$ for $\lambda \leq 0,7$ $\kappa_x = \frac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
		$0 > \Psi \geq -1$		$K = 4\left(0,425 + \frac{1}{\alpha^2}\right)(1 + \Psi) - 5 \cdot \Psi(1 - 3,42\,\Psi)$	
4		$1 \geq \Psi \geq -1$	$\alpha > 0$	$K = \left(0,425 + \frac{1}{\alpha^2}\right)\frac{3 - \Psi}{2}$	

Table 5.12 Plane plate fields

Load case		Edge stress ratio Ψ	Aspect ratio α	Buckling factor K	Reduction factor κ
5		-	$\alpha \geq 1$	$K = K_\tau \cdot \sqrt{3}$ $K_\tau = \left[5{,}34 + \frac{4}{\alpha^2}\right]$	$\kappa_\tau = 1$ for $\lambda \leq 0{,}84$ $\kappa_\tau = \frac{0{,}84}{\lambda}$ for $\lambda > 0{,}84$
			$0 < \alpha < 1$	$K_\tau = \left[4 + \frac{5{,}34}{\alpha^2}\right]$	
6		-		K=K' r K'= K acc. to load case 5 r = reduction factor $r = \left(1 - \frac{d_a}{a}\right)\left(1 - \frac{d_b}{b}\right)$ with $\frac{d_a}{a} \leq 0{,}7$ and $\frac{d_b}{b} \leq 0{,}7$	
7		-	$\alpha \geq 1{,}64$	K = 1,28	$\kappa_x = 1$ for $\lambda \leq 0{,}7$ $\kappa_x = \frac{1}{\lambda^2 + 0{,}51}$ for $\lambda > 0{,}7$
			$\alpha < 1{,}64$	$K = \frac{1}{\alpha^2} + 0{,}56 + 0{,}13\,\alpha^2$	
8		-	$\alpha \geq \frac{2}{3}$	K = 6,97	$\kappa_x = 1$ for $\lambda \leq 0{,}83$ $\kappa_x = 1{,}13\left[\frac{1}{\lambda} - \frac{0{,}22}{\lambda^2}\right]$ for $\lambda > 0{,}83$
			$\alpha < \frac{2}{3}$	$K = \frac{1}{\alpha^2} + 2{,}5 + 5\,\alpha^2$	
9		-	$\alpha \geq 4$	K = 4	
			$4 > \alpha > 1$	$K = 4 + \left[\frac{4 - \alpha}{3}\right]^4 2{,}74$	
			$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2{,}07 + 0{,}67\,\alpha^2$	
10		-	$\alpha \geq 4$	K = 6,97	
			$4 > \alpha > 1$	$K = 6{,}97 + \left[\frac{4 - \alpha}{3}\right]^4 3{,}1$	
			$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2{,}07 + 4\,\alpha^2$	

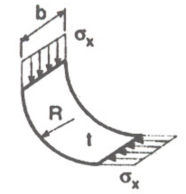
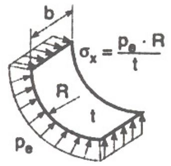
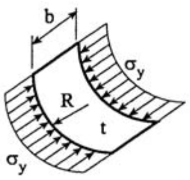
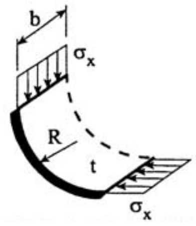
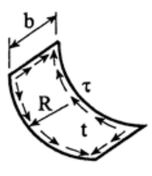
Explanations for boundary conditions :

- - - - - - - - - - *plate edge free*

plate edge simply supported

plate edge clamped

Table 5.13 Curved plate field R/t ≤ 2500 (*)

Load case		Aspect ratio b/R	Buckling factor K	Reduction factor κ
1a		$\frac{b}{R} \le 1{,}63\sqrt{\frac{R}{t}}$	$K = \frac{b}{\sqrt{R \cdot t}} + 3\,\frac{(R \cdot t)^{0{,}175}}{b^{0{,}35}}$	$\kappa_x = 1$ ** for $\lambda \le 0{,}4$ $\kappa_x = 1{,}274 - 0{,}686\lambda$ for $0{,}4 < \lambda \le 1{,}2$ $\kappa_x = \frac{0{,}65}{\lambda^2}$ for $\lambda > 1{,}2$
1b	 p_e = external pressure in [N/mm²]	$\frac{b}{R} > 1{,}63\sqrt{\frac{R}{t}}$	$K = 0{,}3\,\frac{b^2}{R^2} + 2{,}25\left(\frac{R^2}{b \cdot t}\right)^2$	
2		$\frac{b}{R} \le 0{,}5\sqrt{\frac{R}{t}}$	$K = 1 + \frac{2}{3}\,\frac{b^2}{R \cdot t}$	$\kappa_y = 1$ ** for $\lambda \le 0{,}25$ $\kappa_y = 1{,}233 - 0{,}933\lambda$ for $0{,}25 < \lambda \le 1$ $\kappa_y = \frac{0{,}3}{\lambda^2}$ for $1 \le \lambda \le 1{,}5$ $\kappa_y = 0{,}2 / \lambda^2$ for $\lambda > 1{,}5$
		$\frac{b}{R} > 0{,}5\sqrt{\frac{R}{t}}$	$K = 0{,}267\,\frac{b^2}{R \cdot t}\left[3 - \frac{b}{R}\sqrt{\frac{t}{R}}\right]$ $\ge 0{,}4\,\frac{b^2}{R \cdot t}$	
3		$\frac{b}{R} \le \sqrt{\frac{R}{t}}$	$K = \frac{0{,}6 \cdot b}{\sqrt{R \cdot t}} + \frac{\sqrt{R \cdot t}}{b} - 0{,}3\,\frac{R \cdot t}{b^2}$	see load case 1a
		$\frac{b}{R} > \sqrt{\frac{R}{t}}$	$K = 0{,}3\,\frac{b^2}{R^2} + 0{,}291\left(\frac{R^2}{b \cdot t}\right)^2$	
4		$\frac{b}{R} \le 8{,}7\sqrt{\frac{R}{t}}$	$K = K_\tau \cdot \sqrt{3}$ $K_\tau = \left[28{,}3 + \frac{0{,}67 \cdot b^3}{R^{1{,}5} \cdot t^{1{,}5}}\right]^{0{,}5}$	$\kappa_\tau = 1$ for $\lambda \le 0{,}4$ $\kappa_\tau = 1{,}274 - 0{,}686\lambda$ for $0{,}4 < \lambda \le 1{,}2$ $\kappa_\tau = \frac{0{,}65}{\lambda^2}$ for $\lambda > 1{,}2$
		$\frac{b}{R} > 8{,}7\sqrt{\frac{R}{t}}$	$K_\tau = 0{,}28\,\frac{b^2}{R\sqrt{R \cdot t}}$	

Explanations for boundary conditions :

- - - - - - - - - - - *plate edge free*

——————— *plate edge simply supported*

▬▬▬▬▬ *plate edge clamped*

* *For curved plate fields with a very large radius the κ value need not to be taken less than that one derived for the expanded plane field.*

** *For curved single fields. e.g. the bilge strake, which are located within plane partial or total fields, the reduction factor κ may taken as follows:*

Load case 1 b: $\kappa_p = 0{,}8/\lambda^2 \le 1{,}0$; load case 2: $\kappa_y = 0{,}65/\lambda^2 \le 1{,}0$

c_f = Elastic support provided by the stiffener [N/mm^2]

c_{fx} = $F_{Kix} \cdot \dfrac{\pi^2}{a^2} \cdot (1 + c_{px})$ for long. stiffeners

$$c_{px} = \cfrac{1}{1 + \cfrac{0{,}91 \cdot \left(\dfrac{12 \cdot 10^4 \cdot I_x}{t^3 \cdot b} - 1 \right)}{c_{x\alpha}}}$$

$$c_{x\alpha} = \left[\frac{a}{2\,b} + \frac{2\,b}{a} \right]^2 \quad \text{for } a \geq 2\,b$$

$$= \left[1 + \left(\frac{a}{2\,b} \right)^2 + \right]^2 \quad \text{for } a < 2\,b$$

c_{fy} = $c_s \cdot F_{Kiy} \cdot \dfrac{\pi^2}{(n \cdot b)^2} \cdot (1 + c_{py})$ for transv. stiffeners

$$\frac{\sigma_x \cdot S}{\kappa_T \cdot R_{eH}} \leq 1{,}0$$

c_s = Factor accounting for the boundary conditions of the transverse stiffener

= 1,0 for simply supported stiffeners

= 2,0 for partially constrained stiffeners

$$c_{py} = \cfrac{1}{1 + \cfrac{0{,}91 \cdot \left(\dfrac{12 \cdot 10^4 \cdot I_y}{t^3 \cdot a} - 1 \right)}{c_{y\alpha}}}$$

$$c_{y\alpha} = \left[\frac{n \cdot b}{2\,a} + \frac{2\,a}{n \cdot b} \right]^2 \quad \text{for } n \cdot b \geq 2\,a$$

$$= \left[1 + \left(\frac{n \cdot b}{2\,a} \right)^2 \right]^2 \quad \text{for } n \cdot b < 2\,a$$

W_{st} = Section modulus of stiffener (long. or transverse) [cm^3] including effective width of plating according to 2.2

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 biaxial stress field at the plating side).

Note

Longitudinal and transverse stiffeners not subjected to lateral load p have sufficient scantlings if their moments of inertia I_x and I_y are not less than obtained by the following formulae:

$$I_x = \frac{p_{zx} \cdot a^2}{\pi^2 \cdot 10^4} \left[\frac{w_{ox} \cdot h_w}{\dfrac{R_{eH}}{S} - \sigma_x} + \frac{a^2}{\pi^2 \cdot E} \right] \ [\text{cm}^4]$$

$$I_y = \frac{p_{zy} \cdot (n \cdot b)^2}{\pi^2 \cdot 10^4} \left[\frac{w_{oy} \cdot h_w}{\dfrac{R_{eH}}{S} - \sigma_y} + \frac{(n \cdot b)^2}{\pi^2 \cdot E} \right] \ [\text{cm}^4]$$

3.3 Torsional buckling

3.3.1 Longitudinal stiffeners

$$\frac{\sigma_x \cdot S}{\kappa_T \cdot R_{eH}} \leq 1{,}0$$

$\kappa_T = 1{,}0$ for $\lambda_T \leq 0{,}2$

$$\kappa_T = \frac{1}{\varphi + \sqrt{\varphi^2 - \lambda_T^2}} \quad \text{for } \lambda_T > 0{,}2$$

$$\phi = 0{,}5 \cdot [1 + 0{,}21\,(\lambda_T - 0{,}2) + \lambda_T^2]$$

λ_T = Reference degree of slenderness

$$\lambda_T = \sqrt{\frac{R_{eH}}{\sigma_{KiT}}}$$

$$\sigma_{KiT} = \frac{E}{I_P} \left(\frac{\pi^2 \cdot I_\omega \cdot 10^2}{a^2} \cdot \varepsilon + 0{,}385 \cdot I_T \right) \left[\text{N/mm}^2 \right]$$

For I_P, I_T, I_ω see Fig. 5.14 and Table 5.14.

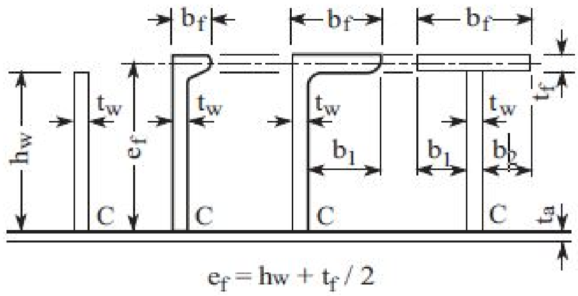


Fig. 5.14 Main dimensions of typical longitudinal stiffeners

I_P = Polar moment of inertia of the stiffener related to the point C [cm^4]

I_T = St. Venant's moment of inertia of the stiffener [cm^4]

I_ω = Sectorial moment of inertia of the stiffener related to the point C [cm^6]

ε = Degree of fixation

$$\varepsilon = 1 + 10^{-4}\sqrt{\frac{a^4}{I_\omega\left(\frac{b}{t^3}+\frac{4 h_w}{3 t_w^3}\right)}}$$

h_w = Web height [mm]

t_w = Web thickness [mm]

b_f = Flange breadth [mm]

t_f = Flange thickness [mm]

A_w = Web area $h_w \cdot t_w$

A_f = Flange area $b_f \cdot t_f$

3.3.2 Transverse stiffeners

For transverse stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, proof is to be provided in accordance with 3.3.1 analogously.

D. Strength Check in Testing Conditions

1. Symbols

t = Net thickness [mm] of plating

w = Net section modulus [cm^3] of ordinary stiffeners

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in A.2.4 and A.3.2

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of stiffeners

η = $1 - s / (2 \cdot \ell)$

z = Z co-ordinate [m] of the calculation point

z_{TOP} = Z co-ordinate [m] of the highest point of the tank

z_{AP} = Z co-ordinate [m] of the deck line of the deck to which the air pipes extend, to be taken not less than z_{TOP}

p_{pv} = Setting pressure [kN/m^2] of safety valves or maximum pressure [kN/m^2] in the tank during loading/unloading, whichever is the greater

d_{AP} = Distance from the top of air pipe to the top of the compartment [m]

p_{ST} = Testing pressure [kN/m^2] defined in 3.

σ_1 = Hull girder normal stress [N/mm^2] to be determined in testing conditions.

2. Strength check

2.1 General

The requirements of this Section provide the minimum scantlings of platings and structural members of compartments subjected to testing conditions.

Where the test conditions are subject to induce additional loads, the strength check is to be carried out by direct calculation.
These requirements are not applicable to bottom shell plating and side shell plating.

Table 5.14 Formulea for the calculation of moments of inertia I_P, I_T and I_ω

Profile	I_P	I_T	I_ω
flat bar	$\dfrac{h_w^3 \cdot t_w}{3 \cdot 10^4}$	$\dfrac{h_w \cdot t_w^3}{3 \cdot 10^4}\left[1 - 0{,}63\dfrac{t_w}{h_w}\right]$	$\dfrac{h_w^3 \cdot t_w^3}{36 \cdot 10^6}$
profiles with bulb or flange	$\left[\dfrac{A_w \cdot h_w^2}{3} + A_f \cdot e_f^2\right]10^{-4}$	$\dfrac{h_w \cdot t_w^3}{3 \cdot 10^4}\left[1 - 0{,}63\dfrac{t_w}{h_w}\right]$ + $\dfrac{b_f \cdot t_f^3}{3 \cdot 10^4}\left[1 - 0{,}63\dfrac{t_f}{b_f}\right]$	for bulb and angle profiles: $\dfrac{A_f \cdot e_f^2 \cdot b_f^2}{12 \cdot 10^6}\left[\dfrac{A_f + 4\,A_w}{A_f + A_w}\right]$ for T- profiles $\dfrac{b_f^3 \cdot t_f \cdot e_f^2}{12 \cdot 10^6}$

2.2 Plating

The net thickness [mm] of plating of compartments or structures defined in Table 5.16 is to be not less than:

$$t = s \cdot \sqrt{k \cdot p_{ST}}$$

where the testing pressure p_{ST} is defined in 3.

2.3 Structural members

The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of structural members of compartments or structures defined in Table 5.16 are to be not less than the values obtained from the formulae given in Table 5.17.

Table 5.15 Resistance partial safety factors γ_R

Structures	Ordinary stiffeners	Primary supporting members
Fore peak structures	1,25	1,25
Structures located aft of the collision bulkhead	1,02	1,02 (1) 1,15 (2)
(1) *in general* **(2)** *for bottom and side girders.*		

3. Testing Pressures

3.1 Still water pressure

The still water pressure to be considered as acting on plates and stiffeners subjected to tank testing is to be obtained, in [kN/m^2], from the formulae in Table 5.16.

The testing conditions of tanks and watertight or weathertight structures are determined by requirements of Section 11, C.

Table 5.16 Testing - Still water pressure

Compartment or structure to be tested	Still water pressure p_{ST} [kN/m^2]
Double bottom tanks	$p_{ST} = 9{,}81.[(Z_{TOP} - Z) + d_{AP}]$
Double side tanks Fore peaks used as tank After peaks used as tank	The greater of the following: $p_{ST} = 9{,}81.[(Z_{TOP} - Z) + d_{AP}]$ $p_{ST} = 9{,}81.[(Z_{TOP} - Z) +1]$
Cargo tank bulkheads Deep tanks Independent cargo tanks Residual cargo tanks	The greater of the following: $p_{ST} = 9{,}81.[(Z_{TOP} - Z) + d_{AP}]$ $p_{ST} = 9{,}81.[(Z_{TOP} - Z) +1]$ $p_{ST} = 9{,}81 \cdot (Z_{TOP} - Z) +1{,}3 \cdot p_{pv}$
Ballast compartments Fuel oil bunkers Cofferdams	The greater of the following: $p_{ST} = 9{,}81.[(Z_{TOP} - Z) + d_{AP}]$ $p_{ST} = 9{,}81.[(Z_{TOP} - Z) +1]$
Double bottom Fore peaks not used as tank After peaks not used as Tank	$p_{ST} = 9{,}81.(Z_{AP} - Z)$
Other independent tanks	The greater of the following: $p_{ST} = 9{,}81.[(Z_{TOP} - Z) + d_{AP}]$ $p_{ST} = 9{,}81.[(Z_{TOP} - Z) + 2{,}4]$

Table 5.17 Strength check of stiffeners in testing conditions

Stiffener	w	A_{sh}
Vertical stiffeners	$w = \frac{4.36 \cdot \gamma_R}{m} k \cdot \lambda_b \cdot \beta_b \cdot p_{ST} \cdot \eta_1 \cdot a \cdot \ell^2$	$A_{sh} = 0{,}045.\ \gamma_R \cdot k \cdot \lambda_s \cdot \beta_s \cdot \eta_1 \cdot p_{ST} \cdot a \cdot \ell$
Transverse stiffeners Longitudinal stiffeners	$w = \frac{4.36 \cdot \gamma_R}{m} k \cdot \beta_b \cdot p_{ST} \cdot \eta_1 \cdot a \cdot \ell^2$	$A_{sh} = 0{,}045.\ \gamma_R \cdot k \cdot \beta_s \cdot \eta_1 \cdot p_{ST} \cdot a \cdot \ell$
Longitudinal stiffeners (in case of testing afloat)	$w = \frac{4.36}{m\left(\frac{230}{\gamma_R} - \sigma_1\right)} k \cdot \beta_b \cdot \eta_1 \cdot p_{ST} \cdot a \cdot \ell^2$	

a = s for ordinary stiffeers
= S for primary supporting members

η_1 = η for ordinary stiffeners
= 1 for primary supporting members

β_b, β_S = Bracket coefficients defined in B.6.2

λ_b, λ_S = Coefficients for vertical structural members defined in B.6.3

γ_R = Resistance partial safety factor defined in Table 5.15

m = Boundary coefficient, to be taken equal to:
= 12 in general, for stiffeners considered as clamped
= 8 for stiffeners considered as simply supported
= 10,6 for stiffeners clamped at one end and simply supported at the other

E. Direct Calculation

1. Symbols

R_{eH} = Minimum yielding stress [N/mm^2] of the material

γ_R = Partial safety factor covering uncertainties regarding resistance, defined in Table 5.18.

2. General

2.1 Application

2.1.1 The following requirements give direct calculation guidance for the yielding and buckling checks of structural members.Direct calculation may be adopted instead of Rule scantling formulae or for the analysis of structural members not covered by the Rules.

2.1.2 Yielding check

The yielding check is to be carried out according to:

- 3. for structural members analysed through isolated beam models
- 4. for structural members analysed through three dimensional beam or finite element models

2.1.3 Buckling check

The buckling check is to be carried out according to C. on the basis of the stresses in primary supporting members calculated according to 3. or 4. depending on the structural model adopted.

2.2 Analysis documentation

2.2.1 The following documents are to be submitted to **TL** for review/approval 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 **TL** 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 4.3 and C.

2.2.2 According to the results of the submitted calculations, **TL** may request additional runs of the model with structural modifications or local mesh refinements in highly stressed areas.

2.3 Net scantlings

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 B.7.

2.4 Resistance partial safety factors

The values of resistance partial safety factor covering uncertainties on resistance to be considered for checking structural members are specified in Table 5.18 for analyses based on different calculation models.

Table 5.18 Resistance partial safety factor γ_R

Calculation model	Yielding check		Buckling check
	General	Watertight bulkhead	
Isolated beam model: - in general - bottom and side girders - collision bulkhead	 1,02 1.15 NA **(1)**	 1,02 NA **(1)** 1,25	1,10
Three dimensional beam model	1,20	1,02	1,02
Coarse mesh finite element model	1,20	1,02	1,02
Fine mesh finite element model	1,05	1,02	1,02
(1) *NA= not applicable*			

3. Yielding Check of Structural Members Analysed Through an Isolated Beam Structural Model

3.1 General

3.1.1 The following requirements apply for 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.

3.1.2 The yielding check is also to be carried out for structural members subjected to specific loads, such as concentrated loads.

3.2 Load point

3.2.1 Lateral pressure

Unless otherwise specified, lateral pressure is to be calculated at mid-span of the structural member considered.

3.2.2 Hull girder normal stresses

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.

3.3 Load model

3.3.1 General

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 Section 6, C.

3.3.2 Pressure load in service conditions

The pressure load in service conditions is to be determined according to Section 6, C.4. and C.5.

3.3.3 Wheeled loads

For structural members subjected to wheeled loads, the yielding check may be carried out according to 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.

3.3.4 Hull girder normal stresses

The hull girder normal stresses to be considered for the yielding check of structural members are to be determined according to Section 7, C.3.4.

3.4 Checking criteria

It is to be checked that the normal stress σ and the shear stress τ are in compliance with the following formulae:

$$0.98 \cdot \frac{R_{eH}}{\gamma_R} \geq \sigma$$

$$0.49 \cdot \frac{R_{eH}}{\gamma_R} \geq \tau$$

4. Yielding Check of Structural Members Analysed Through a Three Dimensional Structural Model

4.1 General

4.1.1 The following requirements apply for 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.

4.1.2 The yielding check is also to be carried out for structural members subjected to specific loads, such as concentrated loads.

4.2 Analysis criteria

The analysis of structural members based on three dimensional models is to be carried out according to:

- the requirements in G. for structural members subjected to lateral pressure
- the requirements in H. for structural members subjected to wheeled loads.

4.3 Checking criteria

4.3.1 General

For all types of analysis (see G.2.), it is to be checked that the equivalent Von Mises stress σ_{VM}, calculated according to G.5. is in compliance with the following formula:

$$0.98 \cdot \frac{R_{eH}}{\gamma_R} \geq \sigma_{VM}$$

4.3.2 Additional criteria for analyses based on fine mesh finite element models

Fine mesh finite element models are defined with reference to G.3.4

For all the elements of the fine mesh models, it is to be checked that the normal stresses σ_1 and σ_2 and the shear stress τ_{12}, calculated according to G.5. are in compliance with the following formulae:

$$0.98 \cdot \frac{R_{eH}}{\gamma_R} \geq MAX(\sigma_1 ; \sigma_2)$$

$$0.49 \cdot \frac{R_{eH}}{\gamma_R} \geq \tau_{12}$$

4.3.3 Specific case of structural members subjected to wheeled loads

For all types of analysis (see H.), it is to be checked that the equivalent Von Mises stress σ_{VM}, calculated according to H. is in compliance with the following formula:

$$0.98 \cdot \frac{R_{eH}}{\gamma_R} \geq \sigma_{VM}$$

5. Torsion

5.1 Torsion of catamarans

A method for the determination of scantlings of deck beams connecting the hulls of a catamaran subject to torsional moment is given in I.

F. Geometric Properties of Standard Sections

1. Angles, flats and bulb flats

1.1 Notice

1.1.1 Table 5.19 and Table 5.20 give main characteristics of angles, bulb flats and flats currently used, with an attached plating 500 mm wide having a thickness equal to that of the section web.

1.1.2 The sections are listed in the order of increasing values of the section moduli. For each section, the data are listed in the following order:

- Dimensions of the rolled section [mm]
- Then, between brackets:
  - The sectional area [cm^2] of the section
  - The section modulus [cm^3] with the attached plating defined in 1.1.1
  - The mean variation of the section modulus [cm^3] for each 10 % variation in sectional area of the attached plating

The values shown in Table 5.19 and Table 5.20 are, as a rule, valid for sectional area of the attached plating variations not exceeding 50 %.

1.1.3 Examples

a) Consider a DIN bulb flat 200 x 9 welded to a 600 x 10 plating. The data shown in Table 5.19 are:

200 x 9 (23,60 209,1 1,98)

23,60 = Sectional area [cm^2] of the section

209,1 = Section modulus [cm^3] with an attached plating 9 mm thick and 500 mm wide

1,98 = Mean increase of the section modulus for each 10 % increase in sectional area of the attached plating.

The section modulus obtained is thus equal to:
209,1 + 1,98.(60 − 45).10/45 = 215,7 cm^3

b) If the same bulb flat is attached to a 400 x 8 plating, then the section modulus will be:
209,1 + 1,98.(32 − 45).10/45 = 203,4 cm^3

2. Channels

2.1 Notice

2.1.1 Table 5.21 gives main characteristics of European standard channels currently used, with an attached plating 500 mm wide having a thickness equal to that of the channel web (a).

2.1.2 The channels are listed in the order of increasing values of the section moduli. For each channel, the data are listed in the following order:

- Standard designation of the channel section
- Dimensions of the channel [mm]
- Sectional area [cm^2] of the channel
- Section modulus [cm^3] with the attached plating defined in 2.1.1

G. Analyses Based on Three Dimensional Models

1. General

1.1 Application

1.1.1 The following requirements apply for the analysis criteria, structural modelling, load modelling and stress calculation of primary supporting members which are to be analysed through three dimensional structural models, according to E.

1.1.2 The following 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 checks.

1.1.3 In some specific cases, some of simplifications or assumptions laid down below may not be deemed acceptable by **TL** in relation to the type of structural model and the analysis performed.

1.1.4 The yielding and buckling checks of primary supporting members are to be carried out according to E.

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 **TL** 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 3.4.3.

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 **TL**
- 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 **TL** on the basis of the vessel's structural arrangement.

Table 5.19 Geometric particulars with 500 mm wide attached plating of standard DIN unequal angles and bulb flats

w [cm³]	Unequal angles	Bulb flats
2	30 x 20 x 3 (1,42 - 2,5 - 0,02)	
3	40 x 20 x 3 (1,72 - 3,7 - 0,02)	
4	40 x 20 x 4 (2,25 - 4,8 - 0,04)	
5	45 x 30 x 3 (2,19 - 5,7 - 0,03)	
7	45 x 30 x 4 (2,87 - 7,5 - 0,05)	
9	45 x 30 x 5 (3,53 - 9,1 - 0,08)	
10	50 x 40 x 4 (3,46 - 10,5 - 0,06) 50 x 30 x5 (3,78 - 10,6 - 0,08)	
11		60 x 4 (3,58 - 11,0 - 0,07)
12	50 x 40 x 5 (4,27 - 12,8 - 0,1)	60 x 5 (4,18 - 12,4 - 0,09)
13	60 x 30 x 5 (4,29 - 13,7 - 0,1)	
14		60 x 6 (4,78 - 14,0 - 0,13)
16	60 x 40 x 5 (4,79 - 16,5 - 0,11)	
18	60 x 30 x 7 (5,85 - 18,5 - 0,18)	
19	60 x 40 x 6 (5,68 - 19,4 - 0,15)	
20		80 x 5 (5,4 - 20,6 - 0,14)
21	65 x 50 x 5 (5,54 - 21,4 - 0,14)	
22	60 x 40 x 7 (6,55 - 22,4 - 0,2)	
23		80 x 6 (6,2 - 23,2 - 0,18)
25	75 x 50 x 5 (6,04 - 25,9 - 0,16)	80 x 7 (7,0 - 25,7 - 0,22)
27	75 x 55 x 5 (6,30 - 27,8 - 0,17)	
29	80 x 40 x 6 (6,89 - 29,1 - 0,2) 65 x 50 x 7 (7,60 - 29,2 - 0,24)	
35	75 x 50 x 7 (8,3 - 35,3 - 0,27)	100 x 6 (7,74 - 35,4 - 0,26)
36	65 x 50 x 9 (9,58 - 36,5 - 0,38)	
37	80 x 40 x 8 (9,01 - 37,7 - 0,33) 75 x 55 x 7 (8,66 - 37,7 - 0,29)	
39		100 x 7 (8,74 - 39,2 - 0,31)
40	80 x 65 x 6 (8,41 - 40,4 - 0,27)	
43		100 x 8 (9,74 - 43,0 - 0,38)
44	75 x 50 x 9 (10,5 - 44,4 - 0,43) 90 x 60 x 6 (8,69 - 44,4 - 0,29)	
46	100 x 50 x 6 (8,73 - 46,0 - 0,31)	
47	75 x 55 x 9 (10,9 - 47,3 - 0,44)	
50		120 x 6 (9,31 - 50,6 - 0,38)
52	80 x 65 x 8 (11,0 - 52,4 - 0,42)	
55		120 x 7 (10,5 - 55,7 - 0,44)
57	90 x 60 x 8 (11,4 57,8 0,46)	
59	100 x 50 x 8 (11,5 59,9 0,48)	
60	90 x 75 x 7 (11,1 60,0 0,42)	120 x 8 (11,7 - 60,9 - 0,52)
63	100 x 65 x 7 (11,2 63,0 0,45)	
64	80 x 65 x 10 (13,6 64,2 0,63)	

Table 5.19 Geometric particulars with 500 mm wide attached plating of standard DIN unequal angles and bulb flats -continued-

w [cm^3]	Unequal angles	Bulb flats
69	100 x 75 x 7 (11,9 - 69,5 - 0,49)	
73	100 x 50 x 10 (14,1 - 73,0 - 0,67)	
77		140 x 7 (12,6 - 77,6 - 0,64)
79	100 x 65 x 9 (14,2 - 79,1 - 0,66)	
83		140 x 8 (13,8 - 83,7 - 0,71)
87	100 x 75 x 9 (15,1 - 87,3 - 0,72)	
90		140 x 9 (15,2 - 90,8 - 0,81)
94	100 x 65 x 11 (17,1 - 94,6 - 0,91)	
102	130 x 65 x 8 (15,1 - 102,0 - 0,79)	
104	100 x 75 x 11 (18,2 - 104,5 - 0,99) 120 x 80 x 8 (15,5 - 104,6 - 0,79)	160 x 7 (14,6 - 104,7 - 0,87)
111	130 x 75 x 8 (15,9 - 111,3 - 0,85)	
113		160 x 8 (16,2 - 113,5 - 0,98)
122		160 x 9 (17,8 - 122,5 - 1,11)
124	130 x 65 x 10 (18,6 - 124,7 - 1,07)	
127	120 x 80 x 10 (19,1 - 127,9 - 1,08)	
136	130 x 75 x 10 (19,6 - 136,2 - 1,16)	
146	130 x 65 x 12 (22,1 - 146,9 - 1,41)	
150	150 x 75 x 9 (19,5 - 150,4 - 1,23) 120 x 80 x 12 (22,7 - 150,9 - 1,43)	
151		180 x 8 (18,9 - 151,9 - 1,36)
154	130 x 90 x 10 (21,2 - 154,9 - 1,30)	
160	130 x 75 x 12 (23,3 - 106,8 - 1,52)	
162		180 x 9 (20,7 - 162,2 - 1,51)
173	120 x 80 x14 (26,2 - 173,1 - 1,82)	
174		180 x 10 (22,5 - 174,5 - 1,67)
180	150 x 75 x 11 (23,6 - 180,7 - 1,62)	
182	130 x 90 x 12 (25,1 - 182,1 - 1,69)	
186		180 x 11 (24,3 - 186,4 - 1,85)
187	150 x 90 x 10 (23,2 - 187,5 - 1,59)	
190	160 x 80 x 10 (23,2 - 190,1 - 1,65)	
201	150 x 100 x 10 (24,2 - 201,3 - 1,70)	
209		200 x 9 (23,6 - 209,1 - 1,98)
220	150 x 90 x 12 (27,5 - 220,8 - 2,04)	
222		200 x 10 (25,6 - 222,0 - 2,17)
224	160 x 80 x 12 (27,5 - 224 - 2,10)	
236		200 x 11 (27,6 - 236,8 - 2,38)
237	150 x 100 x 12 (28,7 - 237,2 - 2,17)	
240	180 x 90 x 10 (26,2 - 240,8 - 2,12)	
251		200 x 12 (29,6 - 251,3 - 2,61)

Table 5.19 Geometric particulars with 500 mm wide attached plating of standard DIN unequal angles and bulb flats -continued-

w [cm^3]	Unequal angles	Bulb flats
257	160 x 80 x 14 (31,8 - 257,2 - 2,60)	
272	150 x 100 x 14 (33,2 - 272,8 - 2,71)	
283		220 x 10 (29,0 - 283,8 - 2,83)
284	180 x 90 x 12 (31,2 - 284,9 - 2,68)	
297	200 x 100 x 10 (29,2 - 297,3 - 2,66)	
299		220 x 11 (31,2 - 299,0 - 3,07)
312		220 x 12 (33,4 - 312,9 - 3,32)
327	180 x 90 x 14 (36,1 - 327,3 - 3,31)	
344		240 x 10 (32,4 - 344,9 - 3,57)
351	200 x 100 x 12 (34,8 - 351,5 - 3,36)	
368		240 x 11 (34,9 - 368,9 - 3,88)
382	250 x 90 x 10 (33,2 - 382,0 - 3,74)	
386		240 x 12 (37,3 - 386,8 - 4,17)
404	200 x 100 x 14 (40,3 - 404,2 - 4,11)	
447		260 x 11 (38,7 - 447,0 - 4,83)
452	250 x 90 x 12 (39,6 - 452,6 - 4,65)	
456	200 x 100 x 16 (45,7 - 456,5 - 4,90)	
468		260 x 12 (41,3 - 468,5 - 5,18)
489		260 x 13 (43,9 - 489,5 - 5,52)
521	250 x 90 x 14 (45,9 - 521,3 - 5,60)	
532		280 x 11 (42,6 - 532,8 - 6,05)
560		280 x 12 (45,5 - 560,0 - 6,48)
584		280 x 13 (48,3 - 584,6 - 7,02)
588	250 x 90 x 16 (52,1 - 588,3 - 6,61)	
634		300 x 11 (46,7 - 634,4 - 7,26)
665		300 x 12 (49,7 - 665,7 - 7,8)
696		300 x 13 (52,8 - 696,0 - 8,45)
724		300 x 14 (55,8 - 724,5 - 8,96)
776		320 x 12 (54,2 - 776,9 - 9,24)
811		320 x 13 (57,4 - 811,6 - 9,88)
845		320 x 14 (60,7 - 845,6 - 10,64)
877		320 x 15 (63,9 - 877,4 - 11,25)
897		340 x 12 (58,8 - 897,2 - 10,08)
937		340 x 13 (62,2 - 937,7 - 11,57)
975		340 x 14 (65,5 - 975,2 - 12,32)
1012		340 x 15 (68,9 - 1012,2 - 13,05)
1153		370 x 13 (69,6 - 1153,7 - 14,43)
1192		370 x 14 (73,3 - 1192,4 - 15,26)
1238		370 x 15 (77,0 - 1238,3 - 16,2)
1310		370 x 16 (80,7 - 1310,9 - 1,12)

Table 5.20 Geometric particulars with 500 mm wide attached plating of standard DIN flats and equal angles

w [cm^3]	Flats		Equal angles	
3	50 x 4	(2,0 - 3,6 - 0,03)		
4	50 x 5	(2,5 - 4,6 - 0,05)		
5	50 x 6	(3,0 - 5,7 - 0,08)		
6	60 x 5 55 x 6	(3,0 - 6,4 - 0,06) (3,3 - 6,7 - 0,08)		
7	60 x 6	(3,6 - 7,8 - 0,09)	40 x 40 x 4	(3,08 - 7,9 - 0,06)
9	65 x 6 60 x 7	(3,9 - 9,1 - 0,1) (5,2 - 9,4 - 0,12)	40 x 40 x 5	(3,79 - 9,7 - 0,09)
10			45 x 45 x 4	(3,49 - 10,1 - 0,06)
11			40 x 40 x 6	(4,48 - 11,5 - 0,13)
12	70 x 7 65 x 8	(4,9 - 12,4 - 0,14) (5,2 - 12,6 - 0,17)	45 x 45 x 5	(4,3 - 12,4 - 0,10)
14	70 x 8	(5,6 - 14,4 - 0,18)		
16	75 x 8	(6,0 - 16,3 - 0,20)		
18	80 x x8	(6,4 - 18,3 - 0,21)	50 x 50 x 6 55 x 55 x 5	(5,69 - 18,0 - 0,15) (5,32 - 18,7 - 0,13)
20			50 x 50 x 7	(6,56 - 20,7 - 0,21)
21	75 x 10	(7,5 - 21,1 - 0,31)		
22	90 x 8	(7,2 - 22,8 - 0,24)	55 x 55 x 6 60 x 60 x 5	(6,31 - 22,1 - 0,17) (5,82 - 22,3 - 0,14)
23	80 x 10	(8,0 - 23,6 - 0,33)	50 x 50 x 8	(7,41 - 23,5 - 0,27)
25	90 x 9	(8,1 - 25,9 - 0,30)		
26			50 x 50 x9 60 x 60 x 6	(8,24 - 26,0 - 0,34) (6,91 - 26,3 - 0,19)
27	100 x 8	(8,0 - 27,7 - 0,28)		
28			55 x 55 x 8	(8,23 - 28,6 - 0,30)
29	90 x 10	(9,0 - 29,2 - 0,37)		
31			65 x 65 x 6	(7,53 - 31,1 - 0,22)
34			60 x 60 x 8	(9,03 - 34,1 - 0,33)
35	100 x 10	(10,0 - 35,4 - 0,42)	65 x 65 x 7	(8,7 - 35,7 - 0,29)
36			70 x 70 x 6	(8,13 - 36,1 - 0,25)
37	110 x 9	(9,9 - 37,5 - 0,39)		
38	120 x 8	(9,6 - 38,8 - 2,98)		
40			65 x 65 x 8	(9,85 - 40,2 - 0,36)
41			70 x 70 x 7 75 x 75 x 6	(9,40 - 41,5 - 0,32) (8,75 - 41,7 - 0,28)
42	110 x 10	(11,0 - 42,1 - 0,47)		
43	100 x 12	(12,0 - 43,5 - 0,59)		
44			65 x 65 x 9	(11,0 - 44,7 - 0,45)
45	130 x 8	(10,4 - 45,1 - 0,43)		
46	110 x 11	(12,1 - 46,8 - 0,56)	70 x 70 x 8	(10,6 - 46,7 - 0,40)
47			75 x 75 x 7	(10,1 - 47,8 - 0,35)
49	120 x 10	(12,0 - 49,5 - 0,54)		

Table 5.20 Geometric particulars with 500 mm wide attached plating of standard DIN flats and equal angles -continued-

w [cm^3]	Flats		Equal angles	
51	130 x 9 140 x 8	(11,7 - 51,2 - 0,52) (11,2 - 51,9 - 0,50)		
52			70 x 70 x 9	(11,9 - 52,1 - 0,49)
54			75 x 75 x 8 80 x 80 x 7	(11,5 - 54,1 - 0,45) (10,8 - 54,5 - 0,39)
57	130 x 10	(13,0 - 57,3 - 0,61)	70 x 70 x 10	(13,1 - 57,2 - 0,60)
59	150 x 8	(12,0 - 59,0 - 0,57)		
60	120 x 12	(14,4 - 60,5 - 0,74)		
61			80 x 80 x 8	(12,3 - 61,6 - 0,49)
62			70 x 70 x 11	(14,3 - 62,2 - 0,71)
63	130 x 11	(14,3 - 63,6 - 0,72)		
65	140 x 10	(14,0 - 65,8 - 0,70)		
66			75 x 75 x 10	(14,1 - 66,0 - 0,65)
70	130 x 12	(15,6 - 70,0 - 0,83)		
74	150 x 10	(15,0 - 74,8 - 0,79)		
75			80 x 80 x 10	(15,1 - 75,1 - 0,72)
77			75 x 75 x 12	(16,7 - 77,5 - 0,91)
78			90 x 90 x 8	(13,9 - 78,2 - 0,60)
80	140 x 12	(16,8 - 80,2 - 0,93)		
87			90 x 90 x 9	(15,5 - 87,0 - 0,72)
88			80 x 80 x 12	(17,9 - 88,7 - 0,99)
91	150 x 12	(18,0 - 91,1 - 1,05)		
95			90 x 90 x 10	(17,1 - 95,7 - 0,86)
97			100 x 100 x 8	(15,5 - 97,0 - 0,73)
101			80 x 80 x 14	(20,6 - 101,7 - 1,31)
104			90 x 90 x 11	(18,7 - 104,3 - 1,00)
107	150 x 14	(21,0 - 107,8 - 1,34)		
112			90 x 90 x 12	(20,3 - 112,7 - 1,17)
116	150 x 15	(22,5 - 116,3 - 1,51)		
119			100 x 100 x 10	(19,2 - 119,2 - 1,03)
120			90 x 90 x 13	(21,8 - 120,7 - 1,33)
140			100 x 100 x 12	(22,7 - 140,0 - 1,37)
145			90 x 90 x 16	(26,4 - 145,2 - 1,93)
160			100 x 100 x 14	(26,2 - 160,5 - 1,77)
170			100 x 100 x 15	(27,9 - 170,5 - 1,99)
180			100 x 100 x 16	(29,6 - 180,3 - 2,23)
219			100 x 100 x 20	(36,2 - 219,3 - 3,31)
237			130 x 130 x 12	(30,0 - 237,1 - 2,76)
244			120 x 120 x 15	(33,9 - 244,7 - 3,6)
271			130 x 130 x 14	(34,7 - 271,8 - 3,64)
296			140 x 140 x 13	(35,0 - 296,8 - 3,51)
305			130 x 130 x 16	(39,3 - 305,5 - 4,48)

Table 5.20 Geometric particulars with 500 mm wide attached plating of standard DIN flats and equal angles -continued-

w [cm^3]	Flats	Equal angles
317		150 x 150 x 12 (34,8 - 317,6 - 3,48)
336		140 x 140 x 15 (40,0 - 336,5 - 4,5)
364		150 x 150 x 14 (40,3 - 364,2 - 4,48)
387		150 x 150 x 15 (43,0 - 387,3 - 4,95)
409		150 x 150 x 16 (45,7 - 409,8 - 5,6)
442		160 x 160 x 15 (46,1 - 442,8 - 5,55)
454		150 x 150 x 18 (51,0 - 454,8 - 6,84)
498		150 x 150 x 20 (56,3 - 498,5 - 8,2)
544		160 x 160 x 19 (57,5 - 544,6 - 8,17)
595		180 x 180 x 16 (55,4 - 595,8 - 7,36)
661		180 x 180 x 18 (61,9 - 661,6 - 9,0)
725		180 x 180 x 20 (68,4 - 725,6 - 10,6)
736		200 x 200 x 16 (61,8 - 736,7 - 8,8)
787		180 x 180 x 22 (74,7 - 787,0 - 12,54)
818		200 x 200 x 18 (69,1 - 818,5 - 10,62)
898		200 x 200 x 20 (76,4 - 898,9 - 12,6)

Table 5.21 Geometric particulars with 500 mm wide attached plating of European standard channels

Shape	h x b x a [mm]	A [cm^2]	W [cm^3]	
				
UPN 8	80 x 45 x 6	11,0	35,8	28,4
UPN 10	100 x 50 x 6	13,5	54,0	38,9
UPN 12	120 x 55 x 7	17,0	80,5	56,1
UPN 14	140 x 60 x 7	20,4	111,9	72,0
UPN 16	160 x 65 x 7,5	24,0	149,0	93,2
UPN 18	180 x 70 x 8	28,0	193,5	118,1
UPN 20	200 x 75 x 8,5	32,2	245,1	147,3
UPN 22	220 x 80 x 9	37,4	311,4	181,2
UPN 24	240 x 85 x 9,5	42,3	380,9	218,1
UPN 26	260 x 90 x 10	48,3	468,4	261,8
UPN 28	280 x 95 x 10	53,4	557,3	300,1
UPN 30	300 x 100 x 10	58,8	656,5	340,7

3. Structural Modelling of Primary Supporting Members

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 modelled with their net scantlings according to Section 5, F. Therefore, also the hull girder stiffness and inertia to be reproduced by the model are those obtained by 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 modelling 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.5.15).

However, larger models may need to be adopted when deemed necessary by **TL** on the basis of the vessel's structural arrangement.

3.2.3 In the case of structural symmetry with respect to the vessel's centreline longitudinal plane, the hull structures may be modelled over half the vessel's breadth.

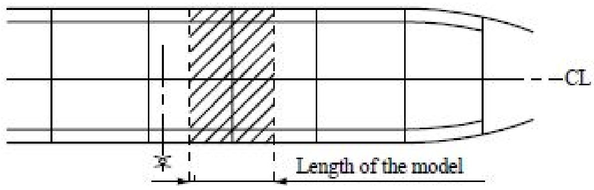


Fig. 5.15 Model longitudinal extension

3.3 Finite element modelling criteria

3.3.1 Modelling of primary supporting members

The analysis of primary supporting members based on fine mesh models, as defined in 3.4.3, is to be carried out by applying one of the following procedures (see Fig. 5.16), 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 Modelling 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.

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 midside nodes.

Meshing is to be carried out following uniformity criteria among the different elements.
In general, for some of the most common elements, the quadrilateral elements are to be such that the ratio between the longer side length and the shorter side length does not exceed 4 and, in any case, is less than 2 for most elements. 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 modelling criteria depend on the accuracy level of the mesh, as specified in 3.4.2 to 3.4.4.

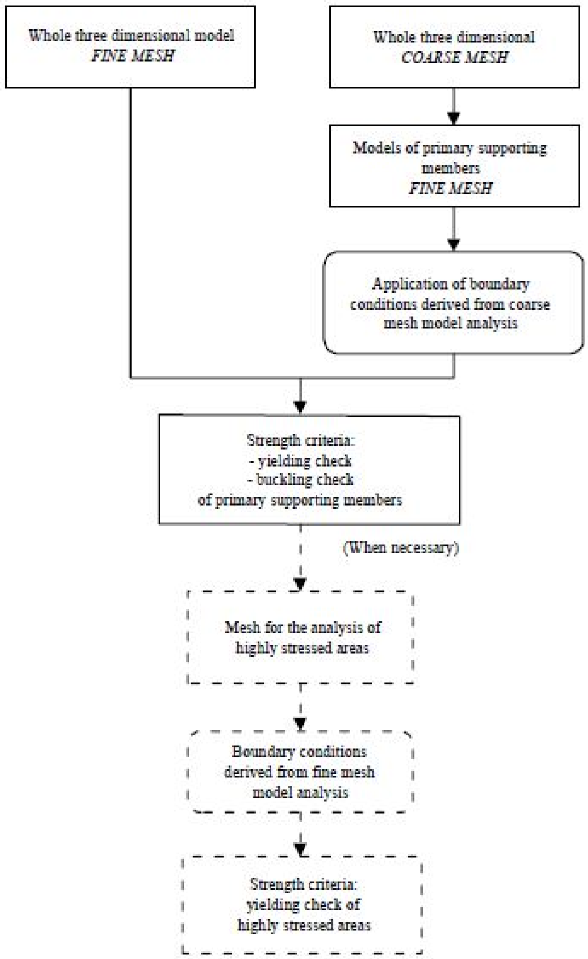


Fig. 5.16 Finite element modelling criteria

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 modelled by rod elements and grouped at regular intervals.

- Webs of primary supporting members may be modelled 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 modelled 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.

3.4.3 Fine mesh

The vessel's structure may be considered as finely meshed when each longitudinal ordinary stiffener is modelled; 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 modelled with at least three elements on their height.

- The plating between two primary supporting members is to be modelled with at least two element stripes.

- 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 **TL** in relation to the type of structural model and the analysis performed.

3.4.4 Mesh for the analysis of structural details

The structural modelling is to be accurate; the mesh dimensions are to be such as to enable a faithful representation of the stress gradients. The use of membrane elements is only allowed when significant bending effects are not present; in other cases, elements with general behaviour are to be used.

3.5 Beam models

3.5.1 Beams representing primary supporting members

Primary supporting members are to be modelled 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 modelling 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 modelling the hull girder bending strength

- On deck, side shell, longitudinal bulkheads, if any, and bottom for modelling 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 modelled over half the vessel's breadth (see 3.2.3), in way of the vessel's centreline longitudinal plane, symmetry or antisymmetry boundary conditions as specified in Table 5.22 are to be applied, depending on the loads applied to the model (symmetrical or anti-symmetrical, respectively).

Table 5.22 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	free	fixed	free
Anti-symmetry	fixed	free	fixed

(1) *X, Y and Z directions and axes are defined with respect to the reference co-ordinate system in Section 4, A.1.4*

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 Table 5.23.

When the hull structure is modelled over half the vessel's breadth (see 3.2.3), in way of the vessel's centreline longitudinal plane, symmetry or antisymmetry boundary conditions as specified in Table 5.22 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 5.23 Symmetry conditions at the model fore and aft ends

Displacement İn 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 Section 4, A.1.4*

4. Primary Supporting Members Load Model

4.1 General

4.1.1 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 longitudinal structure and primary supporting members.

The following loading conditions are generally to be considered:

- Homogeneous loading conditions at draught T
- Non-homogeneous loading conditions at draught T, when applicable
- Partial loading conditions at the relevant draught
- Ballast conditions at the relevant draught

4.1.2 Lightweight

The light weight of the modelled portion of the hull is to be uniformly distributed over the length of the model in order to obtain the actual longitudinal distribution of the still water bending moment.

4.1.3 Models extended over half vessel's breadth

When the vessel is symmetrical with respect to its centreline longitudinal plane and the hull structure is modelled over half the vessel's breadth, nonsymmetrical loads are to be broken down into symmetrical and anti-symmetrical loads and applied separately to the model with symmetry and antisymmetry 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 Section 6, C.4.
- the still water internal loads, defined in Section 6, C.5. 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 modelled or are modelled 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 modelling of cargoes other than those mentioned under 4.2.2 to 4.2.4 will be considered by **TL** 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 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.

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

Vertical and transverse concentrated loads are to be applied to the model, as shown in Fig. 5.17, to compensate the portion of distributed loads which, due to the positioning of beams on their neutral axes, are not modelled.

In this Figure, F_Y and F_Z represent concentrated loads equivalent to the dashed portion of the distributed loads which is not directly modelled.

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.

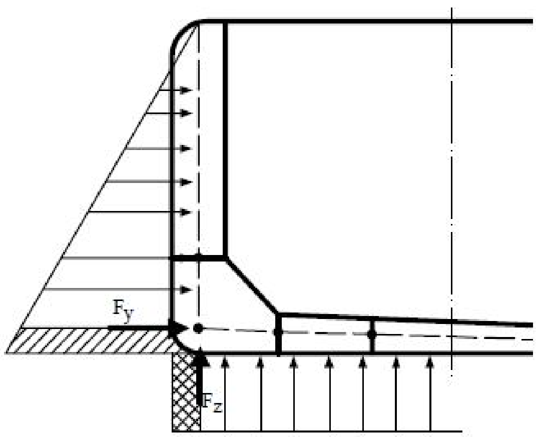


Fig. 5.17 Concentrated loads equivalent to non-modelled distributed loads

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. 5.18. The orientation of the element co-ordinate system may or may not coincide with that of the reference coordinate system in Section 4, A.1.4.

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

$$\sigma_{VM} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \cdot \sigma_2 + 3 \cdot \tau_{12}^2}$$

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.

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:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + 3 \cdot \tau_{12}{}^2}$$

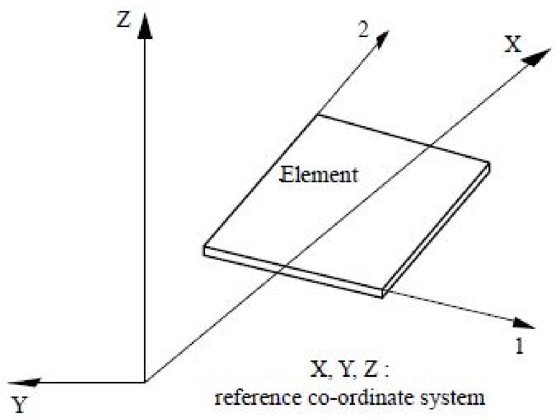


Fig. 5.18 Reference and element co-ordinate systems

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.

H. Analyses of Primary Supporting Members Subjected to Wheeled Loads

1. General

1.1 Scope

1.1.1 The following requirements apply to the analysis criteria, structural modelling, load modelling and stress calculation of primary supporting members subjected to wheeled loads which are to be analysed through three dimensional structural models, according to E.

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 **TL**, 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 E.3.3.

1.2 Application

1.2.1 The following requirements 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 **TL** 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

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

The presence of lashing for vehicles is generally to be disregarded, but may be given consideration by **TL**, on a case by case basis, at the request of the interested parties.

2. Analysis Criteria

2.1 Beam model analyses

2.1.1 For inland navigation vessels, beam models, built according to G.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 **TL**.

- Their behaviour is not substantially influenced by the transmission of shear stresses through the shell plating.

2.1.2 Finite element models may need to be adopted when deemed necessary by **TL** on the basis of the vessel's structural arrangement.

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 modelled with their net scantlings according to B.6.

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 nonmodelled 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 modelling 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 Table 5.24.

Table 5.24 Symmetry conditions at the model fore and aft ends

Displacement İn 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 Section 4, A.1.4*					

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 **TL**, 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. 5.19).

Each spring, which simulates the effects of the deck in way of which it is modelled, has a stiffness obtained [kN/m] from the following formula:

$$R_D = \frac{24 \cdot E \cdot J_D \cdot s_a \cdot 10^3}{2 \cdot x^4 - 4 \cdot J_D \cdot x^3 + L_D{}^2 \left(x^2 + 15.6 \frac{J_D}{A_D} \right) + L_D{}^3 \cdot x}$$

J_D = Net moment of inertia [m^4] of the average cross-section of the deck, with the attached side shell plating

A_D = Net area [m^2] of the average crosssection of deck plating

s_a = Spacing of side vertical primary supporting members [m]

x = Longitudinal distance [m] measured from the transverse section at mid-length of the model to any deck end

L_D = Length of the deck [m] to be taken equal to the vessel's length. Special cases in which such value may be reduced will be considered by **TL** on a case-by-case basis.

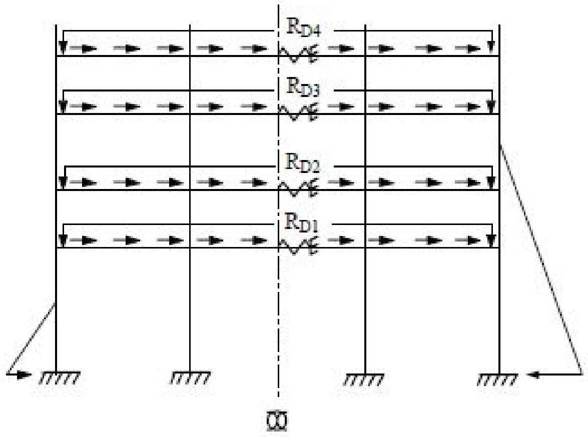


Fig. 5.19 **Springs at the fore and aft ends of models subjected to transverse loads**

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 Section 6, C.4.
- the still water forces induced by wheeled cargoes, defined in Section 6, C.6.6.

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

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

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. 5.20. The orientation of the element co-ordinate system may or may not coincide with that of the reference coordinate system in Section 4, A.1.4.

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:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \cdot \sigma_2 + 3 \cdot \tau_{12}{}^2}$$

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_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:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + 3 \cdot \tau_{12}{}^2}$$

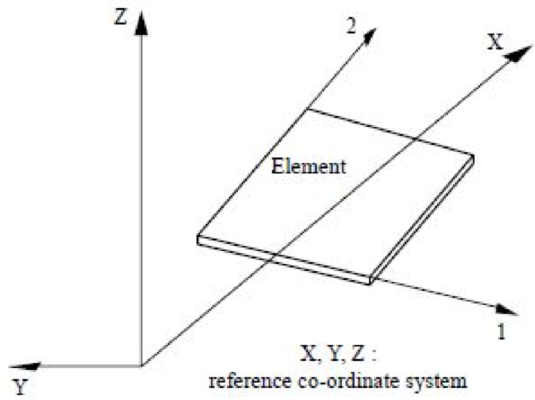


Fig. 5.20 Reference and element co-ordinate systems

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

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-modelled 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 Table 5.23.

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 İn 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 [kN.m/rad] from the following formulae:

- for intermediate decks:

$$R_F = \frac{3 \cdot E \cdot (J_1 + J_2) \cdot (\ell_1 + \ell_2)}{\ell_1^2 + \ell_2^2 - \ell_1 \cdot \ell_2} \cdot 10^{-5}$$

- for the uppermost deck:

$$R_F = \frac{6 \cdot E \cdot J_1}{\ell_1} \cdot 10^{-5}$$

ℓ_1 , ℓ_2 = Height [m] of the tween decks, respectively below and above the deck under examination (see Fig. 5.21)

J_1, J_2 = Net moments of inertia [cm^4] of side primary supporting members with attached shell plating, relevant to the tween decks, respectively below and above the deck under examination

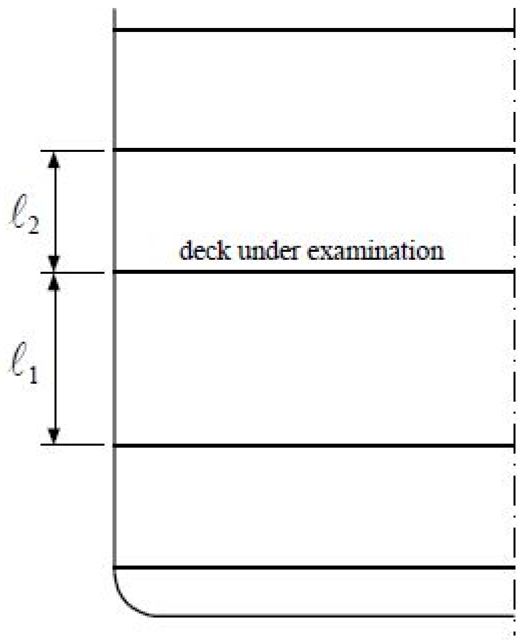


Fig. 5.21 Heights of tween decks for grillage analysis of deck primary supporting members

6.4 Load model

Hull girder and local loads are to be calculated and applied to the model according to 4.

6.5 Stress calculation

Stress components are to be calculated according to 5.1 and 5.3.

I. Torsion of Catamarans

1. Transverse Strength in the Special Case of Catamaran Craft When The Structure Connecting Both Hulls is Formed By a Deck With Single Plate Stiffened by M Reinforced Beams Over the Deck

1.1 Calculation example

1.1.1 General

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.

1.1.2 Definitions

Refer to Fig. 5.22.

G = Centre of the stiffnesses r_i, of the m deck beams

O = Origin of abscissae, arbitrarily chosen

m = Number of deck transverses

xi = Abscissa [m] of deck beam i with respect to origin O

Si = Span of deck beam i [m] between the inner faces of the hulls

Ii = Bending inertia of deck beam i [m^4]

Ei = Young's modulus of deck beam i, in [N/mm^2]

ri = Stiffness of deck beam i [N/m] equal to:

$$= \frac{12 \cdot E_i \cdot I_i}{S_i^3} \cdot 10^6$$

a = Abscissa [m] of the centre G with respect to the origin O

$$= \frac{\Sigma r_i \cdot x_i}{\Sigma r_i}$$

If F_i [N] is the force taken over by the deck beam i, the deflection yi [m] of the hull in way of the beam i, is:

$$y_i = \frac{F_i \cdot S_i^3 \cdot 10^{-6}}{12 \cdot E_i \cdot I_i} = \frac{F_i}{r_i} = d_i \cdot \omega$$

d_i = Abscissa [m] of the deck beam i with respect to the origin G:

= $x_i - a$

ω = Rotation angle [rad] of one hull in relation to the other around a transverse axis passing through G.

1.1.3 Transverse torsional connecting moment

The catamaran transverse torsional connecting moment [kN.m] about a transverse axis is given by:

M_{tt} = $0.125 \cdot \Delta \cdot L \cdot a_{CG} \cdot g$

Δ = Vessel displacement [t]

a_{CG} = Design vertical acceleration at LCG [m/s^2] to be taken not less than:

$$= 0.67 \cdot Soc \cdot \frac{v}{\sqrt{L}}$$

v = Vessel speed [m/s]

S_{oc} = Coefficient depending on the navigation notation n

= 0,1 . (n + 1,1)

n = Navigation coefficient defined in Section 6,B.

h = Significant wave height [m]

Moreover, the transverse torsional moment may be expressed as:

M_{tt} = $F_i \cdot di \cdot 10^{-3}$

1.1.4 Calculation of rotation angle

The rotation angle may be derived from 1.1.3 and is given by the formula:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3$$

1.1.5 Determination of stresses in deck beams

As M_{tt} , r_i and di are known, ω is thus deduced, then F_i [N], the bending moment M_i [N.m] and the corresponding normal and shear stresses can be evaluated in each beam:

F_i = $\omega \cdot ri \cdot d_i$

M_i = $F_i \cdot S_i / 2$

1.1.6 Checking criteria

It is to be checked that the normal stress σ and the shear stress are in compliance with the following formulae:

$$\frac{R_{eH}}{\gamma_R \cdot \gamma_m} \geq \sigma$$

$$0.5 \cdot \frac{R_{eH}}{\gamma_R \cdot \gamma_m} \geq \tau$$

R_{eH} = Minimum yield stress [N/mm^2] of the material, to be taken equal to 235/k, unless otherwise specified

γ_R = Partial safety factor covering uncertainties regarding resistance, to be taken equal to 1,10

γ_m = Partial safety factor covering uncertainties regarding material, to be taken equal to 1,02.

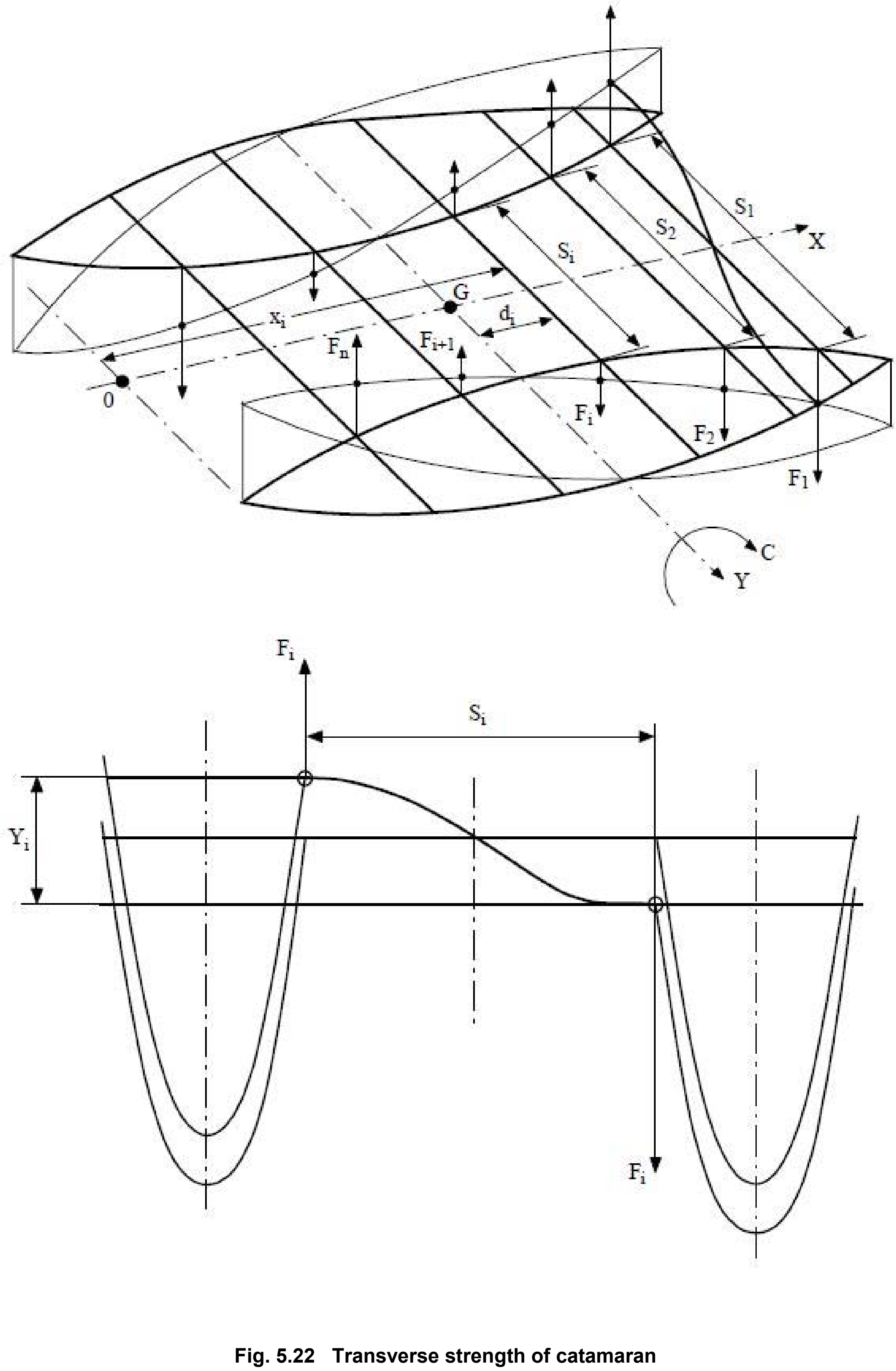


Fig. 5.22 Transverse strength of catamaran

SECTION 6

HULL DESIGN and CONSTRUCTION - DESIGN LOADS

A. General

1. Definitions

1.1 Local loads

Local loads are pressures and forces which are directly applied to the individual structural members: plating panels, ordinary stiffeners and primary supporting members.

1.2 Hull girder loads

Hull girder loads are forces and moments which result as effects of local loads acting on the vessel as a whole and considered as a girder.

1.3 Loading condition

A loading condition is a distribution of weights carried in the vessel spaces arranged for their storage.

2. Application

2.1 Fields of application

2.1.1 The design loads defined in these Rules are to be used for the determination of the hull girder strength and structural scantlings in the central part of vessels.

2.1.2 Load direct calculation

As an alternative to the formulae in Section 7, B., the designer may provide, under his responsibility, the values of hull girder loads. In this case, the justified calculations of these values are to be submitted to **TL**.

B. Range of Navigation

1. Range of Navigation

1.1 General

Each vessel is granted a range of navigation according to its scantlings and other constructional arrangements.

The ranges of navigation considered in these Rules are defined in Section 2, B.10. The significant wave heights corresponding to ranges of navigation are listed in Table 6.1.

1.2 Navigation coefficient

The navigation coefficient to be used for the determination of vessel scantlings is given by the formula:

$$n = 0{,}85 \cdot h$$

h = Significant wave height [m]
(wave height measured from crest to trough)

1.3 Length-to-depth ratio

In principle, the length-to-depth ratio is not to exceed the following values:

- for **I (1,2)** to **I (2,0)** = L/H = 25

- for **I (0,6)** = L/H = 35

Vessels having a different ratio are to be considered by **TL** on a case-by-case basis.

1.4 Ranges of navigation I (1,2) to I (2)

On vessels assigned the range of navigation **I (1,2)** to **I (2)**, the hatchways are to be fitted with efficient means of closing. The openings of the engine room, if there is an engine room, are to be protected by a superstructure or by a deckhouse.

Table 6.1 Values of significant wave height [m]

Range of navigation	Wave height, h
I (0)	0
I (0,6)	0,6
I (1,2) to I (2,0)	1,2 to 2,0

C. Local Loads

1. Symbols

L = Rule length [m], defined in Section 4, A.1.

B = Breadth [m], defined in Section 4, A.1.

H = Depth [m], defined in Section 4, A.1.

T = Draught [m], defined in Section 4, A.1.

C_B = Block coefficient, defined in Section 4, A.1.

P = Design pressure [kN/m^2]

x, y, z = x, y and z co-ordinates [m] of the calculation point with respect to the reference coordinate system defined in Section 4, A.1.4

z_L = z co-ordinate [m] of the highest point of the liquid

= $z_{TOP} + d_{AP}$

z_{TOP} = z co-ordinate [m] of the highest point of the tank or compartment

d_{AP} = Distance from the top of the air pipe to the top of the tank [m]. For minimum distance for the top of the air pipe above deck, see Section 12, C.13.1.1.

p_{pv} = Setting pressure [kN/m^2] of safety valves or maximum pressure [kN/m^2] in the tank during loading/unloading, which is the greater

ρ_L = Density [t/m^3] of the liquid carried

n = Navigation coefficient defined in B.

= 0,85.h

where h is the significant wave height [m]

a_B = Motion and acceleration parameter

$$= 0.33 \cdot n \cdot \left(0.04 \cdot \frac{V}{\sqrt{L}} + 1.1 \cdot \frac{h_W}{L}\right)$$

h_W = Wave parameter [m]

$$= \left|11.44 \quad - \left|\frac{L - 250}{110}\right|^3\right.$$

a_{SU} = Surge acceleration [m/s^2] defined in 4.2.1

a_{SW} = Sway acceleration [m/s^2] defined in 4.2.2

a_H = Heave acceleration [m/s^2] defined in 4.2.3

α_R = Roll acceleration [rad/s^2] defined in 4.2.4

α_P = Pitch acceleration [rad/s^2] defined in 4.2.5

α_Y = Yaw acceleration [rad/s^2] defined in 4.2.6

T_{SW} = Sway period [s] defined in 4.2.2

T_R = Roll period [s] defined in 4.2.4

T_P = Pitch period [s] defined in 4.2.5

A_R = Roll amplitude [rad] defined in 4.2.4

A_P = Pitch amplitude [rad] defined in 4.2.5

V = Maximum ahead service speed [km/h]

2. General

2.1 Application

The following requirements apply for the definition of local loads to be used for the scantling checks of:

- Platings
- Ordinary stiffeners
- Primary supporting members

2.2 Inertial loads

For range of navigation higher than **I (1,2)**, inertial local loads induced by vessel relative motions and accelerations are to be taken into account.

3. Load Definition Criteria

3.1 Cargo and ballast distributions

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.

3.2 Draught 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 3.1. The vessel draught is to be taken as the distance measured vertically on the hull transverse section at the middle of the length 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 still water and wave external pressures are considered as acting alone without any counteraction from the vessel's interior

b) Light ballast condition, when one or more ballast tanks are considered as being loaded and the cargo compartments are considered as being empty.

4. Vessel Motions and Accelerations

4.1 General

4.1.1 Vessels motions and accelerations are defined,

with their signs, according to the reference coordinate system in Section 4, A.1.4.

4.1.2 Vessel motions and accelerations are assumed to be periodic. The motion amplitudes are half of the crest to through amplitudes.

4.1.3 As an alternative to the formulae **TL** 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.

4.2 Vessel absolute motions and accelerations

4.2.1 Surge

The surge acceleration a_{SU} is to be taken equal to 0,5 m/s^2.

4.2.2 Sway

The sway period and acceleration are obtained from the formulae in Table 6.2.

Table 6.2 Sway period and acceleration

Period T_{SW} [s]	Acceleration a_{SW} [m/s^2]
$\dfrac{0.8 \cdot \sqrt{L}}{0.10 \cdot \dfrac{V}{\sqrt{L}} + 1}$	$7.6 \cdot a_B$

4.2.3 Heave

The heave acceleration is obtained [m/s^2] from the following formula:

$a_H = 9.81 \cdot a_B$

4.2.4 Roll

The roll amplitude, period and acceleration are obtained from the formulae in Table 6.3.

4.2.5 Pitch

The pitch amplitude, period and acceleration are obtained from the formulae in Table 6.4.

4.2.6 Yaw

The yaw acceleration is obtained [rad/s^2] from the following formula:

$$\alpha_Y = 15.5 \cdot \frac{a_B}{L}$$

4.3 Vessel relative accelerations

4.3.1 Definition

At any point, the accelerations in X, Y and Z direction are the acceleration components which result from the vessel motions defined from 4.2.1 to 4.2.6.

4.3.2 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, roll and yaw.

Table 6.3 Roll amplitude, period and acceleration

Amplitude A_R [rad]	Period T_R [s]	Acceleration α_R [rad/s^2]
$a_B \cdot \sqrt{E}$ without being taken greater than 0,35	$0.77 \cdot \frac{B}{\sqrt{GM}}$	$\frac{40 \cdot A_R}{T_R^2}$
$E = 11.34 \cdot \frac{GM}{B} \geq 1.0$ 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 values may be, in general, assumed: - full load: GM = 0.07 · B - lightship: GM = 0.18 · B		

Table 6.4 Pitch amplitude, period and acceleration

Amplitude A_P [rad]	Period T_P [s]	Acceleration α_P [rad/s^2]
$0.328 \cdot a_B \cdot \left(1.32 - \frac{h_W}{L}\right) \cdot \left(\frac{0.6}{C_B}\right)^{0.75}$	$0.575 \cdot \sqrt{L}$	$\frac{40 \cdot A_p}{T_P^2}$

4.3.3 Accelerations

The reference values of the longitudinal, transverse and vertical accelerations at any point are obtained from the formulae in Table 6.5 for upright and inclined vessel conditions.

5. External Pressure

5.1 Pressure on sides and bottom

The external pressure at any point of the hull, in [kN/m^2], is to be obtained from the following formulae:

- for $z \leq T$: $p_E = 9,81\ (T - z + 0,6.n)$

- for $z > T$: $p_E = MAX\ (5,9.n\ ;\ 3) + p_{WD}$

p_{WD} = Specific wind pressure [kN/m^2] defined in Table 6.6.

Table 6.5 Reference values of the accelerations a_x , a_y and a_z

Direction	Upright vessel condition	Inclined vessel condition
X - Longitudinal a_{X1} and a_{X2} [m/s^2]	$a_{X1} = \sqrt{a_{SU}^2 + [9{,}81 \cdot Ap + \alpha p \cdot (z - T_1)]^2}$	$a_{X2} = 0$
Y - Transverse a_{Y1} and a_{Y2} [m/s^2]	$a_{Y1} = 0$	$a_{Y2} = \sqrt{a_{SW}^2 + [9{,}81 \cdot A_R + \alpha_R \cdot (z - T_1)]^2 + \alpha_Y^2 \cdot K_X \cdot L^2}$
Z - Vertical a_{Z1} and a_{Z2} [m/s^2]	$a_{Z1} = \sqrt{a_H^2 + \alpha_p^2 \cdot K_X \cdot L^2}$	$a_{Z2} = \sqrt{0{,}25 \cdot a_H^2 + \alpha_R^2 \cdot Y^2}$
K_X= coefficient defined as : $= 1{,}2 \cdot \left(\frac{x}{L}\right)^2 - 1{,}1 \cdot \frac{x}{L} + 0{,}2 \geq 0{,}018$ T_1 = Draught [m] defined in 3.2.		

Table 6.6 Specific wind pressure

Navigation notation	Wind pressure p_{WD} [kN/m^2]
I (1,2) , I (2)	0,4 .n
I (0,6), I (0)	0,25

5.2 Pressure on exposed decks

On exposed decks, the pressure due to the load carried is to be considered. This pressure is to be defined by the Designer and, in general, it may not be taken less than the values given in Table 6.7.

Table 6.7 Pressure [kN/m^2] on exposed decks

Exposed deck location	P_E
Weather deck	3,75 (n+0,8)
Exposed deck of superstructure or deckhouse: - First tier (non public) - Upper tiers (non public) - Public	 2,0 1,5 4,0

5.3 Pressure on watertight bulkheads

The still water pressure [kN/m^2] to be considered as acting on platings and stiffeners of watertight bulkheads of compartments not intended to carry liquids is obtained from the following formula:

$p_{WB} = 9{,}81 . (z_{TOP} - z)$

6. Internal Pressures

6.1 Liquids

6.1.1 General

The pressure transmitted to the hull structure [kN/m^2] by liquid cargo (p_C) or ballast (p_B) is the combination of the still water pressure p_S and the inertial pressure p_W .

$$p_S = \cdot \frac{9{,}81 \cdot m_c}{L_H \cdot B_1}$$

6.1.2 Still water pressure

- Liquid cargo

The still water pressure is the greater of the values obtained [kN/m^2] from the following formulae:

$p_S \quad = \quad 9{,}81 .\ \rho_L . (z_L - z)$

$p_S \quad = \quad 9{,}81 .\ \rho_L . (z_{TOP} - z) + 1{,}15 . p_{pv}$

- Ballast

$p_S \quad = \quad 9{,}81 . (z_L - z + 1)$

6.1.3 Inertial pressure

The inertial pressure is obtained from the formulae in

Table 6.8 and is to be taken such that:

$p_S + p_W \geq 0$

6.2 Dry bulk cargoes

6.2.1 General

The pressure transmitted to the hull structure is to be obtained using the formula:

$$p_C = \frac{(H - z)}{H - z_H} p_0$$

p_0 = Mean total pressure on the inner bottom (combination of the mean still water pressure p_S defined in 6.2.2 and the mean inertial pressure p_W defined in 6.2.3)

= $p_S + p_W \geq 0$

If $n \leq 1{,}02$: $p_W = 0$

z_H = Z co-ordinate [m] of the inner bottom.

6.2.2 Mean still water pressure on the inner bottom

The mean still water pressure on the inner bottom is obtained [kN/m^2] from the following formula:

$$p_S = \frac{981 \cdot m_C}{L_H \cdot B_1}$$

L_H = Length [m] of the hold, to be taken as the longitudinal distance between the transverse bulkheads which form boundaries of the hold considered

B_1 = Breadth [m] of the hold

m_C = mass of cargo [t] in the hold considered

6.2.3 Mean inertial pressure on the inner bottom

The mean inertial pressure on the inner bottom is obtained [kN/m^2] from the following formula:

$$p_W = \frac{a_{Z1} \cdot m_C}{L_H \cdot B_1}$$

Where m_C, L_H and B_1 are defined in 6.2.2.

6.3 Dry heavy bulk cargoes

6.3.1 Pressure on side and bulkhead structure

The pressure on side and bulkhead structure is to be determined in compliance with 6.2.

6.3.2 Inner bottom design pressure

The inner bottom design pressure, p_{MS} [kN/m^2] is the combination of the still water pressure p_S and the inertial pressure p_W determined in compliance with 6.3.3 and 6.3.4 respectively.

If $n \leq 1{,}02$: $pW = 0$

6.3.3 Inner bottom still water design pressure

The inner bottom still water design pressure p_S is obtained [kN/m^2] from the following formula:

$$p_S = k_S \cdot \sqrt{\frac{L \cdot B \cdot T}{L_H} \cdot C_B}$$

k_S = Coefficient to be determined using the formula:

$= 9{,}81 \cdot \sqrt{0{,}85 \cdot \rho \cdot \tan\varphi}$

L_H = Length [m] of the hold, to be taken as the longitudinal distance between the transverse bulkheads which form boundaries of the hold considered

ρ = cargo density [t/m3]

$\rho \geq 2{,}5$

φ = Angle of repose of the bulk cargo considered

$\varphi \geq 35°$

Table 6.8 Liquids - inertial pressure

Vessel condition	Inertial pressure p_W [kN/m^2] (1)
Upright	$\rho_L\,[0{,}5\cdot a_{X1}\cdot \ell_B + a_{Z1}\cdot(Z_{TOP} - Z)]$
Inclined	$\rho_L\,[a_{TY}\,(Y-Y_H) - a_{TZ}\,(Z-Z_H) + 9{,}81\cdot Z - Z_{TOP}]$

(1) $p_W = 0$ if $n \le 1{,}02$

ℓ_B = longitudinal distance [m] between the transverse tank boundaries, without taking into account small recesses in the lower part of the tank (see Fig. 6.1)

a_{TY}, a_{TZ} = Y and Z components (negative roll angle) [m/s^2] of the total acceleration vector defined as follows:

$a_{TY} = a_{Y2}$

$a_{TZ} = 9{,}81 + a_{Z2}$

Y_H, Z_H = Y and Z co-ordinates [m] of the highest point of the tank in the direction of the total acceleration vector.

6.3.4 Inner bottom inertial design pressure

The inner bottom inertial design pressure p_W is obtained [kN/m^2] from the formula given in 6.3.3, using the following value of k_S:

$$k_S = a_{Z1}\cdot\sqrt{0{,}85\cdot\rho\cdot\tan\varphi}$$

6.4 Dry uniform cargoes

6.4.1 General

The pressure transmitted to the hull structure, p_C [kN/m^2] is the combination of the still water pressure p_S and the inertial pressure p_W.

6.4.2 Still water pressure

The value of the still water pressure p_S is to be specified by the designer.

6.4.3 Inertial pressure

The inertial pressure p_W is obtained [kN/m^2] as specified in Table 6.9.

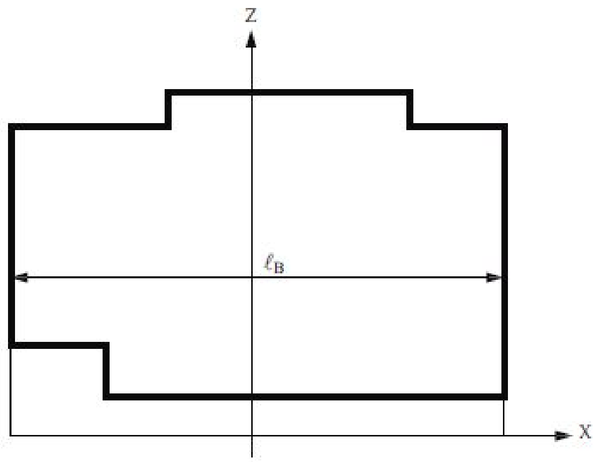


Fig. 6.1 Distance ℓ_B

6.5 Dry unit cargoes

6.5.1 General

The force transmitted to the hull structure is the combination of the still water force F_S and the inertial force F_W.

Account is to be taken of the elastic characteristics of the lashing arrangement and/or the structure which contains the cargo.

Table 6.9 Dry uniform cargoes - Inertial pressures

Vessel condition	Inertial pressure pw [kN/m²] (1)	
Upright (positive heave motion)	$p_{W,Z} = p_S \cdot \frac{a_{Z1}}{9,81}$	in z direction
Inclined (negative roll angle)	$p_{W,y} = p_S \cdot \frac{a_{y2}}{9,81}$	in y direction
	$p_{W,Z} = p_S \cdot \frac{a_{Z2}}{9,81}$	in z direction
(1) $p_W = 0$ if $n \le 1,02$		

6.5.2 Still water force

The still water force transmitted to the hull structure is to be determined on the basis of the force obtained [kN] from the following formula:

$F_S = 9,81\ m_C$

Where m_C is the mass [t] of the cargo.

6.5.3 Inertial forces

The inertial forces are obtained [kN/m²] as specified in Table 6.10.

Table 6.10 Dry unit cargo - inertial forces

Vessel condition	Inertial force F_W [kN] (1)
Upright (positive heave motion)	$F_{W,X} = m_C.a_{X1}$ in x direction $F_{W,Z} = m_C.a_{Z1}$ in z direction
Inclined (negative roll angle)	$F_{W,Y} = m_C.a_{Y2}$ in y direction $F_{W,Z} = m_C.a_{Z2}$ in z direction
(1) $F_W = 0$ *if* $n \le 1,02$ ***Note :*** *m_C = mass [t] of the cargo.*	

6.6 Wheeled cargoes

6.6.1 Tyred vehicles

The forces transmitted through the tyres are comparable to 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.

6.6.2 Non-tyred vehicles

The requirements of 6.6.3 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.

6.6.3 Still water force

The still water force transmitted to the hull structure by one wheel is to be determined on the basis of the force obtained [kN] from the formula:

$$F_S = 9,81 \cdot m_C$$

$$m_C = Q_A / n_W$$

Q_A = Axle load [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

6.6.4 Inertial forces

The inertial forces are obtained [kN] as specified in Table 6.11.

6.7 Accommodation

The still water pressures transmitted to the deck structures are obtained [kN/m²] as specified in Table 6.12.

6.8 Helicopter loads

6.8.1 Landing load

The landing load transmitted through one tyre to the deck is to be obtained [kN] from the following formula:

F_{CR} = $7{,}36 \cdot W_H$

W_H = Maximum weight of the helicopter [t]

Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are quarters, bridge, control room or other normally manned service spaces, the value of F_{CR} is to be multiplied by 1,15.

6.8.2 Emergency landing load

The emergency load resulting from the crash of the helicopter is to be obtained [kN] from the following formula:

F_{CR} = $29{,}43 \cdot W_H$

6.8.3 Helicopter having landing devices other than wheels

In the case of a deck intended for the landing of helicopters having landing devices other than wheels (e.g. skates), the landing load and the emergency landing load are to be examined by **TL** on a case-bycase basis.

7. Testing Pressures

7.1 Still water pressures

The still water pressures to be considered as acting on plates and stiffeners subject to tank testing are specified in Section 5, D.3.

Table 6.11 Wheeled cargoes - inertial forces

Vessel condition	Inertial force F_W [kN] (2)
Upright (positive heave motion)	$F_{W,Z} = m_C.a_{Z1}$ in z direction
Inclined (negative roll angle) **(1)**	$F_{W,Y} = m_C.a_{Y2}$ in y direction $F_{W,Z} = m_C.a_{Z2}$ in z direction
(1) *This condition is to be considered for the racking analysis of vessels with the type and service Notation* ***RoRo vessel*** *or with the additional class Notation* ***Ferry****, with* m_C *taken equal to the mass [t] of wheeled loads located on the structural member under consideration.* **(2)** $F_W = 0$ *if* $n \le 1{,}02$	

Table 6.12 Deck pressure in accommodation compartments

Type of accommodation compartment	p [kN/m^2]
- 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

D. Hull Girder Loads

1. General

1.1 Definition and convention

1.1.1 Definition

The hull girder loads are forces and moments which result as effects of local loads acting on the vessel as a whole and considered as a girder.

1.1.2 Sign convention

The vertical bending moment is positive when it induces tensile stresses in the deck (hogging bending moment); it is negative in the opposite case (sagging bending moment).

2. Vertical Bending Moment Calculation

2.1 Still water vertical bending moments

2.1.1 The design still water vertical bending moments are the maximum still water bending moments calculated, in hogging and sagging conditions at the midship transverse section for the loading conditions specified in 2.1.2.

2.1.2 Loading conditions

For all vessels, the following loading conditions are to be considered:

- Light ship

- Fully loaded vessel

- Loading and unloading transitory conditions, where applicable

2.1.3 The design still water vertical bending moments are to be obtained from formulae given in Section 7, B.

2.2 Additional bending moments

For vessels assigned the **I (0,6)** or **I (1,2)** to **I (2)** range of navigation defined in Section 2, B.10, an additional vertical bending moment, calculated according to Section 7, B.7. is to be added to the still water hogging and sagging bending moments, under both loaded and light conditions, for the determination of the hull girder strength and structural scantlings.

SECTION 7

HULL DESIGN and CONSTRUCTION - HULL GIRDER STRENGTH

A. General

1. Symbols

L = Rule length [m], defined in Section 4, A.1.

B = Breadth [m], defined in Section 1, A.1.

H = Depth [m], defined in Section 1, A.1.

T = Draught [m], defined in Section 1, A.1.

C_B = Block coefficient, defined in Section 1, A.1.

R = Loaded length ratio

$$= \frac{L - d_{AV} - d_{AR}}{L}$$

where d_{AV} and d_{AR} are parameters defined in B.2.1.1

2. General

2.1 Application

2.1.1 The following requirements apply to vessels with length up to 135 m, of types and characteristics listed hereafter:

- Self-propelled cargo carriers with machinery aft

  $0{,}6 \le R \le 0{,}82$

  $0{,}79 \le C_B < 0{,}95$

- Non-propelled cargo carriers

  $0{,}8 \le R \le 0{,}92$

  $C_B \ge 0{,}92$

- Passenger vessels with machinery aft

  $0{,}79 \le C_B < 0{,}95$

- Service vessels with machinery amidships

2.1.2 For other vessel types or vessels of unusual design or loading sequences, a direct calculation of still water bending moment is to be carried out and submitted to **TL**.

Direct calculation of still water bending moment is to be performed also if the actual lightship displacement shows at least 20 % deviation from standard value derived from B.6.1.1 or B.6.2.1 as applicable.

2.1.3 For cargo carriers, the cargo is assumed to be homogeneously distributed, and loading and unloading are assumed such as not to create excessive stresses.

3. Standard Loading Conditions for Cargo Carriers

3.1 Lightship

For non-propelled cargo type, the vessel is assumed empty, without supplies nor ballast.

For self-propelled cargo type, the light standard loading conditions are:

- Supplies: 100 %

- Ballast: 50 %

3.2 Fully loaded vessel

For non-propelled cargo type, the vessel is considered to be homogeneously loaded at its maximum draught, without supplies nor ballast.

For self-propelled cargo type, the vessel is considered to be homogeneously loaded at its maximum draught with 10 % of supplies (without ballast).

3.3 Transitory conditions

3.3.1 General

Transitory standard conditions are listed in items 3.3.2 to 3.3.4.

For non-propelled cargo type, the vessel is assumed without supplies nor ballast.

For self-propelled cargo type, the vessel without ballast, is assumed to carry following amount of supplies:

- in hogging condition: 100 % of supplies

- in sagging condition: 10 % of supplies

3.3.2 Loading/unloading in two runs

Loading and unloading are performed uniformly in two runs of almost equal masses.

For self-propelled vessels, the first loading/unloading run is carried out from the aft end of the cargo space, progressing to the fore end, the second run being performed from the fore end towards the aft end.

For non-propelled vessels, the two loading/unloading runs can be carried out from either the aft end or the fore end, progressing towards the opposite end.

3.3.3 Loading/unloading in one run

Loading and unloading are performed uniformly in one run, starting from the aft end of the cargo space, for self-propelled vessels, and from any cargo space end for non-propelled vessels.

3.3.4 Loading/unloading for liquid cargoes

Loading and unloading for liquid cargoes are assumed to be performed in two runs (see 3.3.2), unless otherwise specified.

4. Non-Homogeneous Loading Conditions

4.1 General

If requested, in addition to design bending moments occurring in standard loading conditions described in 2., the hull girder loads may be determined, by direct calculation, in any non-homogeneous loading conditions approved by **TL**.

B. Design Bending Moments

1. Symbols

L = Rule length [m], defined in Section 4, A.1

B = Breadth [m], defined in Section 4, A.1

H = Depth [m], defined in Section 4, A.1

T = Draught [m], defined in Section 4, A.1

C_B = Block coefficient, defined in Section 4, A.1

M_H = Design hogging bending moment [kNm]

M_S = Design sagging bending moment [kNm]

MH_0 = Still water hogging bending moment in light ship conditions [kNm]

MS_0 = Still water sagging bending moment in fully loaded conditions [kNm]

MH_1 = Still water hogging bending moment while loading / unloading in one run [kNm]

MH_2 = Still water hogging bending moment while loading / unloading in two runs [kNm]

MS_1 = Still water sagging bending moment while loading/unloading in one run [kNm]

MS_2 = Still water sagging bending moment while loading/unloading in two runs [kNm]

M_c = Correction value [kNm], given in 7., taking into account the deviation from standard loading conditions, light ship weight and weight distribution

M_{ad} = Additional bending moment [kNm], defined in 6., for **I (0,6)**, **I (1,2)** and **I (2)** ranges of navigation

F = Loading factor

= P / P_T

P = Actual cargo weight

P_T = Cargo weight corresponding to the maximum vessel draught T

2. General

2.1 Definitions

2.1.1 Parameters d_{AV} and d_{AR}

d_{AV}, and d_{AR} are defined as follows (see Fig. 7.1):

d_{AV} = Distance between fore cargo hold bulkhead or fore cargo tank bulkhead and fore end (FE) [m]

d_{AR} = Distance between aft cargo hold bulkhead or aft cargo tank bulkhead and aft end (AE) [m]

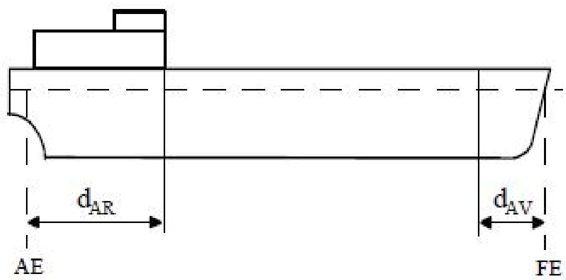


Fig. 7.1 Parameters d_{AV} and d_{AR}

2.1.2 Loaded lengths ℓ_1 and ℓ_2

Loaded lengths ℓ_1 and ℓ_2 are parameters defined as:

$$\ell_1 = \frac{-k_3}{k_2} \cdot L$$

$$\ell_2 = \frac{-k_3}{k_4} \cdot L$$

k_2, k_3, k_4 = coefficients, defined in Table 7.1.

Table 7.1 Coefficient k_i

Vessel	Conditions	k_1	k_2	k_3	k_4
Non-propelled	Hogging	0,063	0,01L	-0,743	3,479
	Sagging	0	5	-1,213	4,736
Self-propelled	Hogging	-	3,455	-0,780	4,956
	Sagging	-	4,433	-0,870	3,735

2.1.3 Loaded lengths L_1 and L_2

Loaded lengths L_1 and L_2 are parameters defined as:

$L_1 = 0{,}5 \cdot L - \ell_1 - d_{AV}$

$L_2 = 0{,}5 \cdot L - \ell_2 - d_{AR}$

2.1.4 Loaded length ratios

Following coefficients are required for still water bending moment calculation:

$$R_{21} = \frac{0{,}5 \cdot L - d_{AR} - L_2}{L - d_{AV} - d_{AR}}$$

$$R_{22} = \frac{L_2}{0{,}5 \cdot L - d_{AR} - L_2}$$

$$R_{11} = \frac{0{,}5 \cdot L - d_{AV} - L_1}{L - d_{AV} - d_{AR}}$$

$$R_{12} = \frac{L_1}{0{,}5 \cdot L - d_{AV} - L_1}$$

3. Principle of Calculation Using Formulae

3.1 Dry cargo carriers

3.1.1 Hogging conditions

The design bending moment in hogging conditions is given by the formula:

M_H = MAX (M_1 ; M_2)

M_1 = total hogging bending moment of lightship [kNm]

= $M_{H0} + M_{ad} + \sum M_C$

M_2 = Total hogging bending moment in corresponding transitory conditions:

- for loading/unloading in one run

= $M_{H1} + \sum M_C$

- for loading/unloading in two runs

= $MH_2 + \sum M_C$

3.1.2 Sagging conditions

The design bending moment in sagging conditions is given by the formula:

M_S = MAX (M_3 ; M_4)

M_3 = Total sagging bending moment of loaded vessel [kNm]

= $M_{S0} + M_{ad} - \sum Mc$

M_4 = Total sagging bending moment in corresponding transitory conditions:

- for loading/unloading in one run

= $M_{S1} - \sum Mc$

- for loading/unloading in two runs

= $M_{S2} - \sum Mc$

3.2 Tankers

Where the loading/unloading is carried out according to A.3.3 for liquid cargoes:

- the hogging design bending moment is equal to:

  M_H = MAX (M_1 ; M_2)

  with $M_2 = M_{H2} + \sum M_C$

- the sagging design bending moment is equal to:

  M_S = MAX (M_3 ; M_4)

  with $M_4 = M_{S2} - \Sigma M_C$,

where M_1 and M_2 are defined in 3.1.

3.3 Other vessels

For vessels other than cargo carriers:

- The hogging design bending moment is equal to:
  $M_H = M_{H0} + M_{ad}$

- The sagging design bending moment is equal to:

  $M_S = M_{S0} + M_{ad}$

4. Vertical Shear Force

4.1 Design shear force

4.1.1 The vertical design shear force [kN] is to be obtained from the following formula:

$$T_s = \frac{\pi \cdot M}{L}$$

M = Maximum design bending moment [kNm]

= MAX (M_H ; M_S)

5. Direct Calculation

5.1 Direct calculation

5.1.1 In the case of direct calculation, all calculation documents are to be submitted to TL.

5.1.2 Design still water bending moments

The design still water bending moments are to be determined by direct calculation for:

- Vessels of unusual type or design

- Unusual loading/unloading sequences

The actual hull lines, lightweight distribution and the characteristics of the intended service are to be taken into account.

5.1.3 Additional bending moment

An additional bending moment taking into account the stream and water conditions in the navigation zone is to be considered.

This additional bending moment may be calculated according to 7. or determined by the designer.

6. Still Water Bending Moments

6.1 Non-propelled cargo carriers

6.1.1 Standard light weights and weight distribution

The hull weight is assumed to be uniformly distributed on the vessel length, and [t] equal to:

- $P_0 = 0{,}12.L.B.H$ for $H < 3{,}7$ m

- $P_0 = 0{,}10.L.B.H$ for $H \geq 3{,}7$ m

6.1.2 Standard cargo weight and cargo distribution

The cargo is assumed to be uniformly distributed on the cargo space, and its weight [t] is equal to:

- $P_0 = 0{,}9.L.B.T.C_B$

6.1.3 Still water bending moments

The hogging and sagging bending moments in stil water conditions are to be obtained from formulae given in Table 7.2.

Where the actual lightship weight or location of the centre of gravity presents a deviation greater than 10 % with respect to the standard value, the still water bending moment is to be corrected using formulae given in Table 7.7.

See also A.2.1.2

6.2 Self-propelled cargo carriers

6.2.1 Standard light weights and weight distribution

The formulae of still water bending moments are based on standard weights and weight distribution defined in Table 7.3.

6.2.2 Standard cargo weight and cargo distribution

The cargo is assumed to be uniformly distributed on the cargo space, and its weight [t] is equal to:

- $P_0 = 0{,}85 \cdot L \cdot B \cdot T \cdot C_B$

6.2.3 Still water bending moments

The hogging and sagging bending moments in stil water conditions are to be obtained from formulae given in Table 7.4.

Where the weight or location of the centre of gravity of a lightship component presents a deviation greater than 10 % with respect to standard value (see Table 7.3), the still water bending moment is to be corrected using formulae given in Table 7.8.

See also A.2.1.2.

6.3 Passenger vessels

The values of the maximum still water bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the still water hogging bending moment [kNm] for passenger vessels (other than ro-ro vessels) with machinery aft may be determined using the following formula:

$$M_{H0} = 0{,}273 \cdot L^2 \cdot B^{1{,}342} \cdot T^{0{,}172} \cdot (1{,}265 - C_B)$$

6.4 Dredgers

The values of the maximum still water bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the maximum still water bending moment is to be as required in 6.1 or 6.2 for hopper barges and hopper dredgers respectively.

6.5 Tugs and pushers

6.5.1 Application

The following requirements apply to tugs and pushers whose engines are located amidships and whose bunkers are inside the engine room or adjoin it.

6.5.2 Still water bending moments

The values of the maximum hogging and sagging bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the still water bending moments [kNm] may be determined using the following formulae:

- still water hogging bending moment:

$$M_{H0} = 1{,}96 \cdot L^{1{,}5} \cdot B \cdot D \cdot (1 - 0{,}9 \cdot C_B)$$

- still water sagging bending moment:

$$M_{S0} = 0{,}01 \cdot L^2 \cdot B \cdot T \cdot (\varphi_1 + \varphi_2)$$

$$\varphi_1 = 5{,}5 \cdot \left(0{,}6 \cdot (1 + C_B) - \frac{x}{L}\right)$$

$$\varphi_2 = 10 \cdot \Phi / L^2 \cdot B$$

X = Length [m] of the machinery space in creased by the length of adjacent bunkers.

Φ = Total brake power of the propelling installation [kW]

6.6 Pontoons

The still water bending moments are to be obtained by direct calculation, according to the intended loading conditions.

7. Additional Bending Moments

7.1 Ranges of navigation I (1,2) and I (2)

For ranges of navigation **I (1,2)** and **I (2)**, a waveinduced bending moment, taking into account the significant wave height [m] of the navigation area, is to be added to the still water bending moment.

The absolute value of the wave-induced bending moment amidships is to be obtained [kNm] from the following formula:

$$M_{ad} = 0{,}021.n.C.L^2.B.(C_B + 0{,}7)$$

C = Parameter, defined in Table 7.6

N = Navigation coefficient, defined in Section 6, B.2.2

For intermediate significant wave heights, the value of the wave-induced bending moment may be obtained by interpolation.

7.2 Range of navigation I (0,6)

For range of navigation **I (0,6)**, the absolute value of the additional bending moment amidships is to be obtained [kNm] from the following formula:

$$M_{ad} = 0{,}01 \cdot C \cdot L^2 \cdot B \cdot (C_B + 0{,}7)$$

where parameter C is defined in Table 7.6.

8. Correction Formulae

8.1 Non-propelled cargo carriers

The correction formulae applicable to non-propelled cargo carriers are given in Table 7.7, where values of coefficients k_1, k_2, k_3, and k4 are defined in Table 7.1.

Table 7.2 Non-propelled cargo carriers - still water bending moments

Load cases	Hogging moments [kN-m]	Sagging moments [kN-m]
Lightship	$M_{H0} = 0{,}62 \cdot L^2 \cdot B^{0,84} \cdot T^{0,8} \cdot (1 - C_B)$	
Fully loaded vessel		$M_{S0} = 1{,}4 \cdot L^{0,88} \cdot B^{1,17} \cdot T^2 \cdot C_B \cdot [R_{11} \cdot (0{,}52 \cdot L - 1{,}84 \cdot \ell_1) \cdot (1 - R_{12}) + R_{21} \cdot (0{,}5 \cdot L - 1{,}23 \cdot \ell_2) \cdot (1 - R_{22})]$ **(1)**
Loading and unloading in one run	$M_{H1} = M_{H0} + (M_{S1} - M_{S0})$	$M_{S1} = 0{,}7 \cdot L^{0,88} \cdot B^{1,17} \cdot T^2 \cdot C_B \cdot [R_{11} \cdot (0{,}52 \cdot L - 1{,}84 \cdot \ell_1) \cdot (1 - R_{12}) + 1{,}15 \cdot R_{21} \cdot (0{,}5 \cdot L - 1{,}23 \cdot \ell_2)]$
Loading and unloading in two runs	$M_{H2} = M_{H0} + (M_{S2} - M_{S0})$	$M_{S2} = 0{,}7 \cdot L^{0,88} \cdot B^{1,17} \cdot T^2 \cdot C_B \cdot [R_{11} \cdot (0{,}52 \cdot L - 1{,}84 \cdot \ell_1) \cdot (1 - R_{12}) + R_{21} \cdot (0{,}5 \cdot L - 1{,}23 \cdot \ell_2)]$

ℓ_1, ℓ_2 = Parameters defined in 1.1.2

R_{11}, R_{12} = Coefficients defined in 1.1.4

R_{21}, R_{22} = Coefficients defined in 1.1.4.

(1) *In the case of partly filled barge, Mso is to be substituted by M_{SF} given by the formula:*

$M_{SF} = F\,(M_{H0} + M_{S0}) - M_{H0}$

Table 7.3 Self-propelled cargo carriers - standard weights and weight distribution

Item	Weight [t] P_0	Centre of gravity from AE [m]	Location X_1	Location X_2
Hull:				
H ≥ 3,7 m	$0{,}150 \cdot L \cdot B \cdot H$		0	L
H < 3,7 m	$0{,}100 \cdot L \cdot B \cdot H$		0	L
Deckhouse:				
H ≤ 3,7 m	$0{,}010 \cdot L \cdot B \cdot H$		0	d_{AR}
H > 3,7 m	$0{,}006 \cdot L \cdot B \cdot H$		0	d_{AR}
Machinery (main)	$0{,}005 \cdot L \cdot B \cdot T$	$d_{AR}/2$		
Machinery installations	$0{,}010 \cdot L \cdot B \cdot T$		0	d_{AR}
Piping **(1)**	$0{,}005 \cdot L \cdot B \cdot T$		d_{AR}	$L - d_{AV}$
Mooring gear	$0{,}005 \cdot L \cdot B \cdot T$	$L - d_{AV}/3$		
Supplies (fore)	$0{,}005 \cdot \alpha_1 \cdot L \cdot B \cdot T$	$L - d_{AV}/2$		
Supplies (aft)	$0{,}005 \cdot \alpha_1 \cdot L \cdot B \cdot T$	$d_{AR}/2$		
Ballast (fore):				
H ≤ 3,7 m	$0{,}010 \cdot \alpha_2 \cdot L \cdot B \cdot H$	$L - d_{AV}/2$		
H > 3,7 m	$0{,}003 \cdot \alpha_2 \cdot L \cdot B \cdot H$	$L - d_{AV}/2$		
Ballast (aft)				
H ≤ 3,7 m	$0{,}010 \cdot \alpha_2 \cdot L \cdot B \cdot H$	$d_{AR}/2$		
H > 3,7 m	$0{,}003 \cdot \alpha_2 \cdot L \cdot B \cdot H$	$d_{AR}/2$		

d_{AR}, d_{AV} = parameters defined in A.

α_1, α_2 = coefficients defined in Table 7.5.

(1) *for tankers.*

Table 7.4 Self-propelled cargo carriers - still water bending moments

Load cases	Hogging moments [kNm]	Sagging moments [kNm]
Lightship	$M_{H0} = 0{,}273 . L^2 . B^{1{,}342} . T^{0{,}172} . (1{,}265 - C_B)$ $M_{HH} = 0{,}344 . L^2 \cdot B^{1{,}213} \cdot T^{0{,}352} \cdot (1{,}198 - C_B)$	$MHS = 0{,}417 . L^2 \cdot B^{1{,}464} \cdot (0{,}712 - 0{,}622\, C_B)$
Fully loaded vessel		$M_{S0} = M_{CS} - M_{HS}$ $M_{CS} = 0{,}4 . F . L^{1{,}86} . B^{0{,}8} . T^{0{,}48} . (C_B - 0{,}47)$ $. [3{,}1 + R_{11} . (10{,}68 . L - 53{,}22 . \ell_1) . (1 - R_{12})$ $+ R_{21}\ (0{,}17 \cdot L - 0{,}15 \cdot \ell_2) \cdot (1 - R_{22})]$
Loading and unloading in one run	$M_{H1} = M_{HH} + M_L$	$M_{S1} = 0{,}8 . M_{S0} + M_L$
Loading and unloading in two runs	$M_{H2} = M_{HH} + 0{,}5\, M_L$	$M_{S2} = 0{,}8 . M_{S0} + 0{,}5\, M_L$

M_L = parameter defined as:

$= P_L \cdot (k_2 \cdot \ell_3 + k_3 \cdot L)$

k_2 , k_3 = Coefficient defined in Table 7.1

P_L = Parameter defined as:

$$= \frac{0{,}77 \cdot L_1}{L - d_{AR} - d_{AV}} F \cdot L \cdot B \cdot T \cdot C_B$$

ℓ_1, ℓ_2 = Parameters defined in 2.1.1

ℓ_3 = $0{,}5 . L - 0{,}5 . L_1 - d_{AV}$

L_1 = Parameter defined in 2.1.3

R_{11}, R_{12} = Coefficient defined in 2.1.4

R_{21}, R_{22} = Coefficient defined in 2.1.4

Table 7.5 Values of coefficients α_1 and α_2

Loading conditions	α_1	α_2
Lightship	1	0,5
Fully loaded vessel	0,1	0
Transitory conditions		
- hogging	1	0
- sagging	0,1	0

Table 7.6 Values of parameter C

Significant wave height	C		
	L < 60	60 ≤ L ≤ 90	90 < L
h < 1,2 m	$C = (130 - 0{,}36 \cdot L) \cdot \frac{L}{1000}$	C = 9,14 - 0,044L	$C = (90 - 0{,}36 \cdot L) \cdot \frac{L}{1000}$
h ≥ 1,2 m	$C = (118 - 0{,}36 \cdot L) \cdot \frac{L}{1000}$		$C = 10{,}75 - \left(\frac{300 - L}{1000}\right)^{1{,}5}$

Table 7.7 Non-propelled cargo carriers - correction formulae

Item	X > L / 2	X ≤ L / 2
Concentrated weights or loads	$M_C = P \cdot (k_1 \cdot d_2 + k_2 \cdot d + k_3 \cdot L)$ $- P_0 \cdot (k_1 \cdot d_0^2 + k_2 \cdot d_0 + k_3 \cdot L)$	$M_C = P \cdot (k_4 . d + k_3 . L) - P_0 \,.\, (k_4 . d_0 + k_3 . L)$
Distributed weights or loads	$M_C = M - M_0$	
Hull weight **(1)**	$M_C = [0{,}0416 . k_1 . L^2 + (0{,}125 . k_2 + k_3 + 0{,}125 . k_4) . L] \,.\, (P - P_0)$	

$M = P.\{0{,}33 \cdot k_1 \cdot (d_{22} + d_2 . d_1 + d_1^2) + 0{,}5 \cdot k_2 \cdot (d_2 + d_1) + k_3 \cdot L\}$

$M_0 = P_0.\{0{,}33 \cdot k_1 \cdot (d_{02}^2 + d_{02} . d_{01} + d_{01}^2) + 0{,}5 \cdot k_2 \cdot (d_{02} + d_{01}) + k_3 \cdot L\}$

P = Actual weight or load [t]

P_0 = Standard weight or load [t] defined in 6.1
= 0, if not defined in 6.1.

D = Actual distance from midship [m] of centre of gravity of concentrated weights (see Fig. 7.2):
= L / 2 - X for X ≤ L / 2
= X - L / 2 for X > L / 2

d_0 = Standard distance from midship [m] of centre of gravity of concentrated weights ($d_0 \geq 0$)

d_1, d_2 = Distances measured from midship [m] defining the extent of actual distributed weight (see Fig. 7.2)

d_{01}, d_{02} = Distances measured from midship [m] defining the extent of standard distributed weight.

(1) *Uniform weight distribution*

Table 7.8 Self-propelled cargo carriers - correction formulae

Item	X > L / 2	X ≤ L / 2
Concentrated weights or loads Distributed weights or loads	$M_C = P \cdot (k_2 \cdot d + k_3 \cdot L) - P_0 \cdot (k_2 \cdot d_0 + k_3 \cdot L)$	$M_C = P \cdot (k_4 \cdot d + k_3 \cdot L) - P_0 \cdot (k_4 \cdot d_0 + k_3 \cdot L)$
Hull weight **(1)**	$M_C = (0{,}125 \cdot k_2 + k_3 + 0{,}125 \cdot k_4) \cdot (P - P_0) \cdot L$	

P = Actual weight or load [t]

P_0 = Standard weight or load [t] defined in 6.2
= 0, if not defined in 6.2

d = Actual distance from midship [m] of the weight centre of gravity (see Fig. 7.2):
= L / 2 − X for X ≤ L / 2
= X − L / 2 for X > L / 2

d0 = Standard distance from midship [m] of the weight centre of gravity ($d_0 \geq 0$).

(1) *Uniform weight distribution*

8.2 Self-propelled cargo carriers

The correction formulae applicable to self-propelled cargo carriers are given in Table 7.8, where the coefficients k_2, k_3 and k_4 are given in Table 7.1.

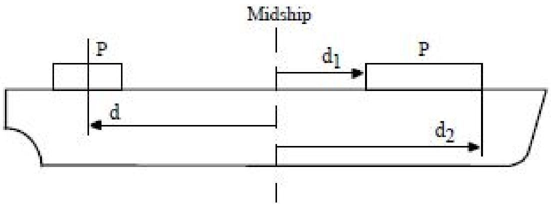


Fig. 7.2 Definition of distances d, d_1, d_2

C. Strength Characteristics of the Hull Girder Transverse Sections

1. Symbols

Z = Hull girder section modulus [cm^3]

M_H = Design hogging bending moment [kNm]

M_S = Design sagging bending moment [kNm]

2. General

2.1 Application

In the following, the criteria are specified for calculating the hull girder strength characteristics to be used for the checks, in association with the hull girder loads.

3. Characteristics of the Hull Girder Transverse Sections

3.1 Hull girder transverse sections

3.1.1 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 3.2, taking into account the requirements of 3.1.2 to 3.1.5.

3.1.2 Longitudinal bulkheads with vertical corrugations

Longitudinal bulkheads with vertical corrugations may not be included in the hull girder transverse sections.

3.1.3 Members in materials other than steel

Where a member is made in material other than steel, its contribution to the longitudinal strength will be determined by **TL** on case-by-case basis.

3.1.4 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.

3.1.5 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 [mm].

Otherwise, the excess is to be deducted from the sectional area or compensated.

3.2 Strength deck

3.2.1 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 deckhouse.

3.2.2 For additional requirements about passenger vessels, see Section 15, D.

3.3 Hull girder section modulus

3.3.1 The section modulus at any point of a hull transverse section is obtained [cm3] from the following formula:

$$Z = \frac{I_Y}{100 \cdot |z - N|}$$

I_Y = Moment of inertia [cm^4] of the hull girder transverse section defined in 3.1, about its horizontal neutral axis

N = Z co-ordinate [m] of the centre of gravity of the hull transverse section

Z = Z co-ordinate [m] of the calculation point of a structural element.

3.4 Hull girder normal stresses

3.4.1 The normal stresses induced by vertical bending moments are obtained [N/mm^2] from the following formulae:

- in hogging conditions:

$$\sigma_1 = \frac{M_H}{Z} \cdot 10^3$$

- in sagging conditions:

$$\sigma_1 = \frac{M_S}{Z} \cdot 10^3$$

SECTION 8

HULL DESIGN and CONSTRUCTION - HULL SCANTLINGS

A. General

1. General

1.1 Application

This Section contains the requirements for the determination of the minimum hull scantlings applicable to the central part (see Section 4, A.1.3.3) of all types of inland waterway vessels.

These requirements are to be integrated with those specified under applicable Sections of the Additional Requirements for Notations, depending on the vessel Notations.

1.2 Summary table

The following requirements are to be applied for the scantlings and arrangements of the vessel central part according to Table 8.1.

Table 8.1 Summary table

Main subject	Reference
Bottom scantlings	B
Side scantlings	C
Deck scantlings	D
Bulkhead scantlings	E
Vessels less than 40 m in length	F

1.3 Material factor

When aluminium alloys or steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor defined in Section 5, A.2.4 and Section 5, A.3.2 as follows:

- Thickness:

  See relevant requirements of the following paragraphs

- Section modulus:

  $w = k \cdot w_0$

- sectional area:

  $A = k \cdot A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

2. Hull arrangements

2.1 Arrangements for hull openings

Arrangements for hull openings are to be in compliance with Section 9, G.

2.2 River chests

2.2.1 Shell plating

The shell plate gross thickness [mm] in way of river chests as well as the gross thickness of all boundary walls of the river chests is not to be less than:

$$t = 1{,}2 \cdot s \cdot k^{0,5} \cdot p^{0,5} + 1{,}5$$

s = Width of the plate panel or stiffener spacing, respectively [m]

p = Pressure at the safety relief valve [kN/m^2]:

- In general, $p \geq 196$ kN/m^2
- For river chests without any compressed air connection and which are accessible at any time, $p = 98$ kN/m^2

2.2.2 Stiffeners

The gross section modulus [cm3] of river chest stiffeners is not to be less than:

$$w = 0{,}58 \cdot s \cdot p \cdot \ell^2$$

s, p = Parameters defined in 2.2.1

ℓ = Unsupported span of stiffener [m]

2.3 Pipe connections at the shell plating

Scupper pipes and valves are to be connected to the shell by weld flanges. Instead of weld flanges shortflanged sockets with an adequate thickness may be used if they are welded to the shell in an appropriate manner.

B. Bottom Scantlings

1. Symbols

L = Rule length [m], defined in Section 4, A.1.

B = Breadth [m], defined in Section 4, A.1.

H = Depth [m], defined in Section 4, A.1.

T = Draught [m], defined in Section 4, A.1.

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

σ_1 = Hull girder normal stress [N/mm2]

β_b, β_s = Bracket coefficients defined in Section 5, B. 6.2

η = 1 − s / (2 .ℓ)

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

B_1 = Breadth [m] of the hold

B_2 = Breadth [m] of the side tank

M_H = Design bending moment [kN.m] in hogging condition

M_S = Design bending moment [kN.m] in sagging condition

2. General

2.1 Application

The following requirements apply to longitudinally or transversely framed single and double bottom structures of inland waterway vessels.

The requirements applicable to specific vessel Notations are defined in Sections 14-17.

2.2 General arrangement

2.2.1 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.

2.2.2 The bottom is to be locally stiffened where concentrated loads are envisaged.

2.2.3 Girders or floors are to be fitted under each line of pillars, when deemed necessary by **TL** on the basis of the loads carried by the pillars.

2.2.4 Adequate continuity is to be provided in the case of height variation in the double bottom.

2.2.5 Provision is to be made for the free passage of water from all parts of the bottom to the suctions.

2.3 Keel

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.

2.4 Bilge

2.4.1 Radius

Where the bilge plating is rounded, the radius of curvature is not to be less than 20 times the thickness of the plating.

2.4.2 Extension

The bilge is to extend at least 100 mm on either side of the rounded part and 150 mm above the floor upper edge.

2.4.3 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.

2.5 Drainage and openings for air passage

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.

3. Scantlings

3.1 Bottom, inner bottom and bilge plating

3.1.1 In the central part, the bottom and inner bottom plating net thickness [mm] are not to be less than the values given in Table 8.2.

3.1.2 Rounded bilge

The bilge plating net thickness [mm] is to be not less than the following values, where t0 is the bottom plating net thickness [mm]:

- in the case of a bilge radius of curvature practically equal to the floor depth or bottom transverse depth:

  $t = 1{,}15 \cdot t_0$

- 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:

  $t = 1{,}15 \cdot t_0 + 1$

3.1.3 Square bilge

In the case of a square bilge with chine bars (sketches a, b, c of Fig. 8.1), the net scantling of the chine bar is to be determined as follows:

- Angle bars

  The net thickness of the bars plating [mm] is to be not less than the following formulae, where t_0 is the 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 bilge without chine bars (sketch d of Fig. 8.1):

The thickness of the doublers [mm], is to be not less than:

$t = t_0 + 3$

where t_0 is the bottom plating thickness.

In the case of a double chine bilge with round chine bars (sketch e of Fig. 8.1):

The diameter of the round bars is to be not less than 30 mm. The thickness of the plating is equal to the bottom plating thickness.

Table 8.2 Bottom and inner bottom plating net thickness [mm]

Item	Transverse framing	Longitudinal framing
Bottom plating	t = MAX (t_i) $t_1 = 1{,}85 + 0{,}03 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 68 \cdot \dfrac{s}{k_2} \cdot \sqrt{\dfrac{M_H}{Z_B}}$ if $t_3/s > 22/(k^{0,5} \cdot k_2)$ $t_3 = \dfrac{7{,}1 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \dfrac{M_H}{Z_B}}}$ See **(1)**	t = MAX (t_i) $t_1 = 1{,}1 + 0{,}03 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 39 \cdot s \cdot \sqrt{\dfrac{M_H}{Z_B}}$ if $t_3/s > 12{,}5/k^{0,5}$ $t_3 = \dfrac{4{,}1 \cdot k^{0,5} \cdot s}{\sqrt{0{,}21 - \dfrac{M_H}{Z_B}}}$ See **(1)**
Inner bottom plating	t = MAX (t_i) $t_1 = 1{,}5 + 0{,}016 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 68 \cdot \dfrac{s}{k_2} \cdot \sqrt{\dfrac{M_H}{Z_B}}$ See **(1)**	t = MAX (t_i) $t_1 = 1{,}5 + 0{,}016 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 39 \cdot \sqrt{\dfrac{M_H}{Z_B}}$ See **(1)**

p = Design load [kN/m²]:

- in way of ballast tanks:
  $p = \text{MAX}\,(p_E;\ (p_B - p_M))$ for bottom plating
  $= \text{MAX}\,(p_C;\ p_B)$ for inner bottom plating
- elsewhere:
  $p = p_E$ for bottom plating
  $= p_C$ for inner bottom plating

p_M = Minimum external pressure [kN/m²], $p_M \geq 0$:
$= 9{,}81 \cdot (0{,}15 \cdot T - 0{,}6 \cdot n)$

p_E, p_C, p_B = Pressures transmitted to the hull structure defined in Section 6, C.4. and Section 6, C.5.

k_2 = $1 + \alpha_2$

α = b_2 / b_1

b_1 = Unsupported plate width in y direction [m]

b_2 = Unsupported plate width in x direction [m]

Z_B = Bottom net hull girder section modulus [cm³]

Z_{DB} = Inner bottom net hull girder section modulus [cm³]

(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5,C.*

3.1.4 Bilge plate thickness reduction

Forward of the forward shoulder and aft of the aft shoulder, the bilge plate thicknesses according to 3.1.2 and 3.1.3 may be reduced to the bottom plate thickness according to Section 9, A.3, B.3. and C.4. respectively.

3.1.5 Strength check in testing conditions

Plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

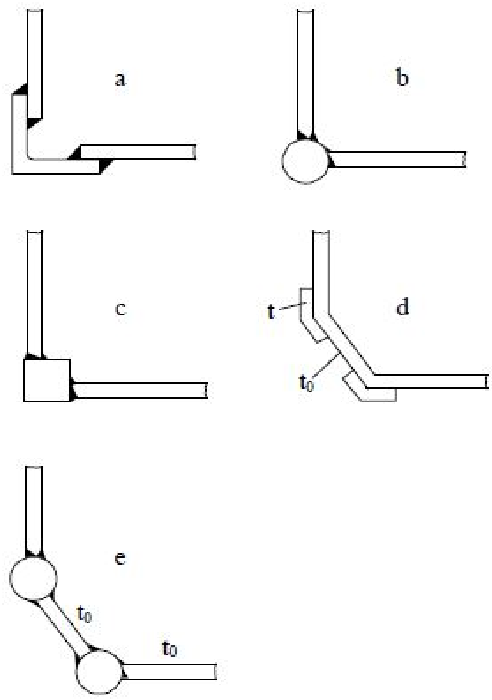


Fig. 8.1 Square bilge

3.2 Bottom and inner bottom structures

3.2.1 Minimum net thickness of web plating

The net thickness [mm] of the web plating of ordinary stiffeners is to be not less than:

$$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0{,}5} + 4{,}5 \cdot s \qquad \text{for } L < 120 \text{ m}$$

$$= 3{,}9 \cdot k^{0{,}5} + s \qquad \text{for } L \geq 120 \text{ m}$$

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0{,}5}$$

3.2.2 Net scantlings of bottom and inner bottom structural members in service conditions

The net scantlings of bottom and inner bottom structural members in service conditions are to be obtained from Table 8.3 for single bottom structure and Table 8.4 for double bottom structure.

3.2.3 Net scantlings of bottom and inner bottom structural members in testing conditions

The net scantlings of bottom and inner bottom structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

3.2.4 Buckling check

Bottom and inner bottom structural members are to comply with the requirements stated under Section 5, C.

4. Transversely framed single bottom

4.1 Floors

4.1.1 It is forbidden to connect the floors to the bottom shell plating by means of a flange.

4.1.2 Floors are to be fitted at every frame.

4.1.3 Minimum shear sectional area of floors

In the region where the shear force is maximum, the minimum shear sectional area Ash of floors [cm^2] is to be not less than the value given in Table 8.3.

TL may waive this rule subject to direct calculation of the shearing stresses.

4.1.4 Floor height

The ratio of the floor height to the web net thickness is to be not more than r_T values, given in Table 8.5.

In the case of vessels with considerable rise of floor, this height may be required to be increased so as to assure a satisfactory connection to the frames.

4.2 Girders

4.2.1 Centre girder

All single bottom vessels are to have a centre girder. **TL** may waive this rule for vessels with breadth B_F measured on the top of floors less than 6 m, where the floor is a rolled section or where the floor stability is covered otherwise.

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, a flat or a flange, the net sectional area of which [cm^2] is not to be less than:

$$A_f = 0{,}764 \cdot B + 3{,}3$$

4.2.2 Side girders

Depending on the breadth B_F measured on the top of floors, side girders are to be fitted in compliance with the following:

- $B_F \leq 6$ m: no side girder
- 6 m $< B_F \leq 9$ 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, a flat 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 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 transverses

5.1.1 Spacing

In general, the transverse spacing is to be not greater than 8 frame spacings, nor than 4 m, which is the lesser.

5.1.2 Minimum shear sectional area of bottom transverses

In the region where the shear force is maximum and taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area A_{sh} of bottom transverses [cm^2] is to be not less than the value given in Table 8.3.

TL may waive this rule subject to direct calculation of the shearing stresses.

5.1.3 Bottom transverse height

The ratio of the bottom transverse height to the web net thickness is to be not more than r_L values, given in Table 8.5.

In the case of vessels with considerable rise of floor, this height may be required to be increased so as to assure a satisfactory connection to the side transverses.

5.2 Girders

The requirements in 3.2 apply also to longitudinally framed single bottoms, with transverses instead of floors.

Table 8.3 Net scantlings of single bottom structure

Item	W [cm^3]	A_{sh} [cm^2]
Bottom longitudinal	$w = \frac{83,3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_E \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p_E \cdot s \cdot \ell$
Floors **(1)**, **(2)**	$w = 0,58 \cdot \beta_b \cdot p_{\gamma E} \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p\gamma_E \cdot s \cdot \ell$
Bottom transverses **(2)**	$w = 0,58 \cdot \beta_b \cdot p_{\gamma E} \cdot S \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p\gamma_E \cdot S \cdot \ell$
Bottom centre and side girders **(3)**	$w = \frac{125}{197 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_{\gamma E} \cdot S \cdot \ell^2$	$A_{sh} = 0,056 \cdot \beta_s \cdot \eta \cdot p\gamma_E \cdot S \cdot \ell$

p_E = Design load [kN/m^2] defined in Section 6, C.5.1

$p_{\gamma E}$ = Design load [kN/m^2] of bottom primary supporting members

= $9,81 (\gamma \cdot T + 0,6 \cdot n)$

γ = Loading sequence coefficient

= 1 for loading/unloading in one run

= 0,575 for loading/unloading in two runs

(1) *In way of side ordinary frames: $\beta_b = \beta_S = 1$*

(2) *Scantlings of floors and bottom transverses have to be adequate to 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.*

Table 8.4 Net scantlings of double bottom structure

Item	Parameter	Transverse framing	Longitudinal framing
Floors in the hold **(1)**	Section modulus [cm^3]	$w = MAX (w_1; w_2)$ $w_1 = 0,58 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell^2$ $w_2 = 0,58 \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot (\ell^2 - 4 \cdot B_2^2)$	NA
	Thickness [mm]	$t = MAX (t_1; t_2)$ $t_1 = 3,8 + 0,016 \cdot L \cdot k^{0,5}$ $t_2 = d/r_T$	NA
	Shear sectional area [cm^2]	$A_{sh} = MAX (A_1; A_2)$ $A_1 = 0,067 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0,067 \cdot \beta s \cdot p_{\gamma l} \cdot s \cdot (\ell - 2 \cdot B_2)$	NA
Floors in the side tank **(1)**	Section modulus [cm^3]	$w = MAX (w_1; w_2)$ $w_1 = 2,32 \cdot \beta_b \cdot p_1 \cdot s \cdot B_2 \cdot (\ell - B_2)$ $w_2 = 2,32 \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot B_2 (\ell - 2 \cdot B_2)$	NA
	Shear sectional area [cm^2]	$A_{sh} = MAX (A_1; A_2)$ $A_1 = 0,067 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0,067 \cdot \beta s \cdot p_{\gamma l} \cdot s \cdot (\ell - 2 \cdot B_2)$	NA
Bottom and inner bottom longitudinals	Section modulus [cm^3]	NA	$w = \frac{83,3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_2 \cdot s \cdot \ell^2$
	Shear sectional area [cm^2]	NA	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p_2 \cdot s \cdot \ell$

Table 8.4 Net scantlings of double bottom structure - continued -

Item	Parameter	Transverse framing	Longitudinal framing
Bottom transverses in the hold	Section modulus [cm^3] Thickness [mm] Shear sectional area [cm^2]	NA NA NA	$w = MAX(w_1; w_2)$ $w_1 = 0{,}58 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell^2$ $w_2 = 0{,}58 \cdot \beta_b \cdot p_{\gamma I} \cdot s \cdot (\ell^2 - 4 \cdot B_2^2)$ $t = MAX(t_1; t_2)$ $t_1 = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$ $t_2 = d/r_T$ $A_{sh} = MAX(A_1; A_2)$ $A_1 = 0{,}067 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0{,}067 \cdot \beta s \cdot p_{\gamma I} \cdot s \cdot (\ell - 2 \cdot B_2)$
Bottom transverses in the side tank	Section modulus [cm^3] Shear sectional area [cm^2]	NA NA	$w = MAX(w_1; w_2)$ $w_1 = 2{,}32 \cdot \beta_b \cdot p_1 \cdot s \cdot B_2 \cdot (\ell - B_2)$ $w_2 = 2{,}32 \cdot \beta_b \cdot p_{\gamma I} \cdot s \cdot B_2 (\ell - 2 \cdot B_2)$ $A_{sh} = MAX(A_1; A_2)$ $A_1 = 0{,}067 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0{,}067 \cdot \beta s \cdot p_{\gamma I} \cdot s \cdot (\ell - 2 \cdot B_2)$
Bottom centre and side girders **(2)**	Shear sectional area [cm^2]	$A_{sh} = 0{,}051 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

p = Design load of primary supporting members [kN/m^2]
= MAX (p_1; $p_{\gamma I}$)
p_1 = $p_{\gamma E}$
p_2 = Design load of bottom and inner bottom longitudinals [kN/m^2]:
- in way of ballast tanks:
  - for bottom longitudinals: $p_2 = MAX [p_E; (p_B - p_M)]$
  - for inner bottom longitudinals: $p_2 = MAX (p_C; p_B)$
- elsewhere:
  - for bottom longitudinals: $p_2 = p_E$
  - for inner bottom longitudinals: $p_2 = p_C$

pM = Minimum external pressure [kN/m^2], $p_M \geq 0$:
= $9{,}81 \, . \, (0{,}15 \cdot T - 0{,}6 \cdot n)$
pγE = External pressure [kN/m^2] taking into account the loading sequence:
= $9{,}81 \, . \, (\gamma \cdot T + 0{,}6 \cdot n)$
γ = Loading sequence coefficient:
= 1 for loading/unloading in one run
= 0,575 for loading/unloading in two runs
$p_{\gamma I}$ = Internal load [kN/m^2] taking into account the loading sequence:
= $\gamma_1 \, . \, p_C - p_M$
γ_1 = $(\gamma - 0{,}15) / 0{,}85$
d = Double bottom height [mm]
r_T, r_L = Coefficients defined in Table 8.5
p_E, p_B, p_C = Pressures transmitted to the hull structure defined in Section 6, C.5. and Section 6, C.6.
(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*
NA = Not applicable

Table 8.5 Values of coefficients r_T (transverse framing) and r_L (longitudinal framing)

Cargo	r_T	r_L
Uniform	100	90
Non-uniform	90	80

5.3 Bottom longitudinals

5.3.1 General

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

5.3.2 Strengthening

The section modulus of longitudinals located in way of the web frames of transverse bulkheads is to be increased by 10 %.

TL may call for strengthening of the longitudinal located in the centreline of the vessel.

6. Transversely framed double bottom

6.1 Double bottom arrangement

6.1.1 Where it is not possible to visit the double bottoms, they are to be well protected against corrosion.

6.1.2 Where the height of the double bottom varies, the variation is generally to be made gradually and over an adequate length; the knuckles of inner bottom plating are to be located in way of plate floors or girders.

Where this is impossible, suitable structures such as partial girders, brackets, etc., fitted across the knuckle, are to be arranged.

6.1.3 In vessels without a flat bottom, the height of double bottom specified in 6.1.2 may be required to be adequately increased such as to ensure sufficient access to the areas towards the sides.

6.1.4 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

In the region where the shear force is maximum, the minimum shear sectional area A_{sh} of floors [cm^2] is to be not less than the value given in Table 8.4.

TL may waive this rule subject to direct calculation of the shearing stresses.

6.2.4 Where the double bottom height does not make it possible to connect the floors and girders to the double bottom top by fillet welding, slot welding may be used. In that case, the floors and girders are to be fitted with a face plate or 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 girder is to be formed by a vertical intercostal plate connected to the bottom plating and fitted with an appropriate face plate.

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 On vessels with ranges of navigation **I (1,2)** to **I (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.

On vessels with ranges of navigation **I (1,2)** to **I (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. 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

The requirements in 6.1, 6.3 and 6.4 are also applicable to longitudinally framed double bottoms.

7.2 Transverses

The spacing of transverses [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.

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.

7.3.2 Struts

Bottom longitudinals may be connected to the inner bottom longitudinals by means of struts having a sectional area not less than those of the connected longitudinals.

Struts are generally to be connected to bottom and inner bottom longitudinals by means of brackets or by appropriate weld sections.

Where struts are fitted between bottom and inner bottom longitudinals at mid-span, the section modulus of bottom longitudinals and inner bottom longitudinals may be reduced by 30 %.

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, **TL** may require a welded flat bar to be arranged in lieu of the flange.

C. Side Scantlings

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

B_1 = Breadth [m] of the cargo hold

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

σ_1 = Hull girder normal stress [N/mm^2]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

λ_b, λ_s = Coefficients for vertical structural members defined in Section 5, B.5.6.3

η = $1 - s / (2 \,.\, \ell)$

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

H_F = Floor height in way of vertical side stiffener [m]

= 0, in way of side web frames and side transverses

2. General

2.1 Application

2.1.1 The following requirements apply to longitudinally or transversely framed single and double side structures of inland waterway vessels.

The requirements applicable to specific vessel Notations are defined in Additional Requirements for Notations.

2.1.2 The transversely framed side structures are built with transverse frames possibly supported by struts, side stringers and web frames.

2.1.3 The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by side vertical primary supporting members.

3. Scantlings

3.1 Side and inner side plating

3.1.1 In the central part, the side and inner side plating net thickness [mm] is not to be less than the values given in Table 8.6.

3.1.2 Strength check in testing conditions

The plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

3.2 Side and inner side structure

3.2.1 Minimum net thickness of web plating

The net thickness of the web plating of ordinary stiffeners is to be not less than:

$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0{,}5} + 4{,}5 \cdot s$ for L < 120 m

$t = 3{,}9 \cdot k^{0{,}5} + s$ for L ≥ 120 m

The minimum net thickness [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 formula:

$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$

3.2.2 Net scantlings of side and inner side structural members in service conditions

The net scantlings of side and inner side structural members in service conditions are to comply with Table 8.7 or Table 8.8, as applicable.

3.2.3 Net scantlings of side and inner side structural members in testing conditions

The net section modulus w [cm3] and the net shear sectional area Ash [cm2] of side and inner side structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

3.2.4 Buckling check

Side and inner side structural members are to comply with the requirements stated under of Section 5, C.

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 **TL** 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. 8.2, or in an equivalent way.

For overlapping connection as to Fig. 8.2 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 hatch coaming, in general
- the side trunk bulkhead, in the case of a trunk vessel.

4.1.5 Reduction of 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. 8.3.

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 [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.

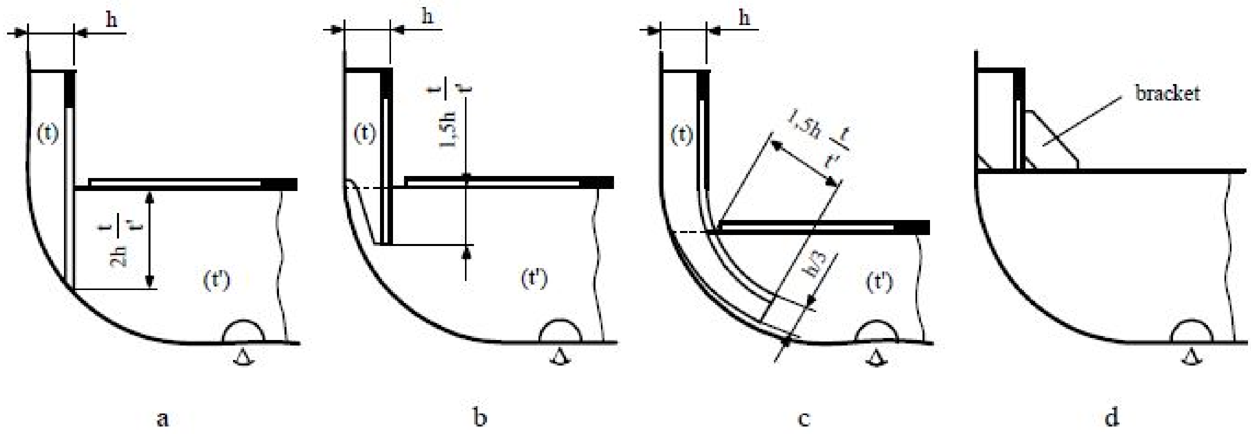


Fig. 8.2 Connection with floors

Table 8.6 Side and inner side plating net thickness [mm]

Item	Transverse framing	Longitudinal framing
Side plating	$t = MAX (t_i)$ $t_1 = 1{,}68 + 0{,}025 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0{,}5}$ $t_3 = k_1 \cdot t_0$	$t = MAX (t_i)$ $t_1 = 1{,}25 + 0{,}02 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0{,}5}$ $t_3 = k_1 . t_0$
Inner side plating	$t = MAX (t_i)$ $t_1 = 2{,}2 + 0{,}013 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0{,}5}$	$t = MAX (t_i)$ $t_1 = 2{,}2 + 0{,}013 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0{,}5}$

p = Design load [kN/m^2]
- in way of ballast tanks:
$p = MAX [p_E ; (p_B - p_M)]$ for side plating
$= MAX (P_C ; p_B)$ for inner side plating
- elsewhere:
$p = p_E$ for side plating
$= p_C$ for inner side plating

p_M = Minimum external load [kN/m^2], $p_M \geq 0$:
for $z \leq 0{,}15 \cdot T$: $p_M = 9{,}81 \cdot (0{,}15 \cdot T - z - 0{,}6 \cdot n)$
for $z > 0{,}15 \cdot T$: $p_M = 0$

t_0 = t_{bottom}

k_1 = 0,85 if transversely framed bottom
0,90 if longitudinally framed bottom

p_E, p_B and p_C are parameters defined in Section 6, C.5. and Section 6, C.6.

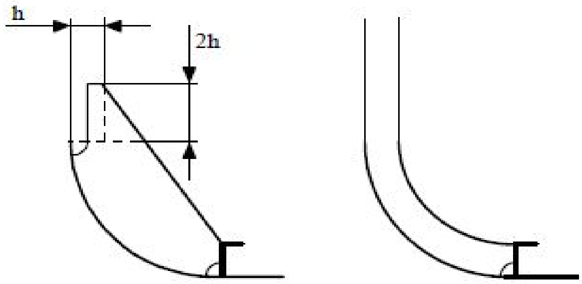


Fig. 8.3 Connection of frames to bottom longitudinals

Table 8.7 Net scantlings of side single hull structure

Item	w	A_{sh}
Side frames	$w = 0{,}58 . \beta_b \cdot \eta \cdot s \cdot (1{,}2 \cdot k_0 \cdot p \cdot \ell_0^2 + \lambda_t \cdot p_{\gamma E} \cdot . \ell_F^2)$	$A_{sh} = 0{,}08 . \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side longitudinals	$w = \dfrac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 . \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames Side transverses **(1)**	$w = 1{,}96 . \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0{,}063 . \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side stringers **(2)**	$w = \dfrac{125}{197 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}056 . \beta_s \cdot p \cdot S \cdot \ell$

H_F = Floor height or bottom transverse height [m]

p = Design load of side structural members [kN/m²]: $p = p_E$

ℓ_F = Floor span [m]

ℓ_0 = $T - H_F + 0{,}6.n$

k_0 = Coefficient given by the formula:

= $1 + (\ell - \ell_0) / \ell_0$

λ_t = Coefficient to be taken equal to:

- in transverse framing:

$$\lambda_t = 0{,}1 \cdot \left(0{,}8 - \frac{\ell^2}{\ell_F^2}\right), \quad \lambda_t \geq 0$$

- in combination framing:

= 0

p_E = External pressure transmitted to the hull structure:

- in general:

p_E is to be determined in compliance with Section 6, C.5.

- for vertical stiffeners:

= $4{,}9 \cdot \ell_0$

$p_{\gamma E}$ = Floor external load [kN/m²] taking into account the loading sequence:

= $9{,}81 \cdot (\gamma \cdot T + 0{,}6 \cdot n)$

γ = Loading sequence coefficient:

= 1,0 for loading/unloading in one run

= 0,575 for loading/unloading in two runs.

(1) *Scantlings of web frames and side transverses at the lower end have to be adequate to 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.*

Table 8.8 Net scantlings of side double hull structure

Item	w	A_{sh}
Side frames subjected to external load	$w = 0{,}7 \cdot \beta_b \cdot \eta_1 \cdot k_0 \cdot p \cdot s \cdot \ell_0^2$	$A_{sh} = 0{,}08 \cdot \beta_s \cdot \eta_1 \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side frames and Inner side frames in other loading cases	$w = 0{,}58 \cdot \lambda_b \cdot \beta_b \cdot \eta_1 \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}058 \cdot \lambda_s \cdot \beta_s \cdot \eta_1 \cdot p \cdot s \cdot \ell$
Side longitudinals and Inner side longitudinals	$w = \dfrac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_E \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames and Side transverses subjected to external load	$w = 0{,}7 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side and inner side web frames and Side and inner side transverses in other loading cases	$w = 0{,}58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \lambda_s . \beta_s \cdot p \cdot S \cdot \ell$
Plate web frames subjected to external load	$w = 1{,}96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Plate web frames in other loading cases	$w = 1{,}63 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \lambda_s . \beta_s \cdot p \cdot S \cdot \ell$
Side stringers and Inner side stringers **(1)**	$w = \dfrac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

η_1 = 1 if no side web frames are fitted
= η otherwise

p = Design load of double side structural members [kN/m^2]:
- in way of ballast tanks:
  for side structure: $p = MAX\ [p_E\ ;\ (p_B - p_M)]$
  for inner side structure: $p = MAX\ (p_C\ ;\ p_B)$
- elsewhere:
  for side structure: $p = p_E$
  for inner side structure: $p = p_C$

H_F = Floor height or bottom transverse height [m]

ℓ_0 = $T - H_F + 0{,}6.n$

k_0 = coefficient given by the formula:
= $1 + (\ell - \ell_0) / \ell_0$

p_E = External pressure transmitted to the hull structure:
- in general:
  p_E is to be determined in compliance with Section 6, C.4.
- for vertical stiffeners:
  = $4{,}9\ \ell_0$

p_M = Minimum external load [kN/m^2], $p_M \geq 0$:
for $z \leq 0{,}15 \cdot T$: $p_M = 9{,}81 \cdot (0{,}15 \cdot T - z - 0{,}6 \cdot n)$
for $z > 0{,}15 \cdot T$: $p_M = 0$

p_B, p_C = Pressures transmitted to the hull structure defined in Section 6, C.5.

(1) *The span of side stringers is to be taken equal to the side transverses spacing or web frames spacing*

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 Section 5, B.5.5.

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 4 m
- 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 of transverse web

In the region where the shear force is maximum and taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area of a transverse web [cm^2] is to be not less than the value given in Table 8.8.

TL may waive this rule subject to direct calculation of the shearing stresses.

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.

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

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

The requirements in 6.1.1 also apply to longitudinally framed double side.

7.2 Side and inner side longitudinals

7.2.1 Struts

Side longitudinals may be connected to the inner side longitudinals by means of struts having a sectional area not less than those of the connected longitudinals.

Struts are generally to be connected to side and inner side longitudinals by means of brackets or by appropriate weld sections.

Where struts are fitted between side and inner side longitudinals at mid-span, the section modulus of side longitudinals and inner side longitudinals may be reduced by 30 %.

7.3 Side transverses

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 [mm] from the following formula:

$$d = \varphi\sqrt{\frac{w + 30}{t}}$$

φ = Coefficient
= 50 for unflanged brackets
= 45 for flanged brackets

w = Required net section modulus of the stiffener [cm^3], given in 8.2.2 and depending on the type of connection

t = Bracket net thickness [mm] to be taken not less than the stiffener thickness

8.2.2 Section modulus of connections

For connections of perpendicular stiffeners located in the same plane (see Fig. 8.4) or connections of stiffeners located in perpendicular planes (see Fig. 8.5), 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 ofstiffeners, as shown in Fig. 8.4 and Fig. 8.5.

8.2.3 All brackets for which:

$$\frac{\ell_b}{t} > 60$$

ℓ_b = Length [mm] of the free edge of the bracket

t = Bracket net thickness [mm]

are to be flanged or stiffened by a welded face plate. The sectional area [cm^2] of the flange or the face plate is to be not less than 0,01. ℓ_b

The width of the face plate is to be not less than 10 t.

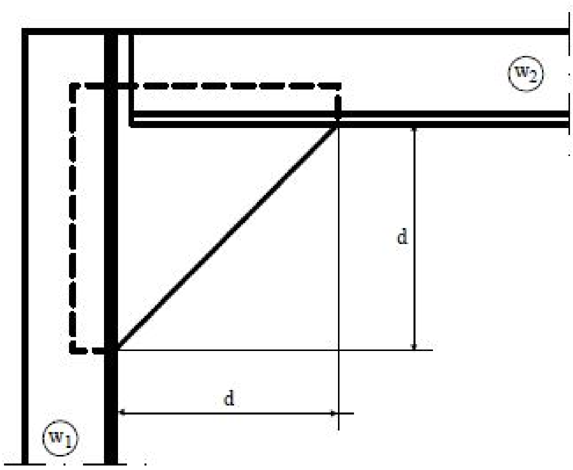


Fig.8.4 Connections of perpendicular stiffeners in the same plane

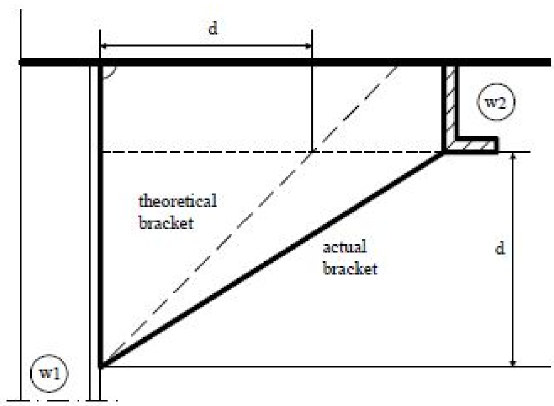


Fig. 8.5 Connections of stiffeners located in perpendicular planes

D. Deck Scantlings

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

D_1 = Unsupported stringer plate length, in [m]

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6,B.

= 0,85.h

h = Significant wave height [m]

σ_1 = Hull girder normal stress [N/mm2]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

η = 1 − s / (2 . ℓ)

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

M_H = Design bending moment [kNm] in hogging condition

M_S = Design bending moment [kNm] in sagging condition

2. General

2.1 Application

2.1.1 The following requirements apply to inland waterway vessels with:

- Open decks, consisting of a stringer plate and a longitudinal hatch coaming (Fig. 8.6)

- Flush decks, consisting of a deck continuous over the breadth of the vessel (Fig. 8.7 and Fig.8.8)

- Trunk decks, differing from flush decks solely by the presence of a trunk.

2.1.2 These decks can be longitudinally or transversely framed and may be sustained by pillars, bulkheads or strong beams.

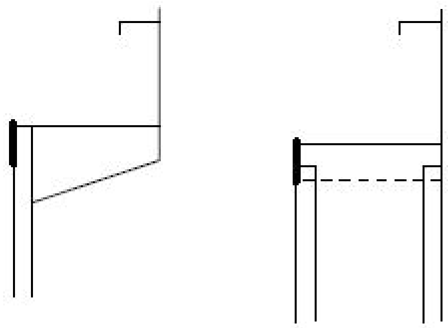


Fig. 8.6 Open deck

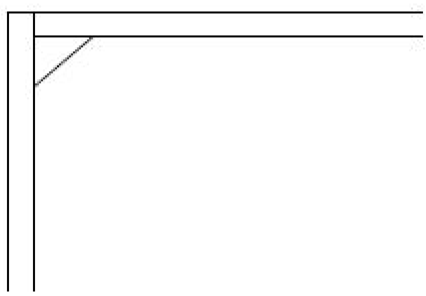


Fig. 8.7 Transversely framed flush deck

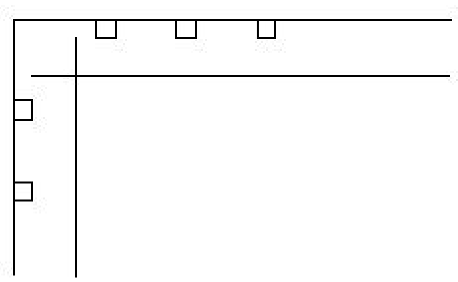


Fig. 8.8 Longitudinally framed flush deck

2.1.3 The requirements applicable to specific vessel Notations are defined in Additional Requirements for Notations.

2.2 General arrangement

2.2.1 It is recommended to avoid breaks in the deck of the cargo hold zone. 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.

2.2.2 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 **TL** for review/approval.

2.2.3 Deck supporting structures under deck machinery, cranes and king posts are to be adequately stiffened.

2.2.4 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.

2.2.5 Stiffeners are to be fitted in way of the ends and corners of deckhouses and partial superstructures.

2.2.6 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.

2.2.7 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.

2.2.8 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 Section 9, G.6.

2.2.9 Stringer plate openings

The openings made in the stringer plate other than scupper openings are to be wholly compensated to the satisfaction of **TL**.

3. Open deck - Single hull vessels

3.1 Stringer plate

3.1.1 Width

The stringer plate is to extend between the side shell plating and the hatch coaming. In principle its width [m] is to be not less than: b = 0,1.B.

The stringer plate width and arrangements are to be so that safe movement is possible.

3.1.2 Stringer plate net thickness

The stringer plate is to have a net thickness [mm] not less than the values obtained from Table 8.9.

3.1.3 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.

Table 8.9 Stringer plate net thickness [mm] Single hull vessels

α ≥ 1	**α < 1**
t = MAX (t_i) $t_1 = 2 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 39 \cdot s \cdot \sqrt{\frac{M_S}{Z_D}}$ if $t_2/s > 12{,}5/(k^{0,5} \cdot k_2)$ $t_2 = \frac{4{,}1 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ See **(1)**	t = MAX (t_i) $t_1 = 2 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_3 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{M_S}{Z_D}}$ if $t_3/s > 23{,}9/(k^{0,5} \cdot k_2)$ $t_3 = \frac{7{,}76 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ See **(1)**

k_2 = coefficient
= $1 + \alpha^2$
α = b_2 / b_1
b_1 = Unsupported stringer plate width in y direction [m]
b_2 = Unsupported stringer plate width in x direction [m]
s = MIN (b_1 ; b_2)
Z_D = Deck net hull girder section modulus [cm³].

(1) *A lower value of thickness t_2 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

3.1.4 In vessels having range of navigation **I (1,2)** or **I (2), TL** may require transverse deck plating strips efficiently strengthened and joining the stringer plates of both sides to be fitted.

3.2 Sheerstrake

3.2.1 General

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

3.2.2 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 [mm] obtained from following formula:

$$t = 3{,}6 + 0{,}11 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$$

Where a doubling plate is provided instead of an inserted side strake, its thickness [mm] is not to be less than:

$$t = 2{,}6 + 0{,}076 \cdot L \cdot k0^{.5} + 3{,}6 \cdot s$$

3.2.3 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 relation:

$$0{,}08 \cdot H \le b \le 0{,}15 \cdot H$$

3.3 Hatch coaming

3.3.1 Height

The height of the hatch coaming above the deck [m] is not to be less than the value obtained from the following formula, where b is the stringer plate width defined in 3.1.1:

$$h_C = 0{,}75 \cdot b$$

Furthermore, the height of the hatch coaming above the deck is to comply with the following relation:

$$H + h_C > T + n / 1{,}7 + 0{,}15$$

3.3.2 Expanded depth

The expanded depth of the underdeck portion of the hatch coaming is to be not less than 0,15 m.

3.3.3 Net thickness

The net thickness of the hatch coaming is to be maintained over the length of the hold and is to be determined according to Table 8.10.

3.3.4 Stiffening

The coaming boundaries are to be fitted 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 hatch coaming longitudinals are to have at least the following characteristics:

- Net cross sectional area [cm^2] without attached plating:

  Upper stiffener: $A = 2{,}5 \cdot h_C \cdot t$

  Additional stiffener: $A = 2{,}5 \cdot h_{AS} \cdot t$

- Radius of gyration [cm] with attached plating:

$$i = 0{,}74 \cdot \ell \cdot \sqrt{\sigma_1}$$

$$\text{if} \quad i/\ell > 0{,}76/k^{0{,}5}$$

$$i = \frac{7{,}79 \cdot k^{0{,}5} \cdot \ell}{\sqrt{210 - \sigma_1}}$$

t = Hatch coaming net thickness [mm] determined according to 3.3.3

h_C = Hatch coaming height [m]

h_{AS} = Distance of the additional stiffener from the deck [m]

ℓ = Span of hatch coaming stiffener [m]

i = Radius of gyration [cm]

$$i = \sqrt{\frac{I_e}{A_e}}$$

I_e = Net moment of inertia [cm^4] of the stiffener with attached plating

A_e = Net cross sectional area [cm^2] of the stiffener with attached plating

σ_1 = Compression hull girder normal stres [N/mm^2]

The upper strake of the hatch coaming (above the upper stiffener) is to be reinforced in way of the stiffening member where its height [m] exceeds $8 \cdot 10^{-3} \cdot t$, t being the hatch coaming net thickness defined in 3.3.3.

Other cases may be accepted on the basis of buckling strength check (direct calculation).

3.3.5 Stays

The coaming boundaries are to be stiffened with stays, the ends of which are to be connected to the deck and to the stiffeners mentioned in 3.3.4 .

These stays are to be fitted with a spacing of maximum 3 m. In any case, they are to be fitted in way of web frames and bulkheads. They may be:

- Sections of net moment of inertia (I_{eS}) with attached plating [cm^4], in compliance with the following formula:

$$I_{eS} = 13 \cdot \left(\frac{h_c}{\ell}\right)^3 \cdot I_e$$

I_e = Net moment of inertia [cm^4], of the upper hatch coaming longitudinal stiffener with attached plating

ℓ = Span of hatch coaming longitudinal stiffener [m]

- or brackets with thickness $t = 6 + 0{,}2.t_0$, (where t0 is the hatch coaming thickness) and with a flanged edge having a width equal to 10 times the bracket thickness.

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.

3.4 Transverse strength of topside structure

3.4.1 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 3.1, 3.2 and 3.3.

The distributed transverse load [kN/m] acting on the topside structure is to be taken not less than:

$$q = 0{,}25 \cdot (1{,}2 \cdot k_0 \cdot p_1 \cdot \ell_0 + \lambda_t \cdot p_2 \cdot B)$$

$$\ell_0 = T - H_F + 0{,}6 \cdot n$$

$$k_0 = 1 + (\ell - \ell_0) / \ell_0$$

ℓ = Side frame span [m]

H_F = Floor height in way of the side frame [m]

p_1 = Side frame design load [kN/m^2]

= $4{,}9.\ \ell_0$

p_2 = Floor design load [kN/m^2]

= $p_{\gamma E}$

see B.2.

λ_t = Coefficient given by the Formula:

$$= 0{,}1 \cdot \left(0{,}8 - \frac{\ell_2}{B_2}\right), \quad \lambda_t \geq 0$$

in the case of combination framing system

= 0

The actual section modulus of the topside structure [cm^3] may be determined by means of the following formula:

$$w = A \cdot b + \frac{t \cdot b^2}{60} \cdot \left(1 + \frac{A_a - A}{A_a + 0{,}05 \cdot t \cdot b}\right)$$

t = Thickness of stringer plate [mm]

b = Width of stringer plate [cm]

A = MIN (A_1 ; A_2)

A_a = MAX (A_1 ; A_2)

A_1 = Sheerstrake sectional area [cm^2] including a part of the shell plating extending on 0,15.D

A_2 = Hatch coaming sectional area [cm^2] including longitudinal stiffeners. The width [m] of the hatch coaming to be considered is:

$h = h_1 + \text{MIN}\ (0{,}75.h_c\ ;\ 1)$

h_1 = Expanded depth of the underdeck portion of the hatch coaming [m] defined in 3.3.2.

3.4.2 Unsupported stringer plate length

The unsupported stringer plate length D_1 [m] is to be taken as the distance between transverse efficient supports (transverse bulkheads, transverse partial bulkheads, reinforced rings).

3.4.3 Topside structure strength check

The minimum required net section modulus [cm^3] of the topside structure is to be obtained using the formula:

$$Z_{TS} = \frac{83{,}3}{k_1 \cdot (197 - \sigma_1)} \cdot q \cdot D_1^2$$

D_1 = Length not to be taken greater than 33,3 m

k_1 = Coefficient

$$= 1 + 0{,}25 \cdot \left(\frac{D_1}{s} - 1\right) \cdot \frac{w}{100 \cdot D}$$

w = Side frame net section modulus [cm^3]

3.4.4 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:

$$w = \frac{125}{214 - \sigma_A} \cdot p \cdot D_1 \cdot \ell_1^2$$

p = Deck design load [kN/m^2] to be defined by the designer. In any case p is not to be taken less than the value derived from formula given under Section 6, C.4.2

σ_A = Deck box beam axial stress [N/mm^2]:

$$\sigma_A = \frac{10 \cdot q \cdot D_1}{A}$$

A = Deck box beam sectional area [cm^2] to be determined in compliance with 10.2.2, where

$P_S = q \cdot D_1$

ℓ_1 = Span of strong box beam [m]

4. Open deck - double hull vessels

4.1 Stringer plate

4.1.1 Width

The stringer plate is to extend between the side shell plating and the hatch coaming. In principle, its width b [m] is not to be less than 0,6 m, unless other wise justified.

4.1.2 Stringer plate net thickness

The stringer plate is to have a net thickness [mm] not less than the values obtained from Table 8.11.

4.1.3 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.

Table 8.10 Hatch coaming plate net thickness [mm]

α ≥ 1	α < 1
t = MAX(t_i) $t_1 = 1{,}6 + 0{,}04 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$	t = MAX(t_i) $t_1 = 1{,}6 + 0{,}04 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
$t_2 = t_0$	$t_2 = t_0$
$t_3 = 26{,}8 \cdot s \cdot \sqrt{\frac{(1{,}1+\psi) \cdot M_S}{Z_H}}$ if $t_3/s > 8{,}65 \cdot [(1{,}1+\psi)/k]^{0,5} \cdot$ $t_3 = \frac{2{,}86 \cdot \sqrt{k \cdot (1{,}1+\psi)}}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_H}}}$ see **(1)**	$t_3 = 51 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{(1{,}1+\psi) \cdot M_S}{Z_H}}$ if $t_3/s > 16{,}5 \cdot [(1{,}1+\psi)/k]^{0,5} \cdot$ $t_3 = \frac{5{,}6 \cdot \sqrt{k \cdot (1{,}1+\psi)}}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_H}}}$ see **(1)**

t_0 = Stringer plate net thickness
k_2 = Coefficient
= $1 + \alpha^2$
α = b_4 / b_3
b_3 = Unsupported hatch coaming height [m]
b_4 = Unsupported hatch coaming width in x direction [m]
s = MIN (b_3 ; b_4)
Z_H = net hull girder section modulus in way of the hatch coaming mid-height [cm^3]
ψ = $\sigma_{1L} / \sigma_{1U}$
σ_{1L} = Compression stress [N/mm^2] on the lower edge of the hatch coaming panel
σ_{1U} = Compression stress [N/mm^2] on the upper edge of the hatch coaming panel.
(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

Table 8.11 Stringer plate net thickness [mm] - Double hull vessels

α ≥ 1	α < 1
t = MAX(t_i)	t = MAX(t_i)
$t_1 = 2 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$	$t_1 = 2 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
$t_2 = 39 \cdot s \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_2/s > 12{,}5/k^{0,5} \cdot$ $t_2 = \frac{4{,}1 \cdot k^{0,5} \cdot s}{\sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ see **(1)**	$t_2 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_2/s > 23{,}9 \cdot (k^{0,5} \cdot k_2)$ $t_2 = \frac{7{,}76 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ see **(1)**

k_2 = Coefficient
= $1 + \alpha^2$
α = b_2 / b_1
b_1 = Unsupported stringer plate width in y direction [m]
b_2 = Unsupported stringer plate width in x direction [m]
s = MIN (b_1 ; b_2)
Z_D = Deck net hull girder section modulus [cm^3]
(1) *A lower value of thickness t_2 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

4.1.4 In vessels having range of navigation **I (1,2)** or **I (2),** TL may require transverse deck plating strips efficiently strengthened and joining the stringer plates of both sides to be fitted.

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.

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 [mm] obtained from the following formula:

$$t = 3{,}6 + 0{,}11 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$$

Where a doubling plate is provided instead of an inserted side strake, its thickness [mm] is not to be less than:

$$t = 2{,}6 + 0{,}076 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$$

4.2.3 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 relation:

$$0{,}08 \cdot H \le b \le 0{,}15 \cdot H$$

4.3 Hatch coaming

4.3.1 Height

The height of the hatch coaming above the deck [m] is not to be less than the value obtained from the following formula, where b is the stringer plate width defined in 4.1.1:

$$h_C = 0{,}75 \cdot b$$

Furthermore, the height of the hatch coaming above the deck is to comply with the following relation:

$$H + h_C > T + n / 1{,}7 + 0{,}15$$

4.3.2 Extension of hatch coaming under the deck

The hatch coaming thickness is to be maintained to a depth under the deck not less than 0,25.b.

4.3.3 Net thickness

The thickness of the hatch coaming is to be maintained over the length of the hold and is to be determined in compliance with 3.3.3.

4.3.4 Stiffening

The coaming boundaries are to be stiffened with an horizontal stiffening member whose scantlings and arrangements are to be in compliance with 3.3.4.

4.3.5 Stays

The coaming boundaries are to be stiffened with stays, the ends of which are to be connected to the deck and to the stiffeners mentioned in 4.3.4.

The scantlings and arrangements of stays are to be in compliance with 3.3.5.

5. Flush deck

5.1 General

In principle, 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.

5.2 Stringer plate

5.2.1 Net thickness

The stringer plate net thickness [mm] is not to be less than that of the adjacent deck plating nor than the value derived from the following formula:

$$t = 2 + 0{,}032 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$$

5.2.2 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.

5.2.3 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.

5.2.4 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.

5.3 Deck plating

5.3.1 The deck plating net thickness [mm] is to be obtained from Table 8.12.

5.3.2 Deck plating subjected to lateral pressure in testing conditions

Deck plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

5.4 Sheerstrake

5.4.1 General

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

5.4.2 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 [mm] obtained from following formula:

$$t = 3{,}6 + 0{,}11 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$$

Where a doubling plate is provided instead of an inserted side strake, its thickness [mm] is not to be less than:

$$t = 2{,}6 + 0{,}076 . L . k^{0,5} + 3{,}6 . s$$

5.4.3 Rounded sheerstrake

In the case of a rounded sheerstrake connecting the side shell to the deck, the radius of curvature of the strake [mm] is not to be less than 5 times its thickness.

5.4.4 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:

$$0{,}08 \cdot H \le b \le 0{,}15 \cdot H$$

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.

5.5 Coamings 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 relation:

$$H + h_C > T + n / 1{,}7 + 0{,}15$$

5.5.2 Net thickness

The net thickness of the coaming boundaries is not to be less than:

$$t = 0{,}25 \cdot a + 3 \le 5 \text{ mm},$$

a being the greater dimension of the hatchway [m].

TL reserves the right to increase the scantlings required herebefore where range of navigation **I (1,2)** or **I (2)** is assigned, or to reduce them where range of navigation **I (0)** is assigned.

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.

The upper strake of the hatch coaming (above the upper stiffener) is to be reinforced in way of the stiffening member where its height [m] exceeds $8.10^{-3}.t$, t being the hatch coaming net thickness defined in 5.5.2.

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. Trunk deck

6.1 Plating net thickness

6.1.1 The trunk sheerstrake, stringer and longitudinal bulkhead plating are to be of the same thickness. That thickness [mm] is not to be less than that of the side shell plating nor than that obtained from following formulae:

- transverse framing:

$$t_1 = 0,2 + 0,04 \cdot L \cdot k^{0,5} + 3,6 \cdot s$$

- longitudinal framing:

$$t_2 = t_1 - 0,5$$

6.1.2 Where the sheerstrake has a thickness greater than that of the adjacent side shell plating, it is to extend to a height at least equal to 25 times its thickness, as measured from the deckline.

6.1.3 The trunk deck plating is to be not less than that obtained from 5.3.

6.1.4 Where the trunk is transversely framed, the thickness of the longitudinal bulkhead of the trunk is to be maintained on the trunk top over a width equal to 25 times its thickness.

7. Deck supporting structure

7.1 General

The deck supporting structure consists of ordinary stiffeners (beams or longitudinals), longitudinally or transversely arranged, supported by primary supporting members which may be sustained by pillars.

7.2 Minimum net thickness of web plating

7.2.1 Deck ordinary stiffeners

The net thickness [mm] of the web plating of ordinary stiffeners is not to be less than:

$$t = 1,63 + 0,004 \cdot L \cdot k^{0,5} + 4,5 \cdot s \qquad \text{for } L < 120 \text{ m}$$

$$= 3,9 \cdot k^{0,5} + s \qquad \text{for } L \geq 120 \text{ m}$$

7.2.2 Deck primary supporting members

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 3,8 + 0,016 \cdot L \cdot k^{0,5}$$

7.3 Net scantlings in service conditions

7.3.1 The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of deck structural members in service conditions are to be obtained from Table 8.13.

7.4 Net scantlings in testing conditions

7.4.1 The net section modulus w [cm^3] and the net shear sectional area Ash [cm^2] of deck structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

7.5 Buckling check

Deck structural members are to comply with the requirements stated under Section 5, C.

8. Transversally Framed Deck

8.1 Deck beams

8.1.1 General

In general, deck beams or deck half-beams are to be fitted at each frame.

8.1.2 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. 8.9.

8.2 Deck girders

8.2.1 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.

8.2.2 Deck girders subjected to concentrated loads are to be adequately strengthened.

8.2.3 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

8.2.4 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.

8.2.5 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.

9. Longitudinally framed deck

9.1 Deck longitudinals

9.1.1 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 %.

9.1.2 Frame brackets, in vessels with transversely framed sides, are generally to have their horizontal arm extended to the adjacent longitudinal ordinary stiffener.

9.2 Deck transverses

9.2.1 Where applicable, deck transverses of reinforced scantlings are to be aligned with floors.

9.2.2 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.

Table 8.12 Deck plating net thickness [mm]

Transverse framing	Longitudinal framing
t = MAX(t_i) $t_1 = 0{,}9 + 0{,}034 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_3/s > 23{,}9 \cdot (k^{0,5} \cdot k_2)$ $t_3 = \frac{7{,}76 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ see **(1)**	t = MAX(t_i) $t_1 = 0{,}57 + 0{,}031 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$ $t_2 = 39 \cdot s \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_2/s > 12{,}5/k^{0,5}$. $t_2 = \frac{4{,}1 \cdot k^{0,5} \cdot s}{\sqrt{0{,}21 - \frac{M_S}{Z_D}}}$ see **(1)**

k_2 = coefficient
= $1 + \alpha^2$
α = b_2 / b_1
b_1 = Unsupported deck width in y direction[m]
b_2 = Unsupported deck width in x direction [m]
Z_D = Deck net hull girder section modulus [cm^3]
p = Deck design load [kN/m^2] to be defined by the designer. In any case p is not to be taken less than the value derived from applicable formulae given under Section 6, C.4.2 and Section 6, C.5.

(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

Table 8.13 Net scantlings of deck supporting structure

Item	w	A_{sh}
Deck beams	$w = 0{,}58 . \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Vertical stiffeners on longitudinal trunk bulkheads **(1)**	$w = 0{,}58 \cdot \lambda_b \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \lambda_b \cdot \beta_s . \eta \cdot p \cdot s \cdot \ell$
Deck longitudinals	$w = \frac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck transverses	$w = 0{,}58 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Web frames on longitudinal trunk bulkheads **(2)**	$w = 0{,}58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \lambda_b \cdot \beta_s . p \cdot S \cdot \ell$
Deck girders	$w = \frac{1000}{m \cdot (214 - \sigma_1)} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Deck design load [kN/m^2] to be defined by the designer. In any case p is not to be taken less than the value derived from applicable formulae given under Section 6, C.5.2 and Section 6, C.6.
m = Boundary coefficient
= 12,0 in general, for stiffeners considered as clamped
= 8,0 for stiffeners considered as simply supported
= 10,6 for stiffeners clamped at one end and simply supported at the other

(1) *Scantlings of vertical stiffeners on longitudinal trunk bulkheads are not to be less than those of deck beams connected to them.*

(2) *Scantlings of web frames on longitudinal trunk bulkheads are not to be less than those of deck transverses connected to them.*

10. Pillars

10.1 General

10.1.1 Pillars or other supporting structures are generally to be fitted under heavy concentrated loads.

10.1.2 Structural members at heads and heels of pillars as well as substructures are to be constructed according to the forces they are subjected to. The connection is to be so dimensioned that at least 1 cm^2 cross sectional area is available for 10 kN of load.

Where pillars are affected by tension loads doublings are not permitted.

10.1.3 Pillars in tanks are to be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

10.1.4 Pillars are to be fitted, as far as practicable, in the same vertical line.

10.1.5 The wall thickness [mm] of tubular pillars which may be expected to be damaged during loading and unloading operations is not to be less than:

$t = 4{,}5 + 0{,}15 \cdot d_a$ for $d_a \leq 30$ cm

$t = 0{,}3 \cdot d_a$ for $d_a > 30$ cm

where d_a is defined in 10.2.1.

10.2 Scantlings

10.2.1 Definitions

p = Deck load [kN/m^2]

P_S = Pillar load [kN]:

= $p.A + P_i$

A = Load area for one pillar [m^2]

P_i = Load from pillars located above the pillar considered [kN]

λ_S = Degree of slenderness of the pillar

= ℓ_S / i_S

ℓ_S = Length of the pillar [cm]

i_S = Radius of gyration of the pillar [cm]:

$$i_S = \sqrt{\frac{I_S}{A_S}}$$

- for solid pillars of circular cross section:

$i_S = 0{,}25 \cdot d_S$

- for tubular pillars:

$$i_S = 0{,}25 \cdot \sqrt{d_a^2 + d_i^2}$$

I_S = Moment of inertia of the pillar [cm^4]

A_S = Sectional area of the pillar [cm^2]

d_S = Pillar diameter [cm]

d_a = Outside diameter of pillar [cm]

d_i = Inside diameter of pillar [cm].

10.2.2 The sectional area [cm^2] of pillars is not to be less than:

$$A = 10 \cdot \frac{P_S}{\sigma_P}$$

σ_P = Permissible compressive stress according to Table 8.14.

Table 8.14 Permissible compressive stres

Degree of slenderness λ_S	Permissible compressive stress σ_P [N/mm^2]	
	Pillars within accommodation	Elsewhere
≤ 100	$140 - 0{,}0067 \cdot \lambda_S^2$	$117 - 0{,}0056 \cdot \lambda_S^2$
> 100	$7{,}3 \cdot 10^5 \cdot \lambda_S^{-2}$	$6{,}1 \cdot 10^5 \cdot \lambda_S^{-2}$

10.2.3 Where pillars support eccentric loads, they are to be strengthened for the additional bending moment.

10.3 Connections

10.3.1 Pillars are to be attached at their heads and heels by continuous welding.

10.3.2 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.

10.3.3 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.

10.3.4 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.

10.3.5 Manholes and lightening holes may not be cut in the girders and floors below the heels of pillars.

11. Bulkheads supporting beams

11.1 Scantlings

Partial or complete bulkheads may be substituted to pillars.

The scantlings of the vertical stiffeners of the bulkheads are to be such as to allow these stiffeners to offer the same compression and buckling strengths as a pillar, taking account of a strip of attached bulkhead plating, whose width is to be determined according to Section 5, C.3.3.

Where a bulkhead supporting beams is part of the watertight subdivision of the vessel or bounds a tank intended to contain liquids, its vertical stiffeners are to be fitted with head and heel brackets and their scantlings are to be increased to the satisfaction of **TL**, taking account of the additional hydrostatic pressure.

12. Hatch supporting structures

12.1 General

12.1.1 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.

12.1.2 Clear of openings, adequate continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

12.1.3 The details of connection of deck transverses to longitudinal girders and web frames are to be submitted to **TL**.

E. Bulkhead Scantlings

1. Symbols

L = Rule length [m], defined in Section 4, A.1.

B = Breadth [m], defined in Section 4, A.1.

H = Depth [m], defined in Section 4, A.1.

T = Draught [m], defined in Section 4, A.1.

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

l = Span [m] of ordinary stiffeners or primary supporting members

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

λ_b, λ_s = Coefficients for vertical structural members defined in Section 5, B.5.6.3

η = $1 - s / (2 . \ell)$

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5 A.3.2.

2. General

2.1 Application

2.1.1 The following requirements apply to transverse or longitudinal bulkhead structures which may be plane or corrugated.

In addition to the following rules bulkheads are to comply with specific requirements stated under the Additional Requirements for Notations.

2.1.2 Bulkheads may be horizontally or vertically stiffened.
Horizontally framed bulkheads consist of horizontal ordinary stiffeners supported by vertical primary supporting members.
Vertically framed bulkheads consist of vertical ordinary stiffeners which may be supported by horizontal girders.

3. Scantlings

3.1 Bulkhead plating

3.1.1 Minimum net thickness

The minimum bulkhead plating thickness [mm] is to be obtained from Table 8.15.

3.1.2 Strength check of bulkhead plating in service conditions

The bulkhead plating net thickness [mm] in service conditions is to be obtained from Table 8.16.

3.1.3 Strength check of bulkhead plating in testing conditions

Bulkhead plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

Table 8.15 Minimum bulkhead plate thickness

Plating	t [mm]
Watertight bulkheads	$t = 0{,}026 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
Cargo hold bulkhead	$t = 2{,}2 + 0{,}013 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
Tank and wash bulkhead	$t = 2{,}2 + 0{,}013 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$

Table 8.16 Bulkhead plating thickness

Plating	t [mm]
- Watertight bulkhead - Hold bulkhead - Tank bulkhead	$t = s.(k \cdot p)^{0,5}$
Collision bulkhead	$t = 1{,}1.s \cdot (k \cdot p)^{0,5}$
p = p_{WB}, p_B or p_C bulkhead plating design load [kN/m^2] defined in Section 6, C.5. and C.6.	

3.1.4 Buckling check

Bulkhead plating is to comply with requirements stated under Section 5, C.

3.2 Bulkhead ordinary stiffeners

3.2.1 Minimum net thickness of web plating

The net thickness of the web plating of ordinary stiffeners is not to be less than:

$$t = 1{,}1 + 0{,}0048 \cdot L \cdot k^{0,5} + 4{,}8 \cdot s$$

3.2.2 Net scantlings of bulkhead ordinary stiffeners in service conditions

The net section modulus w [cm3] of bulkhead ordinary stiffeners in service conditions is to be obtained from Table 8.17.

The minimum net shear sectional area A_{sh} [cm^2] of the stiffener is not to be less than the value given by the formulae in Table 8.17.

3.2.3 Net scantlings of bulkhead ordinary stiffeners in testing conditions

The net section modulus [cm^3] and the net shear sectional area [cm^2] of bulkhead ordinary stiffeners being part of compartments or structures containing liquid is to comply with Section 5, D.

3.2.4 Buckling check

Ordinary stiffeners of bulkheads are to comply with the requirements stated under Section 5. C.

3.3 Net scantlings of bulkhead primary supporting members

3.3.1 Minimum net thickness of web plating

The net thickness [mm] of the web plating of bulkhead primary supporting members is to be not less than:

- in general: $t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$

- for collision bulkhead: $t = 4{,}4 + 0{,}018 \cdot L \cdot k^{0,5}$

3.3.2 Net scantlings of bulkhead primary supporting members in service conditions

The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of bulkhead primary supporting members in service conditions are to be obtained from Table 8.18.

3.3.3 Net scantlings of bulkhead ordinary stiffeners in testing conditions

The net section modulus [cm^3] and the net shear sectional area [cm^2] of bulkhead primary supporting members being part of compartments or structures containing liquid is to comply with Section 5, D.

3.3.4 Buckling check

Bulkhead primary supporting members are to comply with the requirements stated under Section 5, C.

4. Watertight bulkheads

4.1 Number of watertight bulkheads

4.1.1 General

All vessels, in addition to complying with the requirementsof 4.1.2, are to have at least the following transverse watertight bulkheads:

- a collision bulkhead, arranged in compliance with 5.

- an after peak bulkhead, arranged in compliance with 6.

- two bulkheads, complying with 6. 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.

4.1.2 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 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.

4.2 General arrangement

4.2.1 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.

4.2.2 Accommodations, engine rooms and boiler rooms, and the workspaces forming part of these, shall be separated from the holds by watertight transverse bulkheads that extend up to the deck.

Table 8.17 Net scantlings of bulkhead ordinary stiffeners

Item	w	A_{sh}
Vertical stiffeners	$w = k_1 . \lambda_b \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = k_2 . \lambda_s \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Transverse stiffeners	$w = k_1 . \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = k_2 . \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Longitudinal stiffeners	$w = \dfrac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$

p = Bulkhead design load [kN/m²] defined in C.5.

k_1 = In general: $k_1 = 4{,}60$ / m
for collision bulkhead: $k_1 = 5{,}37$ / m

k_2 = In general: $k_2 = 0{,}045$
for collision bulkhead: $k_2 = 0{,}052$

m = Boundary coefficient for ordinary stiffeners
= 8,0 in the case of primary supporting members simply supported at both ends
= 10,6 in the case of primary supporting members simply supported at one end and clamped at the other
= 12,0 in the case of primary supporting members clamped at both ends.

Table 8.18 Net scantlings of bulkhead primary supporting members

Item	w	A_{sh}
Bulkhead web frames, bulkhead transverses	$w = k_1 . \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = k_2 . \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Stringers on transverse bulkheads	$w = k_1 . \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = k_2 . \beta_s \cdot p \cdot S \cdot \ell$
Stringers on longitudinal bulkheads	$w = \dfrac{125}{214 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p, k_1, k_2 = as defined in Table 8.17.

4.2.3 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.

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

4.2.5 The height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck.

Requirements in C.6.3 or C.7.3 are to be complied with too.

4.3 Height of transverse watertight bulkheads

4.3.1 Transverse watertight bulkheads other than the collision bulkhead and the after peak bulkhead are to extend up to the upper deck.

4.3.2 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.

4.4 Openings in watertight bulkheads

4.4.1 Certain openings below the main 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.

4.5 Watertight doors

4.5.1 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 **TL**.

4.5.2 The thickness of watertight doors is to be not less than that of the adjacent bulkhead plating, taking account of their actual spacing.

4.5.3 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.

4.5.4 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.

4.5.5 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.

4.6 Cofferdams

4.6.1 As a general rule, adequately ventilated cofferdams are to be provided between compartments intended for the carriage of different liquids where, on the basis of information supplied by the owner, there exists a risk of pollution of one product by another.

In particular, cofferdams are to be provided between fuel bunkers and fresh water tanks.

5. Collision bulkhead

5.1 Arrangement of collision bulkhead

5.1.1 The collision bulkhead is to be positioned aft of the fore perpendicular at a distance d_C [m] such that:

$$0{,}04 \cdot L_H \le d_C \le 0{,}04 \cdot L_H + 2$$

L_H = length of the vessel's hull [m], excluding rudder and bowsprit

5.1.2 **TL** may, on a case-by-case basis, accept a greater distance from the collision bulkhead to the forward perpendicular to that specified in 5.1.1, on basis of calculations which show that the buoyancy of the fully loaded vessel is ensured and the residual safety clearance is at least 100 mm when the compartment ahead of the collision bulkhead is flooded.

5.1.3 **TL** may, on a case-by-case basis, accept a reduction of the distance in 5.1.1 up to at least 0,03 L_H, on the basis of calculations which show that the buoyancy of the fully loaded vessel is ensured and the residual safety clearance is at least 100 mm when the compartment ahead of and behind the collision bulkhead is flooded.

5.1.4 The increase/reduction of distances according to 5.1.2 and 5.1.3 is subject to approval to be granted by the competent authority.

5.1.5 The collision bulkhead is to extend to the uppermost deck in the fore part of the vessel.

5.2 Openings in the collision bulkhead

5.2.1 General

Openings may not be cut in the collision bulkhead below the main deck.

The number of openings in the collision bulkhead above the main 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.

5.2.2 Doors and manholes

No doors or manholes are permitted in the collision bulkhead below the bulkhead deck.

5.2.3 Passage of piping

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 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.

6. After peak, machinery space bulkheads and stern tubes

6.1 Extension

These bulkheads are to extend to the uppermost continuous deck.

6.2 Stern tubes

The after peak bulkhead is to enclose the stern tube and the rudder trunk in a watertight compartment. Other measures to minimize the danger of water penetrating into the vessel in case of damage to stern tube arrangements may be taken at the discretion of TL.

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

7. Tank bulkheads

7.1 Number and arrangement of tank bulkheads

7.1.1 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.

7.1.2 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 2.B/3.

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.

8. Tanks

8.1 Arrangements

8.1.1 Liquid fuel or lubrication oil shall be carried in oiltight tanks which shall either form part of the hull or shall be solidly connected with the vessel's hull.

8.1.2 Fuel oil, lubrication oil and hydraulic 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 **TL**.

8.1.3 Where a cargo space is adjacent to a fuel bunker which is provided with a heating system, the fuel bunker boundaries are to be adequately heat insulated.

8.1.4 Arrangements are to be made to restrict leaks through the bulkheads of liquid fuel tanks adjacent to the cargo space.

8.1.5 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.

8.1.6 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.

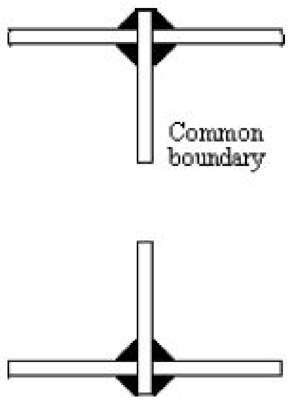
8.1.7 Fuel tanks formed by the vessel's hull shall not have a common wall with cargo tanks, lubricating oil tanks, fresh water tanks or drinking water tanks.

Upon special approval on small vessels the arrangement of cofferdams between fuel oil and lubricating oil tanks may be dispensed with provided that the common boundary is continuous, i.e. it does not abut at the adjacent tank boundaries, see Fig. 8.9.

8.1.8 Fuel tanks or lubrication oil tanks which are in normal service under static pressure of the liquid shall not have any common surfaces with passenger areas and accommodations.

8.1.9 Fuel tanks, lubrication oil and hydraulic oil tanks shall not be located forward of the collision bulkhead.

8.2 Scantlings



Scantlings of fuel tanks are to be in compliance with 2.

Fig. 8.9 Continuous common boundary

9. Plane bulkheads

9.1 General

9.1.1 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.

9.1.2 Bulkheads are generally stiffened in way of deck girders.

9.1.3 The stiffener webs of side tank watertight bulkheads are generally to be aligned with the webs of inner hull longitudinal stiffeners.

9.1.4 Floors are to be fitted in the double bottom in way of plane transverse bulkheads.

9.1.5 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.

9.2 Bulkhead stiffeners

9.2.1 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.

9.2.2 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.

9.3 End connections

9.3.1 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.

9.3.2 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 Section 5, B.4.6.3

10. Corrugated bulkheads

10.1 General

10.1.1 The main dimensions a, b, c and d of corrugated bulkheads are defined in Fig. 8.10.

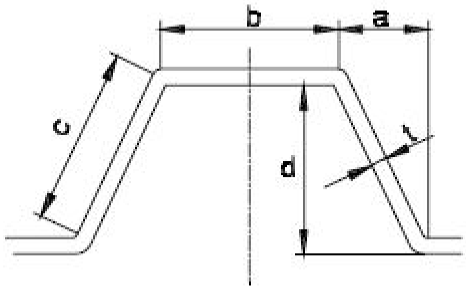


Fig. 8.10 Corrugated bulkhead

10.1.2 Unless otherwise specified, the following requirement is to be complied with:

$a \leq d$

Moreover, in some cases, **TL** may prescribe an upper limit for the ratio b / t.

10.1.3 In general, the bending internal radius R_i is to be not less than the following values [mm]:

- for normal strength steel:

$R_i = 2{,}5\ t$

- for high tensile steel:

$R_i = 3{,}0\ t$

where t is the thickness [mm] of the corrugated plate.

10.1.4 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 **TL** for approval, as a function of the importance of the structural element.

10.1.5 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.

10.1.6 In general, where girders or vertical primary supporting members are fitted on corrugated bulkheads, they are to be arranged symmetrically.

10.2 Bulkhead scantlings

10.2.1 Bulkhead plating

The bulkhead plating net thickness is to be determined as specified in 3.1, substituting the stiffener spacing by the greater of the two values b and c [m] as per 10.1.1.

10.2.2 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 [cm^3] from following formula:

$$w = \frac{t \cdot d}{6} \cdot (3 \cdot b + c) \cdot 10^{-3}$$

t = Net thickness of the plating of the corrugation [mm]

d, b, c = Dimensions of the corrugation [mm] shown in Fig. 8.10

Moreover, where the ratio b / t ≥ 46, the net section modulus required for a bulkhead is to be in accordance with the following formula, where the coefficient ck is defined in Table 8.19.

$$w = c_k \cdot (b + a) \cdot p \cdot \left(\frac{\ell \cdot b}{80 \cdot t}\right)^2 \cdot 10^{-3}$$

10.2.3 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.

Table 8.19 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

10.3 Structural arrangement

10.3.1 The strength continuity of corrugated bulkheads is to be ensured at ends of corrugations.

10.3.2 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.

10.3.3 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 **TL**.

10.3.4 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.

10.3.5 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 **TL**.

10.3.6 In general, the upper and lower parts of horizontally corrugated bulkheads are to be flat over a depth equal to 0,1 . D.

10.4 Bulkhead stool

10.4.1 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.

10.4.2 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.

10.4.3 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.

11. Hold bulkheads of open deck vessels

11.1 Special arrangements

11.1.1 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.

11.1.2 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.

11.1.3 The upper part of horizontally framed bulkheads are to be subject to a special review by **TL**.

12. Non-tight bulkheads

12.1 Definition

A bulkhead is considered to be acting as a pillar when besides the lateral loads, axial loads are added.

12.2 Non-tight bulkheads not acting as pillars

12.2.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

12.3 Non-tight bulkheads acting as pillars

12.3.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- two frame spacings, when the frame spacing does not exceed 0,75 m,
- one frame spacing, when the frame spacing is greater than 0,75 m.

12.3.2 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 D.9., the load supported being determined in accordance with the same requirements.

12.3.3 In the case of non-tight bulkheads supporting longitudinally framed decks, web frames are to be provided in way of deck transverses.

13. Wash bulkheads

13.1 General

13.1.1 The requirements in 12.2 apply to transverse and longitudinal wash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

13.2 Openings

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

In the upper, central and lower portions of the bulkhead (the depth of each portion being 1/3 of the bulkhead height), the areas of openings, expressed as percentages of the corresponding areas of these portions, are to be within the limits given in Table 8.20.

13.2.2 In any case, the distribution of openings is to fulfill the strength requirements specified in 12.3.

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

Table 8.20 Areas of openings in transverse wash bulkheads

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

F. Vessels less than 40 m in Length

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

η = 1 − s / (2 . ℓ)

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

2. General

2.1 Application

2.1.1 As an alternative to requirements of B. to D., the following contains the prescriptions for the determination of the minimum hull scantlings applicable to the central part of all types of single hull inland waterway vessels less than 40 m in length, of normal design and dimensions.

Cargo carriers covered by these requirements have their machinery aft and are assumed to be loaded and unloaded in two runs.

2.1.2 Arrangement and scantlings not covered in the following are to be as specified in B. to E.

2.2 Definition

In the following requirements, the coefficient K_{MZ} to be used for the scantling of small vessels is to be derived from the formula:

$$K_{MZ} = \sqrt{\frac{K_M}{K_Z}}$$

where the coefficients K_M and K_Z are given in Table 8.21 and Table 8.22.

3. Bottom scantlings

3.1 Bottom and bilge plating

3.1.1 The bottom plating net thickness [mm] is not to be less than the values derived from Table 8.23.

3.1.2 The bilge plating scantling is to comply with B.3.1.2 or B.3.1.3, as applicable.

Table 8.21 Values of coefficient K_M

Range of navigation	Vessel type	K_M		
		Bottom plating	Top plating	Stiffeners
I (0)	All	1,0	1,0	1,0
I (0,6)	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
I (1,2) to I (2)	Self-propelled cargo carriers and passenger vessels	$0,83 + 0,98 \cdot n$	$0,88 + 0,69 \cdot n$	$0,83 + 0,98 \cdot n$
	Non-propelled cargo carriers	$0,385 + 2,08 \cdot n$	$0,75 + 0,75 \cdot n$	$0,385 + 2,08 \cdot n$
	Other vessels	$1 + n$	$1 + 2,1\ n$	$1 + 2,1\ n$

Table 8.22 Values of coefficient K_Z

Range of navigation	K_Z	Range of navigation	K_Z
I (0)	1,0	**I (1,2) to I (2)**	$1 + 0,158 \cdot n$
I (0,6)			

Table 8.23 Bottom plating net thickness [mm]

Transverse framing	Longitudinal framing
$t = \text{MAX}\ (t_i)$	$t = \text{MAX}\ (t_i)$
$t_1 = 1,85 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$	$t_1 = 1,1 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$
$t_2 = 1,6 \cdot s \cdot (k \cdot p)^{0,5}$	$t_2 = 1,2\ s \cdot (k \cdot p)^{0,5}$
$t_3 = 1,5 \cdot s \cdot K_{MZ} \cdot (k \cdot L)^{0,5}$	$t_3 = 0,86 \cdot s \cdot K_{MZ} \cdot (k \cdot L)^{0,5}$
p = Design load [kN/m²] = $9,81 \cdot (T + 0,6 \cdot n)$	

3.1.3 Strength check of bottom plating in testing conditions

Bottom plating of compartments or structures to be checked in testing conditions is to comply with Section5, D.

3.2 Bottom structure

3.2.1 Minimum net thickness of web plating

The net thickness [mm] of the web plating of ordinary stiffeners is to be not less than:

$$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$$

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$$

3.2.2 Net scantlings of bottom structural members in service conditions

The net scantlings of bottom structural members in service conditions are to be obtained from Table 8.24.

3.2.3 Net scantlings of bottom structural members in testing conditions

The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of bottom structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

4. Side scantlings

4.1 Side plating

4.1.1 The side plating net thickness [mm] is not to be less than the values given in Table 8.25.

4.1.2 Strength check of side plating in testing conditions

The side plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

4.2 Side structure

4.2.1 Minimum net thickness of web plating

The net thickness of the web plating of ordinary stiffeners is to be not less than:

$$= 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$$

The thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the formula:

$$= 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$$

4.2.2 Net scantlings of side structural members in service conditions

The net scantlings of side structural members in service conditions are to be obtained from Table 8.26.

4.2.3 Net scantlings of side structural members in testing conditions

The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of side structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

5. Deck scantlings

5.1 Open deck vessels

5.1.1 General

The arrangement and stiffening of the topside structure are to be as specified in D.2.

5.1.2 Topside structure scantlings

The topside structure scantlings are to be derived from Table 8.27.

5.2 Flush deck and trunk deck

5.2.1 General

Scantlings of the topside strakes are to comply with D.5. and D.6.

Table 8.24 Net scantlings of bottom structure

Item	w [cm^3]	A_{sh} [cm^2]
Bottom longitudinals	$w = \dfrac{0{,}4 \cdot \beta_b \cdot \eta \cdot p_E \cdot s \cdot \ell^2}{1 - 0{,}18 \cdot K_{MZ}}$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p_E \cdot s \cdot \ell$
Floors **(1) (2)**	$w = 0{,}58 \cdot \beta_b \cdot p \cdot s \cdot B^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot s \cdot B$
Bottom transverses **(2)**	$w = 0{,}58 \cdot \beta_b \cdot p \cdot S \cdot B^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot S \cdot B$
Bottom centre and side girders **(3)**	$w = 0{,}63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2 \geq w_0$	$A_{sh} = 0{,}056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p_E = Design load of bottom longitudinals [kN/m^2] defined in Section 6, C.5.1

p = Design load [kN/m^2] of bottom primary supporting members

= $9{,}81 \cdot (\gamma \cdot T + 0{,}6 \cdot n)$

γ = 0,575 for cargo carriers

= 1,0 for other vessels

w_0 = Section modulus of floors or bottom transverses

(1) *In way of side ordinary frames: $\beta_b = \beta_S = 1$*

(2) *Scantlings of floors and bottom transverses have to be adequate to those of web frames or side transverses connected to them.*

(3) *The span ℓ is to be taken equal to the web frame spacing.*

Table 8.25 Side plating net thickness [mm]

Transverse framing	Longitudinal framing
$t = \mathrm{MAX}(t_i)$	$t = \mathrm{MAX}(t_i)$
$t_1 = 1{,}68 + 0{,}025 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$	$t_1 = 1{,}25 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
$t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$	$t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$
$t_3 = k_1 \cdot t_0$	$t_3 = k_1 \cdot t_0$

p = Design load [kN/m^2]

= $9{,}81 \cdot (T + 0{,}6 \cdot n)$

t_0 = t_{bottom}

k_1 = 0,85 if transversely framed bottom

= 0,90 if longitudinally framed bottom.

Table 8.26 Net scantlings of side structure

Primary supporting members	w [cm^3]	A_{sh} [cm^2]
Side frames	$w = 0{,}58 \cdot s \cdot \beta_b \cdot \eta \cdot (1{,}2 \cdot k_0 \cdot p \cdot \ell_0^2 + \lambda_t \cdot p_F \cdot B^2)$	$Ash = 0{,}08 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side longitudinals	$w = 0{,}40 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$Ash = 0{,}045 \cdot . \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side webs, side transverses **(1)**	$w = 1{,}96 \cdot \beta_b \cdot k_0 \;.\; p \cdot S \cdot \ell_0^2$	$Ash = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side stringers (2)	$w = 0{,}63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$Ash = 0{,}056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Design load of side structural members [kN/m^2]:
= $4{,}9 \cdot \ell_0$ for vertical stiffeners
= p_E for longitudinal stiffeners
where p_E is defined in Section 6, C.5.1

ℓ_0 = $T - H_F + 0{,}6 \cdot n$

H_F = Floor height or bottom transverse height [m]

p_F = Floor design load [kN/m^2] to be obtained from the following formula:
= $9{,}81 \;.\; (\gamma \cdot T + 0{,}6 \cdot n)$
$\gamma = 0{,}575$ for cargo carriers
$= 1{,}0$ for other vessels

k_0 = Coefficient given by the formula:
= $\ell + (\ell - \ell_0) / \ell_0$

λ_t = Coefficient

$$= 0{,}1 \cdot \left(0{,}8 - \frac{\ell^2}{B^2}\right), \lambda_t \geq 0$$

In combination framing: $\lambda_t = 0$

(1) *Scantlings of web frames and side transverses have to be adequate to 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 [m].*

Table 8.27 Topside structure net scantlings

Item	Thickness [mm]		Minimum width / Height [m]
	α ≥ 1	α < 1	
Stringer plate	$t = MAX(t_i)$ $t_1 = 2 + 0{,}02 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s_1$ $t_2 = 1{,}24 \cdot s_1 \cdot K_{MZ} \cdot (k \cdot L)^{0{,}5}$	$t = MAX(t_i)$ $t_1 = 2 + 0{,}02 \cdot L \cdot k^{0{,}5} + 3{,}6 \;.\; s_1$ $t_2 = 1{,}33 \cdot s_1 \cdot K_{MZ} \cdot (k \cdot L)^{0{,}5}$	$b = 0{,}1 \cdot B$
Sheerstrake	$t = 2{,}6 + 0{,}076 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s_2$		$b = 0{,}08 \cdot D$
Hatch coaming	$t = MAX(t_i)$ $t_1 = 1{,}6 + 0{,}04 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s_3$ $t_2 = (1+h/D) \cdot t_0$	$t = MAX(t_i)$ $t_1 = 1{,}6 + 0{,}04 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s_3$ $t_2 = (1+h/D) \cdot t_0$	See D.3.3.1

α = b_2 / b_1
s_1 = MIN (b_1; b_2)
b_1 = Unsupported stringer plate width in y direction [m]
b_2 = Unsupported stringer plate width in x direction [m]
s_2 = Side ordinary stiffener spacing [m]
s_3 = MIN (b_3; b_4)
b_3 = Unsupported hatch coaming height [m]
b_4 = Unsupported hatch coaming width in x direction [m]
t_0 = Stringer plate thickness [mm].
h = Actual hatch coaming height above the deck [m]

Table 8.28 Flush deck net scantlings [mm]

Transverse framing	Longitudinal framing
Deck plating: t = MAX (t_i) $t_1 = 0,9 + 0,034 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 1,33 \cdot s \cdot K_{MZ} \cdot (k \cdot L)^{0,5}$	Deck plating: t = MAX (t_i) $t_1 = 0,57 + 0,031 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,20 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 1,24 \cdot s \cdot K_{MZ} \cdot (k \cdot L)^{0,5}$
p = Deck design load [kN/m^2] to be defined by the designer. In any case p is not to be taken less than: = $3,75 \cdot (n + 0,8)$	

Table 8.29 Net scantlings of deck structure

Item	w [cm^3]	A_{sh} [cm^2]
Deck beams	$w = 0,58 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Vertical stiffeners on longitudinal trunk bulkheads **(1)**	$w = 0,58 \cdot \lambda_b . \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \lambda_S . \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck longitudinals	$w = \dfrac{0,4 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2}{1 - 0,18 \cdot K_{MZ}}$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck transverses	$w = 0,58 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Vertical primary supporting members on longitudinal trunk bulkheads **(1)**	$w = 0,58 \cdot \lambda_b . \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,045 \cdot \lambda_S . \beta_s \cdot p \cdot S \cdot \ell$
Deck girders	$w = 0,63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,056 \cdot \beta_s \cdot p \cdot S \cdot \ell$
p = Deck design load [kN/m^2] to be defined by the designer. In any case p is not to be taken less than: = 3,75.(n + 0,8) **(1)** *Scantlings of vertical structural members on longitudinal trunk bulkheads are not to be less than those of deck stiffeners connected to them.*		

5.2.2 The deck plating net thickness [mm] is to be obtained from Table 8.28.

Within the midship region, the sectional area [cm^2] of the deck structure in way of the hatchways, including the side and top of trunk, is not to be less than:

$$A = 6 \cdot B \cdot s \cdot K_{MZ} \cdot L^{0,5}$$

5.2.3 Deck plating subjected to lateral pressure in testing conditions

Deck plating of compartments or structures to be checked in testing conditions is to comply with Section 5, D.

5.3 Deck structure

5.3.1 Minimum net thickness of web plating

The net thickness [mm] of the web plating of ordinary stiffeners is to be not less than:

$$t = 1,63 + 0,004 \cdot L \cdot k^{0,5} + 4,5 \cdot s$$

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 3,8 + 0,016 \cdot L \cdot k^{0,5}$$

5.3.2 Net scantlings of deck structural members in service conditions

The net scantlings of deck structural members in service conditions are to be obtained from Table 8.29.

5.3.3 Net scantlings of deck structural members in testing conditions

The net section modulus w [cm^3] and the shear sectional area [cm^2] of deck structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

6. Subdivision

The arrangement and scantlings of bulkheads are to be as specified in E.

SECTION 9

HULL DESIGN and CONSTRUCTION - OTHER STRUCTURES

A. Fore Part

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Thickness [mm] of plating

p = Design load [kN/m^2] according to 2.6

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

η = 1 − s / (2 . ℓ)

w = Net section modulus, in [cm^3], of ordinary stiffeners or primary supporting members

Ash = Net web sectional area, in [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

m = Boundary coefficient, to be taken equal to:

= 12,0 in general, for stiffeners considered as clamped

= 8,0 for stiffeners considered as simply supported

= 10,6 for stiffeners clamped at one end and simply supported at the other

f = coefficient defined as follows:

= 1,0 in case of **I (1,2)** and **I (2)**

= 0,9 in case of **I (0,6)**

= 0,8 in case of **I (0)**

2. General

2.1 Application

2.1.1 The following requirements apply to all vessels for the scantling of the fore part structures as defined in Section 4, A.1.3.

As to the requirements which are not explicitly dealt with in the following, refer to the previous Chapters.

2.2 Net scantlings

2.2.1 As specified in Section 5, B.6., 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.

2.3 Resistance partial safety factors

2.3.1 The resistance partial safety factors to be considered for the checking of the fore part structures are as specified in Table 9.1.

Table 9.1 Resistance partial safety factors γ_R

Structures	Ordinary stiffeners	Primary supporting members
Fore peak structures	1,40	1,60
Structure located aft of the collision bulkhead	1,02	1,20

2.4 Material factor

2.4.1 When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor as follows:

- Thickness: see relevant requirements in the following paragraphs

- Section modulus:

  $w = k \cdot w_0$

- Sectional area:

  $A = k \cdot A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2.

2.5 Connections of the fore peak with structures located aft of the collision bulkhead

2.5.1 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.

2.6 Design loads

2.6.1 Pressure on sides and bottom

The design pressure [kN/m^2] on sides and bottom is to be derived from the following formulae:

p_E = 9,81 . (T − z + 0,6 . n) for z ≤ T

= MAX (5,9 . n; 3) + p_{WD} for z > T

p_{WD} = specific wind pressure [kN/m^2]

= 0,25 for **I (0)** and **I (0,6)**

= 0,4.n for **I (1,2)** to **I (2)**.

2.6.2 Pressure on exposed deck

The external pressure on exposed decks is to be defined by the designer and, in general, may not be taken less than:

$p = 3{,}75 \cdot (n + 0{,}8)$ [kN/m^2]

2.6.3 Pressure on tween deck

The external pressure on tween decks is to be defined by the designer and, in general, may not be taken less than:

$p = 4{,}0$ kN/m^2

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 the formulae in Table 9.2.

3.1.2 For bilge plating, see Section 8, B.3.

3.1.3 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 neither to be less than required in Table9.2 nor lower than those of the corresponding side transverses, as defined in 4.2.2.

3.1.4 Fore peak arrangement

Where no centreline bulkhead is to be 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 Table 9.2.

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 Table 9.2.

A relaxation from the Rules of dimensions and scantlings may be granted by TL for very low draught vessels.

3.2.3 Where no centreline bulkhead is to be fitted, a centre bottom girder is to be provided according to 3.1.4.

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.

4. Side scantlings and arrangements

4.1 Arrangement

4.1.1 In way of the anchors, the side plating net 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 net thickness of the sheerstrake is to be increased by 40 % in the region of the break.

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 the formulae in Table 9.3.

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 [cm^3] and net shear sectional area A_{sh} [cm^2] are to be not less than the values derived from Table 9.3.

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 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 Table 9.3, are to be provided.

The net scantlings of plating and side stiffeners are to be not less than the values obtained from the formulae in Table 9.3.

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. In particular, it is recommended to provide a side stringer where intermediate frames are fitted over a distance equal to the breadth B of the vessels.

The side stringer net section modulus w [cm^3] and shear sectional area A_{sh} [cm^2] are to be not less than the values obtained from Table 9.3.

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 Table 9.4.

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 Section 5, E.3.4 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 [mm], is to be not less than the greater of:

- $t = 2 + 0{,}032 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
- $t = t_0$

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 or bulkheads.

The scantlings of bulkheads and platforms are to comply with the requirements of non-tight bulkheads (see Section 8, E.12.).

The number and depth of non-tight platforms within the peak is considered by TL on a case-by-case basis.

The platforms may be replaced by equivalent horizontal structures whose scantlings are to be supported by direct calculations.

Table 9.2 Net scantlings of bottom plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Plating	Net thickness [mm]: $t = MAX (t_1 ; t_2)$ - longitudinal framing: $t_1 = 1,1 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ - transverse framing: $t_1 = 1,85 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,1 \cdot s \cdot \sqrt{k \cdot p}$	
Inner bottom plating	Net thickness [mm]: $t = MAX (t_1 ; t_2)$ $t_1 = 1,5 + 0,016 \cdot L\ k^{0,5} + 3,6 \cdot s$ $t_2 = 1,1 \cdot s \cdot \sqrt{k \cdot p}$	
Bottom longitudinals Inner bottom longitudinals	Net section modulus [cm^3]: $w = \frac{4,36 \cdot \gamma_R}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0,045.\gamma_R.\beta_s.\eta.p.s.\ell$	$t = 1,63 + 0,004 \cdot L \cdot k^{0,5} + 4,5 \cdot s$
Floors Bottom transverses	Net section modulus [cm^3]: $w = 0,54.\gamma_R.\beta_b.p.a.\ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0,045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3,8 + 0,016 \cdot L \cdot k^{0,5}$
p = Design load according to 2.6 and Section 6, C.6. a = Spacing [m] of floors (s) or bottom transverses (S) m = Boundary coefficient defined in 1. γ_R = Resistance partial safety factor defined in Table 9.1.		

Table 9.3 Net scantlings of side plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Plating	Net thickness [mm]: $t = MAX\ (t_1\ ;\ t_2)$ - longitudinal framing: $t_1 = 1{,}25 + 0{,}025 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ - transverse framing: $t_1 = 1{,}68 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Side Longitudinals	Net section modulus [cm³]: $w = \frac{4{,}36 \cdot \gamma_R}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}045 \cdot \gamma_R \cdot \beta_s . \eta \cdot p \cdot s \cdot \ell$	$t = 1{,}63 + 0{,}004 . L \cdot k^{0,5} + 4{,}5 \cdot s$
Side frames	Net section modulus [cm³]: $w = \frac{4{,}36 \cdot \gamma_R}{m} \cdot \beta_b \cdot \eta \cdot \left(1{,}2 \cdot k_0 \cdot p_0 \cdot \ell_0^2 + \lambda_t \cdot p_F \cdot \ell_F^2\right)$ Net shear sectional area [cm²]: $A_{sh} = 0{,}045 . \gamma_R \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	
Intermediate side frames	Net section modulus [cm³]: $w = \frac{5{,}23 \cdot \gamma_R}{m} \cdot \beta_b \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}045 \cdot \gamma R \cdot \beta_s \cdot \eta \cdot k_0 . p_0 . s . \ell_0$	
Side transverses Side web frames	Net section modulus [cm³]: $w = 0{,}54 . \gamma_R . \beta_b \cdot k_0 \cdot p_0 \cdot S \cdot \ell_0^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}045 . \gamma_R \cdot \beta_s \cdot k_0 \cdot p_0 \cdot S \cdot \ell_0$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
Side stringers	Net section modulus [cm³]: $w = 0{,}54 . \gamma_R \cdot \beta_b . p . S . \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}045 . \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	

m = Boundary coefficient defined in 1.

γ_R = Resistance partial safety factor defined in Table 9.1

l_0 = $T - H_F + 0{,}6 . n$

p_0 = $4{,}6 . \ell_0$

p = design load according to 2.6

k_0 = $1 + (\ell - \ell_0) / \ell_0$

ℓ_F = Floor span [m]

H_F = Floor height or bottom transverse height [m]

p_F = Floor design load [kN/m²], defined in 2.6.1

λ_t = Coefficient, $\lambda_t \geq 0$

$$= 0{,}1 \cdot \left(0{,}8 - \frac{\ell^2}{\ell_F^2}\right)$$

= 0 in combination framing system

Table 9.4 Net scantlings of deck plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Plating	Net thickness [mm]: $t = MAX (t_1 ; t_2)$ - longitudinal framing: $t_1 = 0,57 + 0,031 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ - transverse framing: $t_1 = 0,9 + 0,034 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,1 \cdot s \cdot \sqrt{k \cdot p}$	
Plating of tween decks	Net thickness [mm]: $t = MAX (t_1 ; t_2)$ $t_1 = 3,5 + 0,01 \cdot L \cdot k^{0,5}$ $t_2 = 1,1 \cdot s \cdot \sqrt{k \cdot p}$	
Deck ordinary stiffeners	Net section modulus [cm³]: $w = \frac{4,36 \cdot \gamma_R}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0,045 . \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1,6 + 0,004 \cdot L \cdot k^{0,5} + 4,5 \cdot s$
Deck transverses	Net section modulus [cm³]: $w = 0,54 . \gamma_R . \beta_b . p . S . \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0,045 . \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	$t = 3,8 + 0,016 \cdot L \cdot k^{0,5}$
Deck girders	Net section modulus [cm³]: $w = \frac{4,36 \cdot \gamma_R}{m} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0,045 \cdot . \gamma_R \cdot \beta_s \cdot \eta . p \cdot S \cdot \ell$	$t = 3,8 + 0,016 \cdot L \cdot k^{0,5}$

p = Deck design load according to 2.6

m = Boundary coefficient defined in 1.

γ_R = Resistance partial safety factor defined in Table 9.1.

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 [mm] of the plate stem is to be not less than the value obtained [mm] from the following formula:

$$t = 1{,}37 \cdot \left(0{,}95 + \sqrt{L}\right) \leq 15$$

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.

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 Section 10, F.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 [cm^2], from the following formulae:

$$A_p = f \cdot (0{,}006 \cdot L_2 + 12)$$

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 [mm] from the following formula:

$$t = 0{,}33 \cdot L + 10$$

7.3.3 Extension

The bar stem is to extend beyond the forefoot by 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 Table 9.5.

Table 9.5 Stiffened bar stem

Secftional area [cm^2]	**Reduction on sectional area of the bar stem**
> 0,95 t	10 %
> 1,50 t	15 %
t = web thickness [mm] of the plate stiffener	

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 [mm] of the tunnel plating is to be neither less than the thickness of the adjacent bottom plating, increased by 2 mm, nor than that obtained from following formula:

$$t = 4{,}4 + 0{,}024 \cdot L \cdot k^{0,5}$$

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.

B. Aft Part

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Thickness [mm] of plating

p = Design load [kN/m^2]

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

l = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.6.2

η = 1 − s / (2 ℓ)

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

m = Boundary coefficient

= 12 in general, for stiffeners considered as clamped

= 8 for stiffeners considered as simply supported

= 10,6 for stiffeners clamped at one end and simply supported at the other

f = Coefficient defined as follows:

= 1,0 for **I (1,2)** and **I (2)**

= 0,9 for **I (0,6)**

= 0,8 for **I (0)**.

2. General

2.1 Application

The following requirements apply for the scantling of structures located aft of the after peak bulkhead.

As to the requirements which are not explicitly dealt with in the following, refer to the previous Sections.

2.2 Net scantlings

As specified in Section 5, B.6., all scantlings referred to in the following, with the exception of those indicated in 4., are net scantlings, i.e. they do not include any margin for corrosion.

2.3 Material factor

When steels with a minimum guaranteed yield stres ReH other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor as follows:

- Thickness:

  see relevant requirements in the following

- Section modulus:

  $w = k \cdot w_0$

- Sectional area:

  $A = k \cdot A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

2.4 Design loads

2.4.1 Pressure on sides and bottom

The design pressure on sides and bottom is to be derived from following formulae:

$p_E = 9{,}81 \cdot (T - z + 0{,}6 \cdot n)$ for $z \leq T$

$p_E = MAX\,(5{,}9 \cdot n;\ 3) + p_{WD}$ for $z > T$

pWD = Specific wind pressure [kN/m^2]

= 0,25 for **I (0)** and **I (0,6)**

= 0,4.n for **I (1,2)** and **I (2)**.

2.4.2 Pressure on exposed deck

The external pressure on exposed decks is to be defined by the designer and, in general, may not be taken less than:

$p = 3{,}75 \cdot (n + 0{,}8)$

2.4.3 Pressure on tween deck

The external pressure on tween decks is to be defined by the designer and, in general, may not be taken less than:

$p = 4{,}0$ kN/m^2

2.5 Connections of the aft part with structures located fore of the after bulkhead

2.5.1 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.

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 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 **TL** on a case-bycase 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 significantly larger than the frame spacing, the latter should be reduced, or intermediate frames with scantlings in compliance with Table 9.6, 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.

Table 9.6 Net scantlings of bottom plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Bottom plating	Net thickness [mm]: $t = MAX\ (t_1\ ;\ t_2)$ - longitudinal framing: $t_1 = 1{,}1 + 0{,}03 \cdot L \cdot k^{0{,}5} + 3{,}6.s$ - transverse framing: $t_1 = 1{,}85 + 0{,}03 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Inner bottom plating	Net thickness [mm]: $t = MAX\ (t_1\ ;\ t_2)$ $t_1 = 1{,}5 + 0{,}016 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Bottom longitudinals Inner bottom longitudinals	Net section modulus [cm^3] $w = \frac{6{,}1}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}06 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0{,}5} + 4{,}5 \cdot s$
Floors Bottom transverses	Net section modulus [cm^3]: $w = 0{,}87 \cdot \beta_b \cdot p \cdot a \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}069 \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0{,}5}$
a = Spacing [m] of floors (s) or bottom transverses (S) m = Boundary coefficient defined in 1. p = Design load [kN/m^2] defined in 2.4.1 and Section 6, C.6.		

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 to be 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.

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 Table 9.6.

For bilge plating see Section 8, B.3.

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 Table 9.7.

3.3.2 Side transverses

Side transverses are to be located in way of bottom transverse 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.

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 Table 9.8.

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 A.5.1.3

3.4.3 Stringer plate

The net thickness of stringer plate [mm] is to be not less than the greater of:

- $t = 2 + 0{,}032 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$
- $t = t_0$

t_0 = Deck plating net thickness

4. Sternframes

4.1 General

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 [m] including the scarf, at least equal to:

$$d = 0{,}01 \cdot L + 0{,}6 \qquad \text{with } 1{,}2 \le d \le 1{,}8$$

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 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 forcescoming 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, the propeller post over a range of several frames. With the propeller post directly connected, floorplates or plates of longitudinal webs 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 Table 9.9 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 **TL**.

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 Table 9.9.

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 Section 8, A.3.3

Table 9.7 Net scantlings of shell plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Side plating Transom plating	Net thickness [mm]: t = MAX (t_1 ; t_2) - longitudinal framing: $t_1 = 1{,}25 + 0{,}025 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ - transverse framing: $t_1 = 1{,}68 + 0{,}02 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Side longitudinals	Net section modulus [cm³]: $w = \frac{6{,}1}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}063 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$
Side frames	Net section modulus [cm³]: $w = \frac{6{,}1}{m} \cdot \beta_b \cdot \eta \cdot \left(1{,}2 \cdot k_0 \cdot p_0 \cdot \ell_0^2 + \lambda_t \cdot p_F \cdot \ell_F^2\right)$ Net shear sectional area [cm²]: $A_{sh} = 0{,}063 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	
Intermediate side frames	Net section modulus [cm³]: $w = \frac{6{,}1}{m} \cdot \beta_b \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}063 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	
Side transverses Side web frames	Net section modulus [cm³]: $w = 0{,}87 \cdot \beta_b . k_0 . p_0 . S . \ell_0^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}072 \cdot \beta_s \cdot k_0 \cdot p_0 \cdot S \cdot \cdot \ell_0$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
Side stringers	Net section modulus [cm³]: $w = 0{,}87 \cdot \beta_b . p . S . \ell^2$ Net shear sectional area [cm²]: $A_{sh} = 0{,}072 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

m = Boundary coefficient defined in 1.

p = Design load according to 2.4

ℓ_0 = $T - H_F + 0{,}6 \cdot n$

p_0 = $4{,}9 \cdot \ell_0$

k_0 = $1 + (\ell - \ell_0) / \ell_0$

ℓ_F = Floor span [m]

H_F = Floor height or bottom transverse height [m]

p_F = Floor design load [kN/m²] defined in 2.4.1

λ_t = Coefficient, $\lambda_t \geq 0$

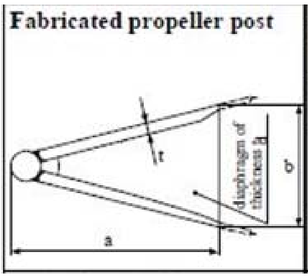
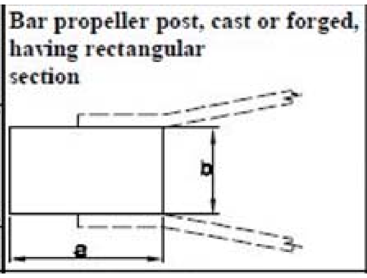
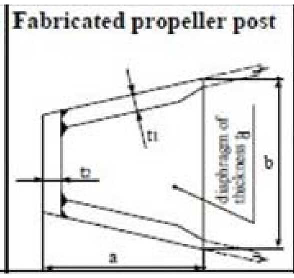
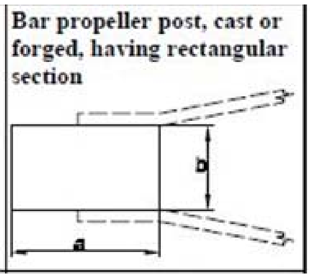
$$= 0{,}1 \cdot \left(0{,}8 - \frac{\ell^2}{\ell_F^2}\right)$$

= 0 in combination framing system

Table 9.8 Net scantlings of deck plating and structural members

Item	Scantlings	Minimum web thickness [mm]
Deck plating	Net thickness [mm]: $t = MAX(t_1 ; t_2)$ - longitudinal framing: $t_1 = 0{,}57 + 0{,}031 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ - transverse framing: $t_1 = 0{,}90 + 0{,}034 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Plating of tween decks	Net thickness [mm]: $t = MAX(t_1 ; t_2)$ $t_1 = 3{,}5 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 1{,}1 \cdot s \cdot \sqrt{k \cdot p}$	
Deck longitudinals Deck beams	Net section modulus [cm^3]: $w = \frac{6{,}1}{m} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}063 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$
Deck transverses	Net section modulus [cm^3]: $w = 0{,}87 \,.\, \beta_b \,.\, p \,.\, S \,.\, \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}072 \cdot \beta_s \cdot p \cdot S \cdot \ell$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
Deck girders	Net section modulus [cm^3]: $w = \frac{4{,}36 \cdot \gamma_R}{m} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \gamma_R \cdot \beta_s \,.\, p \,.\, S \,.\, \ell$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
m = Boundary coefficient defined in 1. p = Design load [kN/m^2], defined in 2.4 γ_R = Resistance partial safety factor defined in Table 9.1.		

Table 9.9 Gross scantlings of propeller posts

Single screw vessels		Twin screw vessels	
			
a [mm] $=29 \cdot L^{1/2}$	a [mm] $=14{,}1 \cdot A^{0,5}$	a [mm] $=29 \cdot L^{1/2}$	a [mm] $=14{,}1 \cdot A^{10,5}$
b/a = 0,7	b/a = 0,5	b/a = 0,7	b/a = 0,5
t [mm] $=2{,}5 \cdot L^{1/2}$ with $t \geq 1{,}3 \cdot t_{bottom\ midship}$	thickness : NA	t_1 [mm] $=2{,}5 \cdot L^{1/2}$ with $t_1 \geq 1{,}3 \cdot t_{bottom\ midship}$ t2 [mm] $=3{,}2 \cdot L^{1/2}$ with $t_2 \geq 1{,}3 \cdot t_{bottom\ midship}$	thickness : NA
Sectional area : NA	For $L \leq 40$: $A[cm^2] = f \cdot (1{,}4 \cdot L + 12)$ For $L > 40$: $A[cm^2] = f \cdot (2 \cdot L + 12)$	Sectional area : NA	$A[cm^2] = f \cdot (0{,}005 \cdot L^2 + 20)$
t_d [mm] $=1{,}3 \cdot L^{1/2}$	t_d =NA	t_d [mm] $=1{,}3 \cdot L^{1/2}$	t_d =NA
f = Coefficient defined in 1. *A = Sectional area [cm²], of the propeller post.* *NA = Not applicable*			

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 [mm] is to be not less than:

$$t = 6 \cdot \sqrt{f \cdot (0{,}7 \cdot L + 6)} \qquad \text{for } L \leq 40$$

$$t = 6 \cdot \sqrt{f \cdot (L - 6)} \qquad \cdots \text{for } L > 40$$

f = Coefficient defined in 1.

4.5 Stern tubes

4.5.1 The stern tube thickness is to be considered by **TL** on a case-by-case basis. In no case, however, may it 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.

C. Machinery Space

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Thickness [mm] of plating

p = Design load [kN/m²]

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

L = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= 0,85 . h

h = Significant wave height [m]

β_b, β_s = Bracket coefficients defined in Section 5, B.6.2

η = 1 − s / (2 ℓ)

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

P = Maximum power [kW] of the engine

n_R = Number of revolutions per minute of the engine shaft at power equal to P

M_H = Design bending moment [kNm] in hogging condition

M_S = Design bending moment [kNm] in sagging Condition

2. General

2.1 Application

2.1.1 The following Rules apply for the arrangement and scantling of the machinery space structures. They are to be considered as recommendations.

As to the requirements which are not explicitly dealt with in the following, refer to the previous Sections.

2.1.2 Alternative arrangements and scantlings on the basis of direct calculations are to be submitted to TL on a case-by-case basis.

2.2 Connections of the machinery space with the structures located aft and forward

2.2.1 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.

2.2.2 Hull girder strength check

On vessels with machinery space aft, the hull girder strength in way of the connection of the machinery space with the central part is to be assessed.

The following indicated value may be used for the design bending moment:

$$M_D = 2 \cdot \frac{d_{AR} \cdot M}{L}$$

M = Design bending moment [kNm] M_H or M_S

= M_H in hogging condition according to Section 7, B.3.

= M_S in sagging condition according to Section 7, B.3.

d_{AR} = Length of aft deck beyond the cargo space [m] (see Section 7, B.2.1.1).

2.2.3 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.

2.3 Arrangements

Every engine room shall normally have two exits. The second exit may be an emergency exit. If a skylight is permitted as an escape, it shall be possible to open it from the inside. See also Section 12, H.2.5 and Section 16.
For the height of entrances to machinery space, see G.9.4

2.4 Material factor

When steels with a minimum guaranteed yield stress ReH other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor as follows:

- Thickness:

See relevant requirements in the following

- Section modulus:

$w = k.w_0$

- Sectional area:

$A = k.A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

3. Design loads

3.1 Local loads

3.1.1 Pressure on sides and bottom

The design pressure on sides and bottom is to be derived from following formulae:

$p_E = 9,81 \cdot (T - z + 0,6 \cdot n)$ for $z \leq T$

$p_E = MAX\,(5,9\ .\ n\ ;\ 3) + p_{WD}$ for $z > T$

p_{WD} = specific wind pressure [kN/m^2]:

= 0,25 for **I (0)** and **I (0,6)**

= 0,4.n for **I (1,2)** and **I (2)**.

3.1.2 Pressure on deck

The external pressure on deck is to be defined by the designer and, in general, may not be taken less than:

$p = 3,75\ .\ (n + 0,8)$

3.2 Hull girder loads

3.2.1 The normal stress, σ_1 induced by hull girder loads is to be neglected if the fore bulkhead of the machinery space is located at a distance less than 0,2.L from the aft end defined in Section 4, A.1.2.5.

4. Hull scantlings

4.1 Shell plating

4.1.1 Where the machinery space is located aft, the shell plating thickness is to be determined as specified in Table 9.10. Otherwise, requirements of Section 8, B., Section 8, C. and Section 8, D. are to be complied with.

4.1.2 For bilge plating see Section 8, B.3.

4.2 Shell structure

4.2.1 Where the machinery space is located aft, the scantlings of ordinary stiffeners and primary supporting members are to be as required by Table 9.11. Otherwise, requirements of Section 8, B., Section 8, C. and Section 8, D. are to be complied with.

4.3 Topside structure

4.3.1 The scantlings and arrangement of the topside structure are to be in compliance with Section 8, D.5.2 and Section 8, D.5.4.

5. Bottom structure

5.1 General

Where the hull is shaped, the bottom is to be transversely framed. In all other cases it may be transversely or longitudinally framed.

5.2 Transversely framed bottom

5.2.1 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.

5.3 Longitudinally framed bottom

5.3.1 Transverses

Where the bottom is longitudinally framed, transverses are to be arranged every 4 frame spacings.

Additional transverses are to be fitted in way of important machinery.

6. Side structure

6.1 General

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.

6.2 Transversely framed side

6.2.1 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.

6.2.2 Side stringers

In the machinery space, where the mean value of the depth exceeds 2 m, a side stringer is generally 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 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.

6.3 Longitudinally framed side

6.3.1 Extension of the hull longitudinal structure within the machinery space

In 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.

6.3.2 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.

7. Machinery casing

7.1 Arrangement

7.1.1 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

7.2 Openings

7.2.1 General

All machinery space openings, which are to comply with the requirements in G.8., are to be enclosed in a steel casing leading to the highest open deck. Casings are to be reinforced at the ends by deck beams 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.

7.2.2 Access doors

Access doors to casings are to comply with G.9.4.

7.3 Scantlings

7.3.1 Design loads

Design loads for machinery casing scantling are to be determined as stated under D.3.

7.3.2 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 D.

Table 9.10 Shell plating net scantlings

Item	Transverse framing	Longitudinal framing
Bottom plating	$t = MAX(t_i)$ $t_1 = 1,85 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,6 . s \cdot (k \cdot p)^{0,5}$	$t = MAX(t_i)$ $t_1 = 1,1 + 0,03 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,2 \cdot s \cdot (k \cdot p)^{0,5}$
Side plating	$t = MAX(t_i)$ $t_1 = 1,68 + 0,025 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,6 . s \cdot (k \cdot p)^{0,5}$	$t = MAX(t_i)$ $t_1 = 1,25 + 0,02 \cdot L \cdot k^{0,5} + 3,6 . s$ $t_2 = 1,2 \cdot s \cdot (k \cdot p)^{0,5}$
Deck plating	$t = MAX(t_i)$ $t_1 = 0,9 + 0,034 \cdot L \cdot k^{0,5} + 3,6 \cdot s$ $t_2 = 1,6 \cdot s \cdot (k \cdot p)^{0,5}$	$t = MAX(t_i)$ $t_1 = 0,57 + 0,031 . L . k^{0,5} + 3,6 . s$ $t_2 = 1,2 \cdot s \cdot (k \cdot p)^{0,5}$
p = design load [kN/m^2] defined in 3.1		

Table 9.11 Shell structure net scantlings

Item	Scantlings	Minimum web thickness [mm]
Bottom, side and deck longitudinals	Net section modulus [cm^3]: $w = 0{,}45 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	- for L < 120 m: $t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$ - for L ≥ 120 m: $t = 3{,}9 \cdot k^{0,5} + s$
Deck beams	Net section modulus, in [cm^3]: $w = 0{,}58 \cdot \beta_b \,.\, \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	
Floors and bottom transverses Deck transverses	Net section modulus [cm^3]: $w = 0{,}58 \cdot \beta_b \cdot p \cdot a \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
Deck girders	Net section modulus [cm^3]: $w = \dfrac{4{,}36 \cdot \gamma_R}{m} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	
Side frames	Net section modulus [cm^3]: $w = 0{,}58 \cdot \beta_b \cdot \eta \cdot s \cdot (1{,}2 \cdot k_0 \cdot p \cdot \ell_0^2 + \lambda_t \,.\, p_{\gamma E} \,.\, \ell_F^2)$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$	- for L < 120 m: $t = 1{,}63 + 0{,}004 \cdot L \cdot k^{0,5} + 4{,}5 \cdot s$ - for L ≥ 120 m: $t = 3{,}9 \,.\, k^{0,5} + s$
Side web frames Side transverses	Net section modulus [cm^3]: $w = 0{,}70 \cdot \beta_b \,.\, k_0 \cdot p \cdot S \cdot \ell_0^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$	$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$
Side stringers	Net section modulus [cm^3]: $w = 0{,}75 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area [cm^2]: $A_{sh} = 0{,}056 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

a = Primary supporting member spacing [m]:
 = s for floors
 = S for other primary supporting members

p = Design load [kN/m^2] to be determined according to 3.1.1, in general
 = $4{,}9 \cdot (T - H_F + 0{,}6 \cdot n)$ for side vertical stiffeners

$p_{\gamma E}$ = Floor design load [kN/m^2]:
 = $9{,}81 \,.\, (T + 0{,}6 \cdot n)$

ℓ_0 = $T - H_F + 0{,}6 \cdot n$

k_0 = $1 + (\ell - \ell_0) / \ell_0$

ℓ_F = Floor span [m]

H_F = Floor height or bottom transverse height [m]

λ_t = Coefficient to be taken equal to:

$$= 0{,}1 \cdot \left(0{,}8 - \frac{\ell^2}{\ell_F^2}\right), \lambda_t \geq 0$$

 = 0 in combination framing system

m = Boundary coefficient defined in 1.

γ_R = Resistance partial safety factor defined in Table 9.1.

8. Engine foundation

8.1 General

The arrangement and scantlings of the engine foundation are to be in compliance with the manufacturer recommendations. The net scantlings of the structural elements in way of the seatings of main engines are to be determined as required in 8.2 to 8.4.

8.2 Longitudinal girders

8.2.1 Extension

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 tobe carefully compensated.

8.2.2 Scantlings

The longitudinal girder net section modulus w [cm^3] and net shear sectional area A_{Sh} [cm^2] are not to be less than:

$$w = 0{,}75 \cdot \beta_b \cdot p \cdot b \cdot \ell_E^2$$

$$A_{sh} = 0{,}056 \cdot \beta_s \cdot p \cdot b \cdot \ell_E$$

b = Plating parameter [m] to be obtained from the following formula:

$$b = \frac{B_1 - n_E \cdot S}{2 \cdot (n_E + 1)} + \frac{S}{2}$$

S = Longitudinal girders spacing [m] (under main engine)

n_E = Number of engines

ℓ_E = Length of the engine foundation [m] to be not taken less than 3 m

B_1 = Width of the machinery space [m]

The ratio of the longitudinal girder height to the web thickness is to be not greater than 50.

Over the outer quarters of the longitudinal girder length, the section modulus of the girder may decrease towards the ends up to a quarter of this value.

The scantlings given herebefore may be reduced when additional longitudinal bottom girders, either centre or side girders, are provided over the full length of the engine room.

The net cross sectional area [cm^2] of top plate is to be not less than:

$$A = 40 + 23 \cdot \frac{P}{n_R}$$

Its minimum net thickness [mm] is to be determined using the formula:

$$t = 18 + 2{,}3 \cdot \frac{P}{n_R}$$

8.3 Floors

8.3.1 Floor strength continuity is to be obtained as shown in Fig. 9.1 or Fig. 9.2, or according to any other method considered equivalent by TL.

8.3.2 Scantlings

In way of the engine foundation, the floor net section modulus w [cm^3] and shear sectional area A_{sh} [cm^2] are not to be less than:

$$w = 0{,}58 \cdot \beta_b \cdot p \cdot s \cdot \ell^2 + 175 \cdot \frac{P}{n_R}$$

$$A_{sh} = 0{,}045 \cdot \beta_S \cdot p \cdot s \cdot \ell + 17{,}5 \cdot \frac{P}{n_R}$$

The section modulus of the floors in the section A-A (see Fig. 9.1 and Fig. 9.2) shall be at least 0,6 times that determined according to the formula here above.

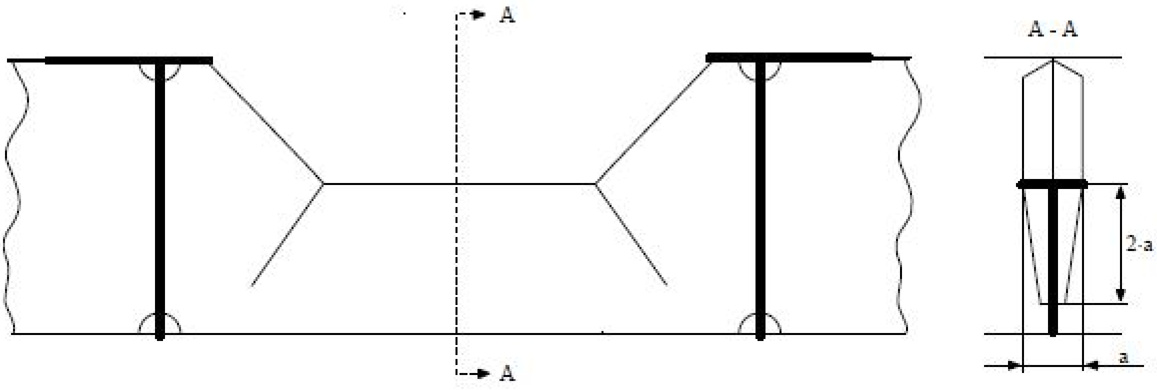


Fig. 9.1 Floor in way of main engine seating: 1st version

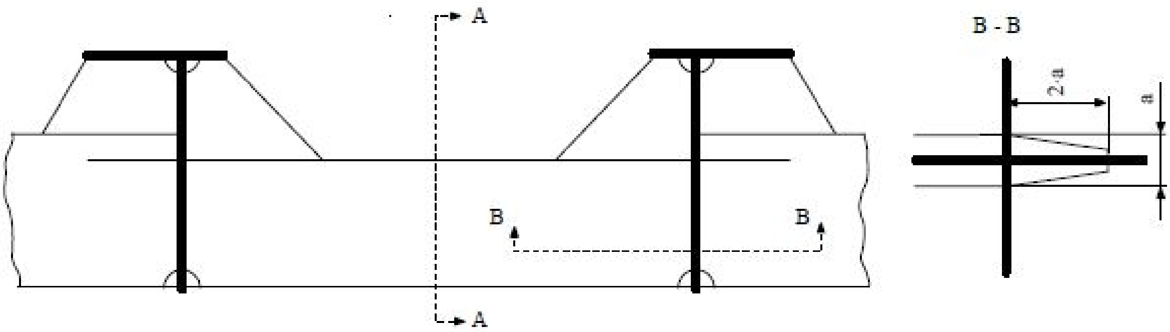


Fig. 9.2 Floor in way of main engine seating: 2nd version

8.4 Bottom plating in way of engine foundation

The net thickness of the bottom plating [mm] in way of the engine seatings is to be determined using the formula:

$$t = t_0 + 2{,}3 \cdot \frac{P}{n_R}$$

t_0 = Net thickness of the bottom plating [mm] in the central part.

D. Superstructures and Deckhouses

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

t = Net thickness [mm] of plating

w = Net section modulus [cm^3]

A_{sh} = Net web sectional area [cm^2]

K = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m] defined in Section 6, B.

2. General

2.1 Application

The following requirements apply for the scantlings of plating and associated structures of front, side and aft bulkheads and decks of superstructures and deckhouses, which may or may not contribute to the longitudinal strength.

As to the requirements which are not explicitly dealt with in the following, refer to the previous Sections.

2.2 Definitions

2.2.1 Deckhouses

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.

The deckhouses considered have:

- for an aft deckhouse: the fore bulkhead less than 0,25.L from the aft perpendicular
- for a midship deckhouse: a length at most equal to L/6
- for a fore deckhouse: the aft bulkhead less than 0,25.L from the fore perpendicular

2.2.2 Superstructures

Superstructures are defined in Section 4, A.1.2.

2.2.3 Superstructures and deckhouses contributing to the longitudinal strength

A superstructure may be considered as contributing to the longitudinal strength if its deck satisfies the basic criteria given in Section 15, D.7.1.

2.2.4 Tiers of superstructures and deckhouses

The lowest tier is normally that which is directly situated above the strength deck defined in Section 4, A.1.2.8.

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

2.3 Material factor

When steels with a minimum guaranteed yield stres ReH other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor as follows:

- Thickness: see relevant requirements in the following
- Section modulus: $w = k.w_0$
- Sectional area: $A = k.A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2.

3. Arrangements

3.1 Connections of superstructures and deckhouses with the hull structure

3.1.1 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.

3.1.2 Connection to the deck of corners of superstructures and deckhouses is considered by **TL** on a case-by-case basis. Where necessary, doublers or reinforced welding may be required.

3.1.3 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.

3.1.4 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 3 frame spacings.

3.2 Arrangement

3.2.1 The accommodation shall be separated from engine rooms, boiler rooms and holds by gastight bulkheads.

3.2.2 The accommodation shall be arranged behind the collision bulkhead.

4. Design loads

4.1 Sides and bulkheads

The lateral pressure to be used for the determination of scantlings of structure of sides and bulkheads of superstructures, deckhouses and machinery casing is to be obtained [kN/m^2] from the following formula:

$$p = 2 + p_{WD}$$

p_{WD} = Specific wind pressure [kN/m^2] defined in Table 9.12.

Table 9.12 Specific wind pressure

Navigation notation	Wind pressure p_{WD} [kN/m^2]
I (1,2) to **I (2)**	0,4.n
I (0,6), **I (0)**	0,25

4.2 Pressure on decks

The pressure on decks is to be defined by the designer and, in general, may not be taken less than the values given in Table 9.13 or Table 9.14.

Table 9.13 Deck pressure in accommodation Compartments

Type of accommodation compartment	p [kN/m^2]
- 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 9.14 Pressure on exposed decks

Exposed deck location	p [kN/m^2]
- First tier (non-public)	2,0
- Upper tiers (non-public)	1,4
- Public	4,0

Local reinforcements are to be provided in way of areas supporting cars or ladders.

5. Scantlings

5.1 Net scantlings

All scantlings referred to in the following are net scantlings, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Section 5, B.6.

5.2 Scantling requirements

5.2.1 General

TL may request additional arrangements deemed necessary in order to keep the level of stresses liable to occur in the superstructure structural members within acceptable limits.

5.2.2 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 Table 9.15.

5.2.3 Superstructures and deckhouses contributing to the longitudinal strength

The net scantlings of superstructures contributing to the longitudinal strength are to be determined in accordance with Table 9.16 and Table 9.17.

6. Additional requirements applicable to movable wheelhouses

6.1 General

6.1.1 The structures of movable wheelhouse are to be checked in low and high position.

6.1.2 Mechanical locking devices are to be fitted in addition to hydraulic systems.

6.1.3 The supports or guide of movable wheelhouses, connections with the deck, under deck reinforcements and locking devices are to be checked considering loads due to list and wind action defined in Section 15, D.6.4 and, eventually, inertial loads defined in Section 15, D.6.5

6.1.4 The safety of persons on board is to be guaranteed in any position of the wheelhouse. The wheelhouse can be fixed in different positions along the vertical axis.

Movements of the wheelhouse are to be signalled by optical and acoustic means.

6.1.5 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.

6.2 Arrangement

6.2.1 The hoisting mechanism is to be capable to hoist at least 1,5 times the weight of the wheelhouse fully equipped and manned.

6.2.2 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.

7. Elastic bedding of deckhouses

7.1 General

7.1.1 The structural members of elastically bedded deckhouses may, in general, be dimensioned in accordance with 5.

7.1.2 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:

  $P = 1{,}2 \cdot G$

- horizontal:

  $P = 0{,}3 \cdot G$

G = total weight of the complete deckhouse, outfit and equipment included

Additional loads due to vessel's heel need not be considered, in general.

Table 9.15 Net scantlings for non-contributing superstructures

Item	Parameter	Scantling
Plating of sides Plating of aft end bulkheads Plating of non-exposed deck	thickness [mm]	t = MAX (t_1; t_2) $t_1 = 3{,}5 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 0{,}8 \cdot s \cdot (k \cdot p)^{0,5}$
Plating of exposed decks Plating of front bulkheads	thickness [mm]	t = MAX (t_1; t_2) $t_1 = 4 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$
Longitudinal ordinary stiffeners	section modulus [cm^3]	$w = 0{,}4 . p \cdot s \cdot \ell^2$
Other ordinary stiffeners	section modulus [cm^3]	$w = k_1 \cdot p \cdot s \cdot \ell^2$
Primary supporting members	section modulus [cm^3]	$w = k_1 \cdot p \cdot S \cdot \ell^2$
p = Design load defined in 4. l = Span [m] of ordinary stiffeners or primary supporting members ≥ 2,5 m k_1 = Load coefficient: = 0,58 for horizontal stiffeners = 0,58 + 0,1.n_t for vertical stiffeners. n_t = Number of tiers above the tier considered		

E. Hatch Covers

1. ymbols

L = Rule length [m] defined in Section 4, A.1.

t = At thickness [mm]

s = Spacing of ordinary stiffeners [m]

S = Spacing of primary supporting members [m]

m = Soundary coefficient for ordinary stiffeners and primary supporting members

= 8 in the case of ordinary stiffeners and primary supporting members simply supported at both ends or supported at one end and clamped at the other

= 12 in the case of ordinary stiffeners and primary supported members clamped at both ends

w = Net section modulus [cm^3], of ordinary stiffeners or primary supporting members

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

P = Hatchway design load [kN/m^2]

n = Navigation coefficient defined in Section 6, B.

= 0,85.h

h = Significant wave height [m]

Table 9.16 Plating net thickness for contributing superstructures

Item	Framing system	Scantling
Side plating	Transverse framing	t = MAX (t_i) $t_1 = 1{,}68 + 0{,}025 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$
	Longitudinal framing	t = MAX (t_i) $t_1 = 1{,}25 + 0{,}025 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$
Deck plating	Transverse framing	t = MAX (t_i) for exposed decks $t_1 = 4 + 0{,}01 \cdot L \cdot k^{0,5}$ for non-exposed decks $t_1 = 3{,}5 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{\psi \cdot M_S}{Z_D}}$ if $t_3/s > 23{,}9/(k^{0,5} \cdot k_2)$ $t_3 = \frac{7{,}76 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{\psi \cdot M_S}{Z_D}}}$ see **(1)**
	Longitudinal framing	t = MAX (t_i) $t_1 = 0{,}57 + 0{,}031 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 39 \cdot s \cdot \sqrt{\frac{\psi \cdot M_S}{Z_D}}$ see **(1)**
Plating of end bulkheads	All	t = MAX (t_i) $t_1 = 3{,}5 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$
Plating of front bulkheads	All	t = MAX (t_i) $t_1 = 4 + 0{,}01 \cdot L \cdot k^{0,5}$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$

p = Design load defined in 4.
k_2 = coefficient
= $1 + \alpha_2$
α = b_2 / b_1
b1 = Unsupported deck width in y direction [m]
b_2 = Unsupported deck width in x direction [m]
Z_D = Net hull girder section modulus at deck level [cm^3]
M_S = Design bending moment [kNm] in sagging condition
ψ = Superstructure efficiency defined in Section 15, D.8.1.1 and 8.1.2
(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

Table 9.17 Structural member net scantlings for contributing superstructures

Item	w	A_{Sh}
Longitudinal ordinary stiffeners	$w = \frac{83,3}{214 - \psi \cdot \sigma_1} p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot p \cdot s \cdot \ell$
Other ordinary stiffeners	$w = k_1 \cdot p \cdot s \cdot \ell^2$	
Longitudinal primary supporting members	$w = \frac{125}{(14 - \psi \cdot \sigma_1)} p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot p \cdot S \cdot \ell$
Other primary supporting members	$w = 0,58 \cdot p \cdot S \cdot \ell^2$	
σ_1 = Hull girder normal stress [N/mm^2] Ψ = Superstructure efficiency defined in Section 15, D.8.1.1 and 8.1.2 For other symbols, see definitions in Table 9.15.		

2. General

2.1 Application

2.1.1 The following requirements apply to hatchways which are closed with self-bearing hatchcovers.

These are to bear on coamings.

2.1.2 Hatch covers supported by hatchway beams and other supporting systems are to be considered by **TL** on a case-by-case basis. In any case, they are to ensure the same degree of strength and weathertightness.

2.1.3 These Rules do not cover the classification of vessels with range of navigation **I (0)**, for which however the Rules applicable to the range of navigation **I (0,6)** may be used.

2.2 Definitions

2.2.1 Weathertightness

Weathertightness is ensured when, for all the navigation conditions envisaged, the closing devices are in compliance with Section 17, F.2.2.7.

Systems to ensure the weathertightness are mentioned in 3.3.

2.2.2 Watertightness

Watertightness is ensured when, for all the navigation conditions envisaged, the closing devices are in compliance with Section 17, F.2.2.8.

2.3 Materials

Hatch covers are to be made of steel or aluminium alloy. The use of other materials is to be considered by **TL** on a case-by-case basis.

2.4 Net scantlings

All scantlings referred to in the following are net, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Section 5, B.6.

2.5 Design loads

2.5.1 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 2.5.2.

2.5.2 Hatch covers carrying uniform cargoes

The expected hatch cover load is to be defined by the designer and, in any case, is not to be taken less than:

$$p = MAX\ (1{,}5;\ 6.n - 1{,}5)$$

3. Arrangements

3.1 Hatch covers on exposed decks

Hatchways on exposed decks are to be fitted with hatchcovers the strength, rigidity and weathertightness of which are to be adequate:

- on vessels assigned the ranges of navigation **I (1,2)** to **I (2)**
- on vessels assigned the range of navigation **I (0,6)** on which the height of the hatch coaming above the deck [m], h_C, is such that:

$$H + h_C > T + n / 1{,}7 + 0{,}15$$

3.2 Hatch covers in closed superstructures

Hatch covers in closed superstructures need not to be weathertight.

However, hatch covers fitted in way of ballast tanks, fuel oil tanks or other tanks are to be watertight.

3.3 Weathertightness of hatch covers

The hatch cover tightness is not subjected to 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.

3.4 Securing of hatch covers

The positioning and securing of hatch covers are to be ensured by supports or guides of efficient construction.

Where broaches or bolts are used, their diameter is to be such that the mean shearing stress, under the action of the loads mentioned in 2.5, does not exceed 44 N/mm^2.

Efficient arrangements are to be made to prevent unexpected displacement or lifting of the hatchcovers.

3.5 The width of each bearing surface for hatch covers is to be at least 65 mm.

3.6 Hatch covers carrying containers

The design, construction and arrangement of hatch covers carrying containers are to be in compliance with the Section 15, B.

3.7 Hatch covers carrying wheeled loads

The design, construction and arrangement of hatch covers carrying wheeled loads are to be in compliance with Section 15, C.

4. Scantlings

4.1 Application

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 steel hatch covers

In any case, the thickness of steel hatch covers is not to be less than:

- Galvanized steel: 2 mm

- Other cases: 3 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:

$$t = 1,2 \cdot s \cdot \sqrt{k \cdot p}$$

nor than the thickness derived from the following formulae:

- for **I (1,2)** to **I (2)**:

$$t = 4,9 \cdot s \cdot \sqrt[3]{k^{1,5} \cdot (1 + 0,34 \cdot p)}$$

- for **I (0,6)**:

$$t = 3,4 \cdot s \cdot \sqrt[3]{k^{1,5} \cdot (1 + p)}$$

4.3 Stiffening members of self-bearing hatch covers

4.3.1 Width of attached plating

The width of the attached plating is to be in compliance with Section 5, B.4.3 or Section 5, B.5.2 as applicable.

4.3.2 Minimum web thickness

The minimum thickness of the web of the stiffeners [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 [cm^3] and the net shear sectional area A_{sh} [cm^2] of self-bearing hatchcover ordinary stiffeners and primary supporting members are not to be less than those obtained from the following formulae:

$$w = 4,6 \cdot k \cdot \frac{p}{m} \cdot a \cdot \ell^2$$

A_{sh} = $0,045 \cdot k \cdot p \cdot a \cdot \ell$

a = Stiffener spacing [m]
  = s for ordinary stiffeners
  = S for primary supporting members

F. Movable Decks and Ramps

1. Movable decks and inner ramps

1.1 Materials

The movable decks and inner ramps are to be made of steel or aluminium alloys complying with the requirements of Sections 14-17. Other materials of equivalent strength may be used, subject to a case-by-case examination by **TL**.

1.2 Net scantlings

As specified in Section 5, B.6. 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 Section 5, B.6.

1.3 Plating

The net thickness of plate panels subjected to wheeled loads is not to be less than the value obtained from Section 15, C.3.2, where (n_P.F) is not to be taken less than 50 kN.

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 [kN]

1.4 Ordinary stiffeners

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 Section 15, C.3.3.1

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 [kN/m^2] taken equal to:

$$p_1 = \frac{n_V \cdot p_V + P_p}{A_p}$$

- Empty movable deck under uniformly distributed masses corresponding to a pressure [kN/m^2] taken equal to:

$$p_0 = \frac{P_p}{A_p}$$

n_V = Maximum number of vehicles loaded on the movable deck or inner ramp

P_V = Weight of a vehicle [kN]

P_P = Weight of the movable deck or inner ramp [kN]

A_P = Effective area of the movable deck or inner ramp [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 [kN/m2] from the following formula:

$$p = p_S + 1{,}10.p_W$$

p_S, p_W = Still water and inertial pressures transmitted to the movable deck or inner ramp structures, obtained [kN/m^2] from Table 9.18.

1.5.4 Checking criteria

It is to be checked that the combined stress σ_{vm} [N/mm^2] is in compliance with the criteria defined in Section 5, E.3.3.3.

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 stres σVM [N/mm$_2$] in rigid supports and locking devices is in compliance with the criteria defined in Section 5, E.3.4.

1.7 Tests and trials

1.7.1 Tests and trials are to be carried out in the presence of the Surveyor, in compliance with TL Rules.

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 Table 9.18.

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 **TL** on a case-by-case basis.

2.1.5 The vessel's structure under the reactions due to the ramp is examined by **TL** on a case-by-case basis.

G. Arrangements for Hull and Superstructure Openings

1. Symbols

L = Rule length [m] defined in Section 4, A.1

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

n = Navigation coefficient defined in Section 6. B.

= 0,85 . h

h = Significant wave height [m] defined in Section 6, B.

2. Side shell openings

2.1 General

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.

2.2 Arrangement

2.2.1 Shell plating openings

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 0,25·L from either end perpendicular.

Compensation is not required for circular openings having a diameter at most equal to 300 mm.

2.2.2 Openings for water intakes

Openings for water intakes are to be well rounded at the corners and, within 0,6.L amidships, located outside the bilge strakes. Where arrangements are such that 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.

2.2.3 Other openings

Other openings are considered by **TL** on a case-bycase basis.

2.2.4 Sheerstrake openings

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.

2.3 Strengthening

Openings in 2.2 and, when deemed necessary by **TL**, 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.

3. Deck openings

3.1 Openings in the strength deck

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.

3.1.1 In case of flush deck vessels, 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.

4. Cargo hatchways on open deck vessels

4.1 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.

4.2 Deck strengthening in way of hatch corners

4.2.1 Plating thickness in way of the corners

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.

4.2.2 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.

Table 9.18 Movable decks and inner ramps - still water and inertial pressures

Vessel condition	Load case	Still water pressure p_S and inertial pressure p_W [kN/m^2]
Still water condition		$p_S = p_0$ in harbour condition during lifting $p_S = p_1$ in other cases
Upright navigation condition		$p_{W,X} = 0,1 \cdot a_{X1} \cdot p_1$ in x direction $p_{W,Z} = 0,1 \cdot a_{Z1} \cdot p_1$ in z direction
Inclined navigation condition		$p_{W,Y} = 0,07 \cdot a_{Y2} \cdot p_1$ in y direction $p_{W,Z} = 0,07 \cdot a_{Z2} \cdot p_1$ in z direction
Harbour condition **(1)**	during lifting	$p_{W,X} = 0,035 \cdot p_0$ in x direction $p_{W,Y} = 0,087 \cdot p_0$ in y direction $p_{W,Z} = 0,200 \cdot p_0$ in z direction
	at rest	$p_{W,X} = 0,035 \cdot p_1$ in x direction $p_{W,Y} = 0,087 \cdot p_1$ in y direction $p_{W,Z} = 0,100 \cdot p_1$ in z direction

(1) *For harbour conditions, a heel angle of 5° and a trim angle of 2° are taken into account.*

p_0, p_1 = Pressures [kN/m^2] to be calculated according to 1.5.2 for the condition considered

a_{X1}, a_{Z1}, a_{Y2}, a_{Z2} = Reference values of the accelerations defined in Section 6, C., Table 6.5.

4.2.3 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.

4.3 Coamings on open deck vessels

4.3.1 Scantling and stiffening

See Section 8, D., deck scantlings.

4.3.2 Cut-outs

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.

4.3.3 Extension and strength continuity

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.

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.

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 longitudinals. Transverse coamings not in line with ordinary deck beams below are to extend below the deck up to the next deck girder.

5. Cargo hatchways on flush deck vessels

5.1 Corners of hatchways

5.1.1 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 athwartships, is considered by **TL** on a case-by-case basis.

5.1.2 Elliptical and parabolic corners

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

5.2 Deck strengthening in way of hatch corners

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 **TL** on the basis of calculations showing that stresses at hatch corners are lower than permissible values.

5.3 Coamings on flush deck vessels

5.3.1 Scantling and stiffening

See Section 8, D., deck scantlings.

The edges of cut-outs are to be carefully rounded.

5.3.2 Extension and strength continuity

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.

5.3.3 Vertical brackets or stays

Where necessary, the coaming boundaries are to be stiffened with stays, as mentioned in Section 8, D.4.3.5.

5.4 Small hatches

5.4.1 The following requirements apply to small hatchways with a length and width of not more than 1,2 m.

5.4.2 In case of 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.

5.4.3 The sill's upper edge is neither to be less than 0,15 m above the deck nor than (n/1,7 + 0,15) m above the load waterline.

5.4.4 Access openings to cofferdams and ballast tanks shall be of the manhole type, fitted with watertight covers fixed with bolts which are closely spaced, and are to be in accordance with a recognized standard, e.g. ISO 5894.

5.4.5 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.

5.4.6 Hatchways of special design are considered by **TL** on a case-by-case basis.

6. Side scuttles, windows and skylights

6.1 Definition

6.1.1 Side scuttles are round or oval openings with an area not exceeding 0,16m^2. Round or oval openings having areas exceeding 0,16m^2 are to be treated as windows.

6.1.2 The safety range is equivalent to the significant wave height h to be deducted from the uppermost load line, but at least up to the bulkhead deck.

6.2 Requirements

6.2.1 Side scuttles shall be built and tested in accordance with ISO 1751.

6.2.2 Windows shall be built and tested in accordance with ISO 3903.

6.2.3 Skylights of fixed or opening type are to have a glass thickness appropriate to their size and position, as required for windows and side scuttles.

Skylight glasses are to be protected from mechanical damage if they can be damaged by e.g. loading operations.

6.2.4 Alternative constructions to the standards mentioned above shall be of equivalent and approved design.

6.2.5 Toughened safety glass pane (ESG) or laminated safety glass (VSG) is to be used, in accordance with ISO 21005.

6.3 Arrangement

6.3.1 Windows and side scuttles fitted in the side shell below the bulkhead deck shall be watertight and of the non-opening type and in accordance with ISO 3903 (type E) or ISO 1751 (type B), each to be provided with a permanently attached inside deadlight.

Windows and side scuttles in the shell are to be adequately protected against direct contact by efficient fenders or are to be recessed into the shell.

Deadlights are not required on ships with the service range **I (0)** and **I (0,6)**.

6.3.2 Windows, side scuttles and skylights situated above the bulkhead deck with their lower glass edges within the safety range defined in 6.1.2 shall be watertight and of the non-opening type.

If they do not protect a direct access leading below bulkhead deck, or are provided with a sill of at least 0.15 m, they shall be weathertight and may be of the opening type.

6.3.3 The examination of windows, side scuttles and skylights located above the range defined in 6.1.2 is no matter of class - except for windows according to 6.3.4.

6.3.4 Windows used for protection against falling down, e.g. windscreens or full-height windows, shall be shown to have equivalent strength against the loads as provided by EN 711. For these windows, laminated safety glass (VSG) or heat-soak-tested toughened safety glass (ESG-H) shall be used.

6.4 Glass thickness

6.4.1 The thickness of toughened safety glass in side scuttles is to be neither less than 6 mm nor less than the value [mm] obtained from the following formula:

$$t = \frac{d}{358} \cdot \sqrt{p}$$

d = Side scuttle diameter [mm]

p = Lateral pressure [kN/m^2] defined in Section 6, C.4. for vessel hull or in D.3. for superstructures and deckhouses.

6.4.2 Thickness of toughened glasses in rectangular windows

The thickness of toughened glasses in rectangular windows is neither to be less than 6 mm nor less than the value [mm] obtained from the following formula:

$$t = \frac{b}{200} \cdot \sqrt{\beta \cdot p}$$

p = Lateral pressure [kN/m^2] defined in 6.4

β = Coefficient defined in Table 9.19 · β may be obtained by linear interpolation for intermediate values of a / b

a = Length [mm] of the longer side of the window

b = Length [mm] of the shorter side of the window

Table 9.19 Coefficient β

a/b	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

6.5 Miscellaneous

6.5.1 National statutory rules and regulations are to be observed, as far as applicable.

6.5.2 Required tests have to be carried out in the presence and to the satisfaction to our surveyor.

6.5.3 **TL** 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.

7. Scuppers and discharges

7.1 Material

The scuppers and discharge pipes are to be constructed of steel. Other equivalent materials are considered by **TL** on a case-by-case basis.

7.2 Wall thickness

The wall 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 needs not exceed 8 mm.

8. Freeing ports

8.1 General provisions

Where bulwarks on weather decks form wells, provisions are to be made for rapidly freeing the decks of water and draining them. A well is any area on the deck exposed to the weather, where water may be entrapped.

9. Machinery space openings

9.1 Closing devices

Openings in machinery space casings are to be surrounded by a steel casing of efficient construction.
The openings of the casings exposed to the weather are to be fitted with strong and weathertight doors.

9.2 Position of openings

The height [m] of the lower edge of the opening above the load waterline is not to be less than n/1,7.

9.3 Entrances

The height [m] of entrances to machinery space, h_C, above the deck is not to be less than the values given in Table 9.20.

Furthermore, this height, h_C, above the deck is to be such that:

$$H + h_C > T + n / 1,7 + 0,15$$

Table 9.20 Height of machinery space entrance

Vessel type	Significant wave height, h [m]	h_C [m]
Carriage of dangerous goods	$0 \le h \le 2$	0,5
Other vessels	$h \le 1,2$	0,3
	$h > 1,2$	0,5

10. Companionway

10.1 Companionway

Companions leading under the freeboard deck are to be protected by a superstructure or closed deckhouse, or by a companionway having equivalent strength and tightness.

10.2 Companionway sill height

In vessels assigned the range of navigation **I (0)**, the companion sill height, above the deck, h_C, is not to be less than 0,05 m.

In other vessels, the sill upper edge is neither to be less than 0,15 m above the deck nor less than (n/1,7 + 0,15) m above the load waterline.

11. Ventilators

11.1 General

11.1.1 Ventilator openings below main deck are to have coamings of steel or other equivalent material, substantially constructed and efficiently connected to the deck.

11.1.2 Coamings

In vessels assigned the range of navigation other than **I (0)**, the coaming height, above the deck, h_C, is not to be less than 0,3 m.

Furthermore, this height, h_C, above the deck is to be such that:

$$H + h_C > T + n / 1,7 + 0,15$$

SECTION 10

HULL DESIGN and CONSTRUCTION – HULL OUTFITTING

A. Rudders

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

n = Navigation coefficient defined in Section 6, B.

= 0,85 . h

h = Significant wave height [m]

V_{AV} = Maximum ahead service speed [km/h] at maximum draught T; this value is not to be taken less than 8

V_{AD} = Maximum astern speed [km/h] to be taken not less than $0{,}5.V_{AV}$

A = Total area of the rudder blade [m^2] bounded by the blade external contour, including the main piece and the part forward of the centreline of the rudder pintles, if any

k_1 = Material factor, defined in 2.4.3

k = Material factor, defined in Section 5, A.2.4 (see also 2.4.5)

C_R = Rudder force [N] acting on the rudder blade, defined in 3.1.2

M_{TR} = Rudder torque [N.m] acting on the rudder blade, defined in 3.1.3

M_B = Bending moment [N.m] in the rudder stock, defined in 5.1

2. General

2.1 Application

2.1.1 Ordinary profile rudders

The following requirements 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.

2.1.2 High lift profiles

The following requirements 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 TL 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.

2.1.3 Steering nozzles

The requirements for steering nozzles are given in 9.

2.1.4 Special rudder types

Rudders others than those in 2.1.1, 2.1.2 and 2.1.3 will be considered by TL on a case-by-case basis.

2.2 Gross scantlings

With reference to Section 5, B.6., all scantlings and dimensions referred to in the following are gross, i.e. they include the margins for corrosion.

2.3 Arrangements

2.3.1 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.

2.3.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

2.3.3 The rudder stock is to be carried through the hull either enclosed in a watertight trunk or with glands to be fitted above the deepest load waterline, so as 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.

2.3.4 The steering system as a whole has to be designed for a permanent heeling of up to 15° and ambient temperatures from –20 °C to +50 °C.

2.4 Materials

2.4.1 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 **TL** Rules for Materials.

2.4.2 The material used for rudder stocks, pintles, keys and bolts is to have a minimum yield stress not less than 200 N/mm^2.

2.4.3 The requirements relevant to the determination of scantlings contained in the following apply to steels having a minimum yield stress equal to 235 N/mm^2.

Where the material used for rudder stocks, pintles, coupling bolts, keys and cast parts of rudders has a yield stress different from 235 N/mm^2, the scantlings calculated with the formulae contained in the requirements are to be modified, as indicated, depending on the material factor k_1, to be obtained from the following formula:

$$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$$

R_{eH} = Yield stress [N/mm^2], of the steel used, and not exceeding the lower of 0,7 R_m and 450 N/mm^2

R_m = Minimum ultimate tensile strength [N/mm^2], of the steel used

n_1 = Coefficient to be taken equal to:

= 0,75 for ReH > 235 N/mm2

= 1,00 for ReH ≤ 235 N/mm2

2.4.4 Significant reductions in rudder stock diameter due to the application of steels with yield stresses greater than 235 N/mm^2 may be accepted by TL subject to the results of a check calculation of the rudder stock deformations.

Large rudder stock deformations are to be avoided in order to avoid excessive edge pressures in way of bearings.

2.4.5 Welded parts of rudders are to be made of approved rolled hull materials. For these members, the material factor k defined in Section 5, A.2.4 is to be used.

3. Force and torque acting on the rudder

3.1 Rudder blade

3.1.1 Rudder blade description

A rudder blade may have trapezoidal or rectangular contour.

3.1.2 Rudder force

The rudder force C_R is to be obtained [N] from the following formula:

$$C_R = 28{,}86.(1 + n)^{0{,}15}\ A \cdot V^2 \cdot r_1 \cdot r_2 \cdot r_3$$

V = V_{AV}, or V_{AD}, depending on the condition under consideration (for high lift profiles see 2.1.2)

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 [m], of the rudder area to be taken equal to (see Fig. 10.1)

$$= \frac{z_3 + z_4 - z_2}{2}$$

A_T = Area [m^2] 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 Table 10.1

r_3 = Coefficient

= 0,8 for rudders outside the propeller jet (centre rudders on twin screw vessels, or similar cases)

= 1,15 for rudders behind a fixed propeller nozzle

= 1,0 in other cases

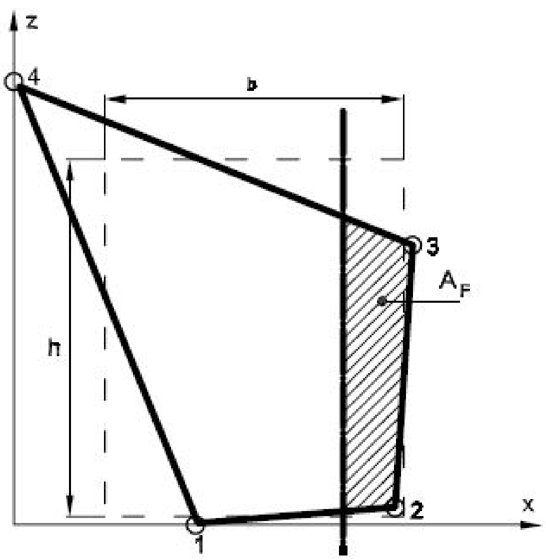


Fig. 10.1 Geometry of rudder blade without cutouts

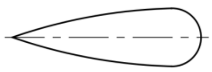
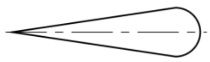
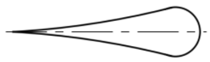
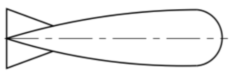
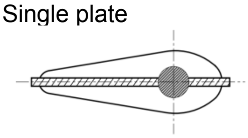
3.1.3 Rudder torque

The rudder torque M_{TR}, for both ahead and astern conditions, is to be obtained [N.m] from the following formula:

$$M_{TR} = C_R \cdot r$$

r = Lever of the force C_R [m], equal to:

Table 10.1 Values of coefficient r_2

Type of rudder/ profile	r_2	
	Ahead condition	**Astern condition**
NACA-00 serie Göttingen profiles 	1,10	0,80
flat side profiles 	1,10	0,90
hollow profiles 	1,35	0,90
high lift 	1,70	1,30
Fish tail 	1,40	0,80
Single plate 	1,00	1,0

$$r = b \cdot \left(\alpha - \frac{A_F}{A} \right)$$

and to be taken not less than 0,1.b for the ahead condition

b = Mean breadth [m], of rudder area (see Fig. 10.1)

$$= \frac{x_2 + x_3 - x_1}{2}$$

α = Coefficient

= 0,33 for ahead condition

= 0,66 for astern condition

A_F = Area [m²], of the rudder blade portion in front of the centreline of rudder stock (see Fig. 10.1)

4. Rudder stock scantlings

4.1 Rudder stock diameter

4.1.1 Rudder stock subjected to torque only

For rudder stocks subjected to torque only, the diameter is to be not less than the value obtained [mm], from the following formula:

$$d_T = 4{,}2 \cdot (M_{TR} \cdot k_1)^{1/3}$$

4.1.2 Rule stock diameter

The rudder stock diameter, at the lower part, is to be not less than the value obtained [mm], from the following formula:

$$d_{TF} = 4{,}2 \cdot (M_{TR} \cdot k_1)^{1/3} \cdot \left[1 + \frac{4}{3} \cdot \left(\frac{M_B}{M_{TR}}\right)^2\right]^{1/6}$$

M_B = Maximum absolute value of bending moment M_{Bi} over the rudder stock length, to be obtained according to 6.1.

4.1.3 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.

5. Rudder stock couplings

5.1 Horizontal flange couplings

5.1.1 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 0,13.d_1, where d_1 is the greater of the rudder stock diameters d_T and d_{TF} [mm] to be calculated in compliance with the requirements in 4.1.

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 grade of the steel used is to be of weldable quality, particularly with a carbon content not greater than 0,25 % and the welding conditions are to be defined to the satisfaction of **TL**. The throat weld at the top of the flange is to be concave shaped to give a fillet shoulder radius as large as practicable.

5.1.2 Bolts

Horizontal flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained [mm] from the following formula:

$$d_b = 0.62 \sqrt{\frac{d_1^3 \cdot k_{1B}}{n_B \cdot e_M \cdot k_{1S}}}$$

d_1 = Rudder stock diameter [mm] defined in 4.1.2

k_{1S} = Material factor k_1 for the steel used for the rudder stock

k_{1B} = Material factor k_1 for the steel used for the bolts

e_M = Mean distance [mm] from the bolt axes 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 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.

5.1.3 Coupling flange

The thickness of the coupling flange is to be not less than the value obtained [mm] from the following formula:

$$t_P = d_B \cdot \sqrt{\frac{k_{1F}}{k_{1B}}}$$

d_B = Bolt diameter [mm] calculated in accordance with 5.1.2, where the number of bolts n_B is to be taken not greater than 8

k_{1F} = Material factor k_1 for the steel used for the flange

k_{1B} = Material factor k_1 for the steel used for the bolts

In any case, the thickness t_P is to be not less than 0,9.dB.

5.1.4 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

5.2 Couplings between rudder stocks and tillers

5.2.1 Application

The requirements of this sub-Article apply in addition to those specified in Section 12, E.4.2.

The requirements specified in 5.2.3 and 5.2.4 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 others than those above will be considered by TL on a case-by-case basis.

5.2.2 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.

5.2.3 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:

$$\Delta_0 \le \Delta_e \le \Delta_1$$

$$\Delta_0 = 6{,}2 \cdot \frac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot d_M \cdot t_S \cdot \mu_A \cdot \beta} \cdot 10^{-3}$$

$$\Delta_1 = \frac{2 \cdot \eta + 5}{1{,}8} \cdot \frac{\gamma \cdot d_0 \cdot R_{eH}}{c} \cdot 10^{-6}$$

η = coefficient

= 1 for keyed connections

= 2 for keyless connections

c = Taper of conical coupling measured on diameter, to be obtained from the following formula:

= $(d_U - d_0) / t_S$

t_S, d_U, d_0 = Geometrical parameters of the coupling, defined in Fig. 10.2

β = Coefficient

$$= 1 - \left(\frac{d_M}{d_E}\right)^2$$

d_M = Mean diameter [mm] of the conical bore, to be obtained from the following formula:

= $d_U - 0,5 \cdot c \cdot t_S$

d_E = External boss diameter [mm]

μ_A = Coefficient

$$= \sqrt{\mu^2 - 0,25 \cdot c^2}$$

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:

$\mu = 0,13$
$\gamma = 1,24 - 0,1 \cdot \beta$

R_{eH} = Defined in 2.4.3

5.2.4 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:

$$\frac{1,8}{2 \cdot \eta + 5} \cdot \frac{\Delta_E \cdot c}{\gamma \cdot d_0} \cdot 10^6 \le R_{eH}$$

Δ_E = Push-up length adopted [mm]

c, η, γ = Defined in 5.2.3

d_0 = Defined in Fig. 10.2

R_{eH} = Defined in 2.4.3

5.2.5 Cylindrical couplings by shrink fit

It is to be checked that the diametral shrinkage allowance δ_E is in compliance with the following formula:

$$\delta_0 \le \delta_e \le \delta_1$$

$$\delta_0 = 6,2 \cdot \frac{M_{TR} \cdot \eta \cdot \gamma}{d_U \cdot t_S \cdot \mu \cdot \beta_1} \cdot 10^{-3}$$

$$\delta_1 = \frac{2 \cdot \eta + 5}{1,8} \cdot \gamma \cdot d_U \cdot R_{eH} \cdot 10^{-6}$$

η, μ, γ = Defined in 5.2.3

d_U = Defined in Fig. 10.2

β_1 = Coefficient

$$= 1 - \left(\frac{d_U}{d_E}\right)^2$$

R_{eH} = Defined in 2.4.3

5.2.6 Keyless couplings through special devices

The use of special devices for frictional connections, such as expansible rings, may be accepted by TL 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.) is to be submitted to **TL**

- The torque transmissible by friction is to be not less than 2 . M_{TR}

- Design conditions and strength criteria are to comply with 5.2.1

- Instructions provided by the manufacturer are to be complied with, notably concerning the prestressing of the tightening screws.

5.3 Cone couplings between rudder stocks and rudder blades

5.3.1 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:

$$\frac{1}{12} \le \frac{d_U - d_0}{t_S} \le \frac{1}{12}$$

- for cone couplings with hydraulic arrangements for assembling and disassembling the coupling (assembling with oil injection and hydraulic nut):

$$\frac{1}{20} \le \frac{d_U - d_0}{t_S} \le \frac{1}{12}$$

d_U, t_S, d_0 = Geometrical parameters of the coupling, defined in Fig. 10.2.

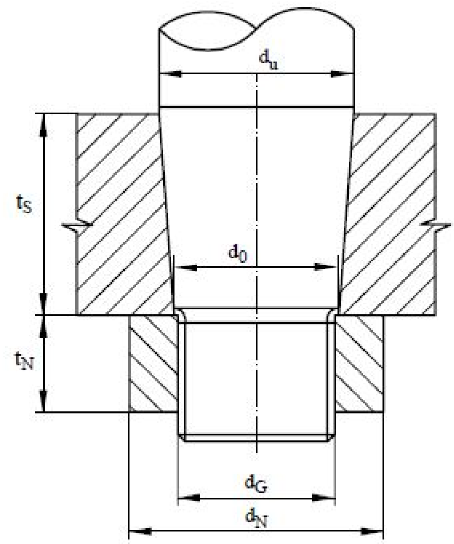


Fig. 10.2 Geometry of cone coupling

5.3.2 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 ΔE 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 Δ_0 and Δ_1 are to be obtained from the formulae in Table 10.2.

5.3.3 Lower rudder stock end

The lower rudder stock end is to be fitted with a threaded part having a core diameter, d_G [mm] not less than:

$$d_G = 0{,}65 \cdot d_1$$

d_1 = Rudder stock diameter defined in 4.1.2.

This threaded part is to be fitted with an adequate slogging nut efficiently locked in rotation.

The dimensions of the massive part and slogging nut are to be in accordance with the following formulae:

$$t_S \ge 1{,}5 \cdot d_1$$

$$d_E \ge d_M + 0{,}6 \cdot d_1$$

$$t_N \ge 0{,}60 \cdot d_G$$

$$d_N \ge 1{,}2 \cdot d_0 \text{ and, in any case, } d_N \ge 1{,}5 \cdot d_G$$

d_1 = Rudder stock diameter defined in 4.1.1

d_E = External diameter [mm] of the massive part of Fig. 10.2, having the thickness t_S

d_M = Mean diameter [mm] of the conical bore, as defined in 5.2.3

t_S, d_G, t_N d_N, d_0 = Geometrical parameters of the coupling, defined in Fig. 10.2

The above minimum dimensions of the locking nut are only given for guidance, the determination of adequate scantlings being left to the designer.

5.3.4 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 0,13 · d_G and an outer diameter not less than 0,13 · d_0 or 1,6 · d_G , whichever is the greater.

5.3.5 Key

For cone couplings without hydraulic arrangements for assembling and disassembling the coupling, a key is to be fitted having a section of (0,25 · d_T · x · 0,10 · d_T) [mm^2] 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 halfthickness into stock and into the solid part of the rudder.

For cone couplings with hydraulic arrangements for assembling and disassembling the coupling, the key may be omitted. In this case the designer is to submit to **TL** shrinkage calculations supplying all data necessary for the relevant check.

5.3.6 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.

5.4 Vertical flange couplings

5.4.1 Vertical flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained [mm], from the following formula:

$$d_B = \frac{0{,}81 \cdot d_1}{\sqrt{n_B}} \cdot \sqrt{\frac{k_{1B}}{k_{1S}}}$$

d_1 = Rudder stock diameter [mm], defined in 4.1.2

k_{1S}, k_{1B} = Material factors, defined in 5.1.2

n_B = Total number of bolts, which is to be not less than 8

5.4.2 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 [cm3] from the following formula:

$$M_S = 0{,}43 \cdot d_1^3 \cdot 10^{-6}$$

d_1 = Rudder stock diameter [mm], defined in 4.1.2

5.4.3 The thickness of the coupling flange [mm] is to be not less than d_B, defined in 5.4.1.

5.4.4 The distance [mm] from the bolt axes to the external edge of the coupling flange is to be not less than 1,2 dB, where dB is defined in 5.4.1.

5.4.5 A suitable locking device is to be provided to prevent the accidental loosening of nuts.

5.5 Couplings by continuous rudder stock welded to the rudder blade

5.5.1 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 4.1.2.

5.5.2 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 nondestructive inspection through dye penetrant or magnetic particle test and ultrasonic testing.

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 4.1.2.

5.6 Skeg connected with rudder trunk

In case of a rudder trunk connected with the bottom of a skeg, the throat weld is to be concave shaped to give a fillet shoulder radius as large as practicable. This radius is considered by TL on a case-by-case basis.

6. Rudder stock and pintle bearings

6.1 Forces on rudder stock and pintle bearings

6.1.1 Support forces F_{Ai}, for i = 1, 2, 3 are to be obtained according to 6.1.2 and 6.1.3.
The spring constant Z_C for the support in the sole piece (see Fig. 10.3) is to be obtained [N/m] from the following formula:

Table 10.2 Push-up length values

Rudder type	Δ_0	Δ_1
Rudder without intermediate pintles Spade rudders	The greater of : $-6{,}2 \cdot \dfrac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot d_M \cdot t_S \cdot \mu_A \cdot \beta} \cdot 10^{-3}$ $-16 \cdot \dfrac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot t_S^2 \cdot \beta} \cdot \sqrt{\dfrac{d_{IL}^6 - d_{IS}^6}{d_{Is}^6}} \cdot 10^{-3}$	$\dfrac{2 \cdot \eta + 5}{1{,}8} \cdot \dfrac{\gamma \cdot d_0 \cdot R_{eH}}{10^6 \cdot c \cdot (1 + p_1)}$
High lift profile and special rudder types	The greater of : $-6{,}2 \cdot \dfrac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot d_M \cdot t_S \cdot \mu_A \cdot \beta} \cdot 10^{-3}$ $-16 \cdot \dfrac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot t_S^2 \cdot \beta} \cdot \sqrt{\dfrac{d_{IL}^6 - d_{IS}^6}{d_{Is}^6}} \cdot 10^{-3}$ $-6{,}2 \cdot \dfrac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot d_M \cdot t_S \cdot \mu_A \cdot \beta} \cdot 10^{-3}$ $-18{,}4 \cdot \dfrac{M_F \cdot \eta \cdot \gamma}{c \cdot t_S^2 \cdot \beta} \cdot 10^{-3}$	The smaller of: $\dfrac{2 \cdot \eta + 5}{1{,}8} \cdot \dfrac{\gamma \cdot d_0 \cdot R_{eH}}{10^6 \cdot c \cdot (1 + p_1)}$ $\dfrac{2 \cdot \eta + 5}{1{,}8} \cdot \dfrac{\gamma \cdot d_0 \cdot R_{eH}}{10^6 \cdot c \cdot (1 + p_2)}$

$$p_1 = \frac{80 \cdot \sqrt{d_{IL}^6 - d_{IS}^6}}{R_{eH} \cdot d_M \cdot t_S^2 \cdot \left[1 - \left(\dfrac{d_0}{d_E}\right)^2\right]}$$

$$p_2 = \frac{7{,}4 \cdot M_F \cdot 10^3}{R_{eH} \cdot d_M \cdot t_S^2 \cdot \left[1 - \left(\dfrac{d_0}{d_E}\right)^2\right]}$$

R_{eH} = Defined in 2.4.3

M_F, M_T = Bending moment and torsional moment, respectively [Nm] provided by the manufacturer

d_{1L} = Rudder stock diameter d_{TF} [mm] calculated in way of the lower part of the rudder stock (between the top of the rudder plate and the lower bearing of the rudder stock) in compliance with 4.1.2, considering k_1 = 1

d_{1S} = Rudder stock diameter d_T [mm] calculated in way of the upper part of the rudder stock (at tiller level) in compliance with 4.1.1, considering k_1 = 1

η, c, β, d_M, d_E, μ_A, μ, γ = defined in 5.2.3

t_S, d_U, d_0 = Defined in Fig.10.2

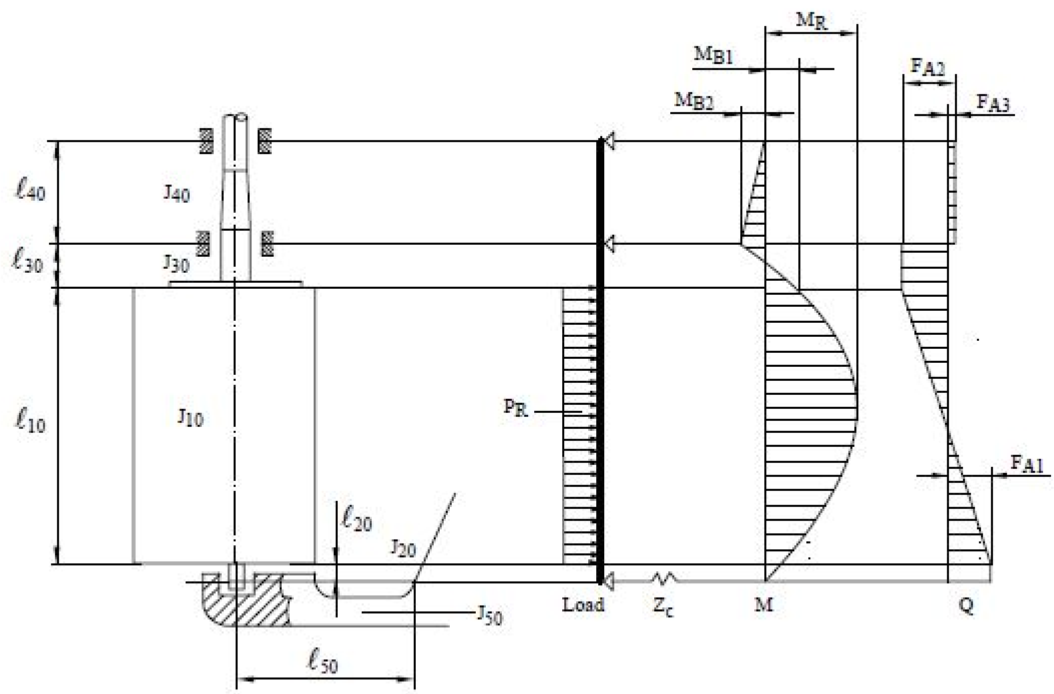


Fig. 10.3 Rudder supported by sole piece

$$Z_C = \frac{6{,}18 \cdot J_{50}}{\ell_{50}^3} \cdot 10^3$$

ℓ_{50} = Length [m] of the sole piece

$J5_0$ = Moment of inertia about the z axis [cm^4] of the sole piece

6.1.2 Rudder supported by sole piece

The rudder structure is to be calculated according to load, shear force and bending moment diagrams shown in Fig. 10.3.

The force per unit length p_R acting on the rudder body is to be obtained [N/m] from the following formula:

$$p_R = \frac{C_R}{\ell_{10}}$$

ℓ_{10} = height of the rudder blade [m]

The spring constant Z_c is to be calculated according to 6.1.1.

6.1.3 Spade rudders

The rudder structure is to be calculated according to load, shear force and bending moment diagrams shown in Fig. 10.4.

The force per unit length p_R acting on the rudder body is to be obtained [N/m] from the following formula:

$$p_{Rz} = p_{R1} + \left(\frac{p_{R2} - p_{R1}}{\ell_{10}} \right) \cdot z$$

z = Position of rudder blade section [m] taken over ℓ_{10} length

p_{Rz} = Force per unit length [N/m] obtained at the z position

p_{R1} = Force per unit length [N/m] obtained for z equal to zero

p_{R2} = Force per unit length [N/m] obtained for z equal to ℓ_{10}

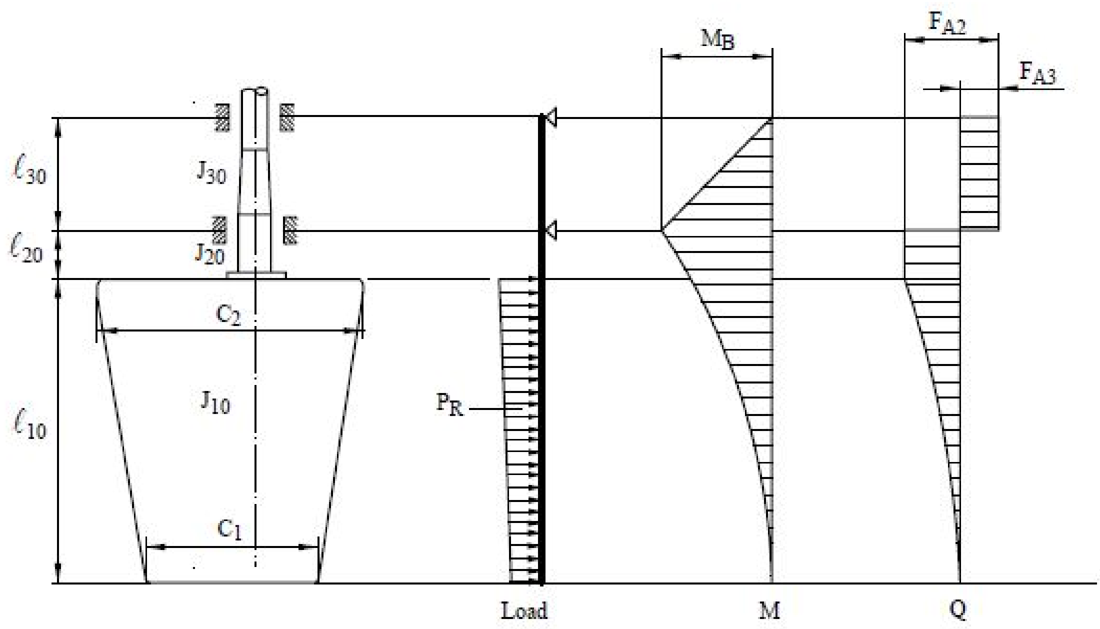


Fig. 10.4 Spade rudders

For this type of rudder, the results of calculations performed according to diagrams shown in Fig.10.4 may also be obtained from the following formulae:

– Maximum bending moment in the rudder stock [N.m]:

$$M_B = C_R \cdot \left[\ell_{20} + \frac{\ell_{10}(2 \cdot C_1 + C_2)}{3 \cdot (C_1 + C_2)} \right]$$

where C_1 and C_2 are the lengths [m] defined in Fig. 10.4

– Support forces [N]:

$$F_{A3} = \frac{M_B}{\ell_{30}}$$

$F_{A2} = C_R + F_{A3}$

– Maximum shear force in the rudder body [N]:

$Q_R = C_R$

6.2 Rudder stock bearing

6.2.1 The mean bearing pressure acting on the rudder stock bearing is to be in compliance with the following formula:

$$p_F \le p_{F,ALL}$$

p_F = Mean bearing pressure acting on the rudder stock bearings [N/mm2]

$$= \frac{F_{Ai}}{d_s \cdot h_m}$$

F_{Ai} = Force acting on the rudder stock bearing [N]

d_m = Actual inner diameter [mm] of the rudder stock bearings (contact diameter)

h_m = Bearing length [mm] (see 6.2.3)

$p_{F,ALL}$ = Allowable bearing pressure [N/mm2] defined in Table 10.3.

Values greater than those given in Table 10.3 may be accepted by **TL** on the basis of specific tests.

6.2.2 An adequate lubrication of the bearing surface is to be ensured.

6.2.3 The length/diameter ratio of the bearing surface is to be not greater than 1,2.

6.2.4 The manufacturing tolerance t_0 on the diameter of metallic supports is to be not less than the value obtained [mm] from the following formula:

$$t_0 = \frac{d_m}{1000} + 1$$

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, the tolerance on support diameter is to be not less than 1,5 mm.

Table 10.3 Allowable bearing pressure

Bearing material	$p_{F,ALL}$ [N/mm²]
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70 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* ***TL****.*

(2) *Stainless and wear-resistant steel in combination with stock liner approved by* ***TL****.*

6.3 Pintle bearings

6.3.1 The mean bearing pressure acting on the gudgeons is to be in compliance with the following formula:

$$p_F \le p_{F,ALL}$$

p_F = Mean bearing pressure acting on the gudgeons [N/mm²]

$$= \frac{F_{Ai}}{d_A \cdot h_L}$$

F_{Ai} = Force acting on the pintle [N] calculated as specified in 6.1

d_A = Actual diameter [mm] of the rudder pintles

h_L = Bearing length [mm] (see 6.3.3)

$p_{F,ALL}$ = Allowable bearing pressure [N/mm²] defined in Table 10.3

Values greater than those given in Table 10.3 may be accepted by **TL** on the basis of specific tests.

6.3.2 An adequate lubrication of the bearing surface is to be ensured.

6.3.3 The length/diameter ratio of the bearing surface is not to be less than 1 and not to be greater than 1,2.

6.3.4 The manufacturing tolerance t0 on the diameter of metallic supports is to be not less than the value obtained [mm] from the following formula:

$$t_0 = \frac{d_A}{1000} + 1$$

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, the tolerance on support diameter is to be not less than 1,5 mm.

6.4 Pintles

6.4.1 Rudder pintles are to have a diameter not less than the value obtained [mm] from the following formula:

$$d_A = \left(\frac{0{,}21 \cdot V_{AV}}{0{,}54 \cdot V_{AV} + 3} \cdot \sqrt{F_{Ai}} + 30 \right) \cdot \sqrt{k_1}$$

F_{Ai} = Force [N] acting on the pintle, calculated as specified in 6.1.1.

6.4.2 Provision is to be made for a suitable locking device to prevent the accidental loosening of pintles.

6.4.3 The pintles are to have a conical coupling with a taper on diameter in accordance with 5.3.1.

The conical coupling is to be secured by a nut the dimensions of which are to be in accordance with 5.3.3.

6.4.4 The length of the pintle housing in the gudgeon is to be not less than the value obtained [mm] from the following formula:

$$h_L = 0,35 \cdot \sqrt{F_{Ai} \cdot k_1}$$

F_{Ai} = Force [N] acting on the pintle, calculated as specified in 6.1.1.

The thickness of pintle housing in the gudgeon [mm] is to be not less than 0,25 d_A, where d_A is defined in 6.4.1.

7. Rudder blade scantlings

7.1 General

7.1.1 Application

The requirements in 7.1 to 7.5 apply to streamlined rudders and, when applicable, to rudder blades of single plate rudders.

7.1.2 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.

7.1.3 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.

7.2 Rudder blade plating

7.2.1 Plate thickness

The thickness of each rudder blade plate panel is to be not less than the value obtained [mm] from the following formula:

$$t_F = \left(5,5 \cdot s \cdot \beta \cdot \sqrt{T + 0,6 \cdot n + \frac{C_R \cdot 10^{-4}}{A}} + 1,5\right) \cdot \sqrt{k}$$

β = Coefficient

$$= \sqrt{1,1 - 0,5 \cdot \left(\frac{s}{b_L}\right)^2}$$

to be taken not greater than 1,0 if $b_L/s > 2,5$

s = Length [m] of the shorter side of the plate panel

b_L = Length [m] of the longer side of the plate panel

7.2.2 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 not less than the thickness t_F defined in 7.2.1, without being less than 1,2 times the thickness obtained from 7.2.1 for the attached side plating.

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.

7.2.3 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.

7.2.4 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 7.2.1. 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 Table 10.4.

7.2.5 Welding

The welded connections of blade plating to vertical and horizontal webs are to be in compliance with the applicable requirements of **TL**'s Rules for 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.

7.2.6 Rudder nose plate thickness

Rudder nose plates are to have a thickness not less than 1,25 t_F, where t_F is defined in 7.2.1.

In general this thickness need not exceed 22 mm, unless otherwise required in special cases to be considered individually by **TL**.

7.3 Connections of rudder blade structure with solid parts in forged or cast steel

7.3.1 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.

7.3.2 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 [cm^3] from the following formula:

$$w_S = c_S \cdot d_1^3 \cdot \left(\frac{H_E - H_X}{H_E}\right) \bullet \frac{k}{k_1} \cdot 10^{-4}$$

c_S = Cefficient

= 1,0 if there is no opening in the rudder plating

= 1,5 if there is an opening in the considered cross-section of the rudder

d_1 = Rudder stock diameter [mm] defined in 4.1.2

H_E = Vertical distance [m] between the lower edge of the rudder blade and the upper edge of the solid part

H_X = Vertical distance [m] between the considered cross-section and the upper edge of the solid part

k, k_1 = Material factors, defined in 2.4, for the rudder blade plating and the rudder stock, respectively

7.3.3 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 [m] from the following formula:

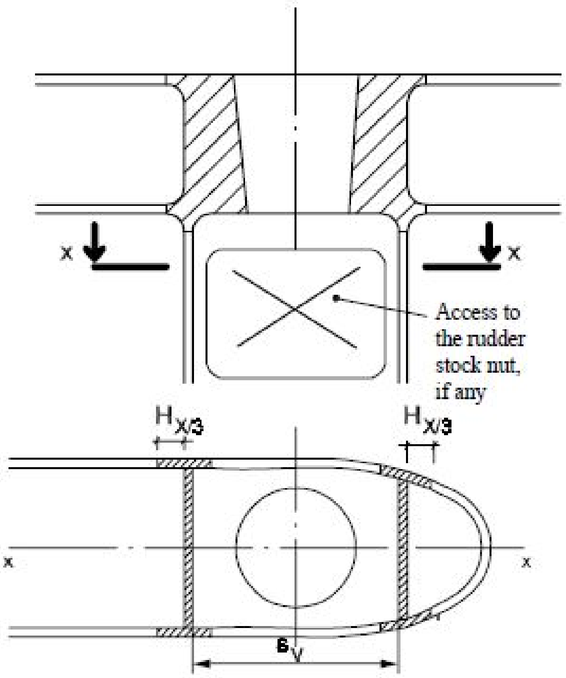
$$b = s_V + 2 \cdot \frac{H_X}{m}$$

s_V = Spacing [m] between the two vertical webs (see Fig. 10.5)

H_X = Distance defined in 7.3.2

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 7.1.3, they are to be deducted (see Fig. 10.5).



Section x-x

Fig. 10.5 Cross-section of the connection between rudder blade structure and rudder stock housing

7.3.4 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 [mm] from the following formulae:

$$t_H = 1{,}2 \cdot t_F$$

$$= 0{,}045 \cdot \frac{d_S^2}{s_H}$$

t_F = Thickness defined in 7.2.1

d_S = Diameter [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 [mm] defined in 4.1.2

d_A = Pintle diameter [mm] defined in 6.4.1

s_H = Spacing [mm] between the two horizontal web plates

Different thickness may be accepted when justified on the basis of direct calculations submitted to TL for review.

7.3.5 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 [mm] from Table 10.4.

7.3.6 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

7.4 Connection of the rudder blade with the rudder stock by means of horizontal flanges

7.4.1 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 [cm^3] from the following formula:

$$w_S = 1{,}3\ d_1^3\ 10^{-4}$$

where d_1 is the rudder stock diameters d_{TF} [mm] to be calculated in compliance with the requirements in 4.1.2, taking k_1 equal to 1.

7.4.2 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 7.3.3.

7.4.3 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.

7.4.4 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 [mm] from Table 10.4.

7.5 Single plate rudders

7.5.1 Mainpiece diameter

The mainpiece diameter is to be obtained from the formulae in 4.1.1 and 4.1.2.

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.

7.5.2 Blade thickness

The blade thickness is to be not less than the value obtained [mm] from the following formula:

$$t_B = \left(0{,}81 \cdot s \cdot V_{AV} + 2{,}5\right) \cdot \sqrt{k}$$

s = Spacing of stiffening arms [m] to be taken not greater than 1 m (see Fig. 10.6).

Table 10.4 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 [mm]		Thickness of rudder plating 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
t_F = defined in 7.2.1.				

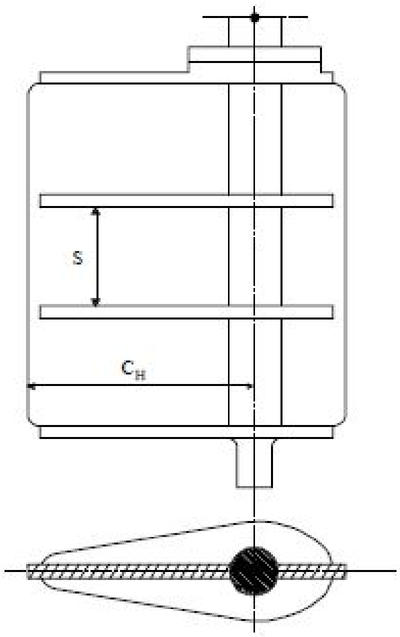


Fig. 10.6 Single plate rudder

7.5.3 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 [cm3] from the following formula:

$$Z_A = 0,15 \cdot s \cdot C_H^2 \cdot V_{AV}^2 \cdot k$$

C_H = Horizontal distance [m] from the aft edge of the rudder to the centreline of the rudder stock (see Fig. 10.6)

s = Defined in 7.5.2

8. Sole piece scantlings

8.1 General

8.1.1 The weight of the rudder is normally supported by a carrier bearing inside the rudder trunk.

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 Section 12, E.4.5 and/or Section 12, E.4.6.

8.1.2 The bottom plate connected to the stern frame sole piece shall have the following gross thickness t [mm] over a length of at least 5 m:

$$t = 1,3 \cdot \sqrt{L + 0,1 \cdot P_1}$$

P_1 = Maximum power [kW] of main engine driving the central propeller

Where equivalent measures are taken to constrain the sole piece in the body, these strengthening may be dispensed with.

8.2 Scantlings

8.2.1 Bending moment

The bending moment acting on the generic section of the sole piece is to be obtained [Nm] from the following formula:

$M_S = F_{A1} \cdot x$

F_{A1} = Supporting force [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:

= CR/2

x = Distance [m], defined in Fig. 10.7

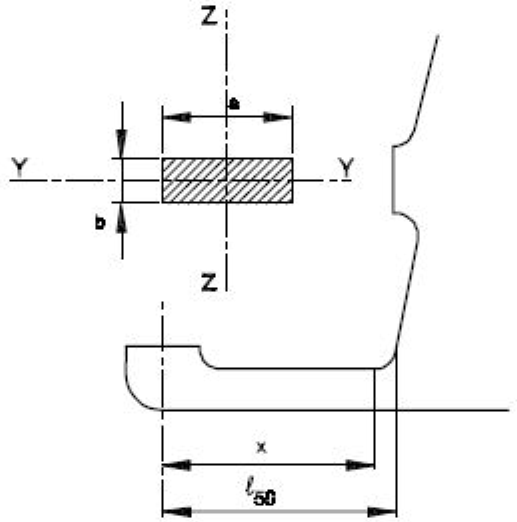


Fig. 10.7 Sole piece geometry

8.2.2 Strength checks

For the generic section of the sole piece within the length ℓ_{50}, defined in Fig. 10.7, it is to be checked that

$\sigma_E \le \sigma_{E,ALL}$

$\sigma_B \le \sigma_{B,ALL}$

$\tau \le \tau_{ALL}$

σ_E = Equivalent stress to be obtained [N/mm^2] from the following formula:

$$= \sqrt{\sigma_B^2 + 3\tau^2}$$

σ_B = Bending stress to be obtained [N/mm^2] from the following formula:

= M_S / W_Z

τ = Shear stress to be obtained [N/mm^2] from the following formula:

= F_{A1} / A_S

M_S = Bending moment at the section considered [N.m] defined in 8.2.1

F_{A1} = Force [N] defined in 8.2.1

W_Z = Section modulus [cm^3] around the vertical axis Z (see Fig. 10.7)

A_S = Shear sectional area in Y direction [mm^2]

$\sigma_{E,ALL}$ = Allowable equivalent stress [N/mm^2]
= $115 / k_1$

$\sigma_{B,ALL}$ = Allowable bending stress [N/mm^2]
= $80 / k_1$

τ_{ALL} = Allowable shear stress, in [N/mm^2]
= $48 / k_1$

8.2.3 Minimum section modulus around the horizontal axis

The section modulus around the horizontal axis Y (see Fig. 10.7) is to be not less than the value obtained [cm^3] from the following formula:

$W_Y = 0{,}5 \cdot W_Z$

Wz = Section modulus [cm^3] around the vertical axis Z

9. Steering nozzles

9.1 General

9.1.1 The following requirements apply to scantling steering nozzles for which the power transmitted to the propeller is less than the value obtained [kW] from the following formula:

$$P = \frac{16900}{d_M}$$

d_M = Inner diameter of the nozzle [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.

9.1.2 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, of greater thickness, is to be placed in way of the axis of rotation of the nozzle.

For nozzles with an inner diameter dM exceeding 3 m, the number of ring webs is to be suitably increased.

9.1.3 Care is to be taken in the manufacture of the nozzle to ensure the welded connection between plating and webs.

9.1.4 The internal part of the nozzle is to be adequately protected against corrosion.

9.2 Nozzle plating and internal diaphragms

9.2.1 The thickness of the inner plating of the nozzle is to be not less than the value obtained [mm] from the following formula:

$$t_F = (0{,}085 \cdot \sqrt{P \cdot d_M} + 9{,}65) \cdot \sqrt{k}$$

P, d_M = defined in 9.1.1.

The thickness t_F is to be extended to a length, across the transverse section containing the propeller blade tips, equal to one third 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.

9.2.2 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 9.2.1 and, in any case, not less than 7 mm.

9.2.3 The thicknesses of ring webs and longitudinal webs are to be not less than (t_F − 7) [mm] where t_F is defined in 9.2.1, 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 .

TL may consider reduced thicknesses where an approved stainless steel is used, in relation to its type.

9.3 Nozzle stock

9.3.1 The diameter of the nozzle stock is to be not less than the value obtained [mm] from the following formula:

$$d_{NTF} = 6{,}42 \cdot (M_T \ k_1)^{1/3}$$

M_T = torque, to be taken as the greater of those obtained [N.m] from the following formulae:

– $M_{TAV} = 0{,}3 \cdot S_{AV} \cdot a$

– $M_{TAD} = S_{AD} \cdot b$

S_{AV} = force [N]

= $43{,}7 \cdot V_{AV}^2 \cdot A_N$

S_{AD} = force [N]

= $58{,}3 \cdot V_{AD}^2 \cdot A_N$

A_N = area [m^2]

= $1{,}35.A_{1N} + A_{2N}$

A_{1N} = area [m^2]

= $L_M.d_M$

A_{2N} = area [m^2]

= $L_1.H_1$

a, b, L_M, d_M, L_1, H_1 = geometrical parameters of the nozzle [m] defined in Fig. 10.8

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 [mm] from the following formula:

$d_{NT} = 0{,}75.d_{NTF}$

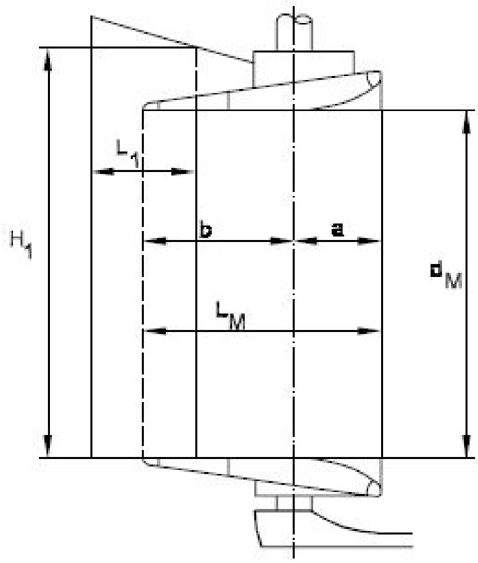


Fig. 10.8 Geometrical parameters of the nozzle

9.4 Pintles

9.4.1 The diameter of the pintles is to be not less than the value obtained [mm] from the following formula:

$$d_A = \left(\frac{0{,}19 \cdot V_{AV}}{0{,}54 \cdot V_{AV} + 3} \cdot \sqrt{S_{AV}} + 30 \right) \cdot \sqrt{k_1}$$

S_{AV} = Defined in 9.3.1

9.4.2 The length/diameter ratio of the pintle is not to be less than 1 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:

$p_F \leq p_{F,ALL}$

p_F = Mean bearing pressure acting on the gudgeon [N/mm^2] from the following formula:

$$= \frac{0{,}6 \cdot S'}{d'_A \cdot h'_A}$$

S' = The greater of the values S_{AV} and S_{AD} [N] defined in 9.3.1

d'_A = Actual pintle diameter [mm]

h'_A = Actual bearing length of pintle [mm]

$p_{F,ALL}$ = Allowable bearing pressure [N/mm^2] defined in Table 10.3

9.5 Nozzle coupling

9.5.1 Diameter of coupling bolts

The diameter of the coupling bolts is to be not less than the value obtained [mm] from the following formula:

$$d_B = 0{,}62 \cdot \sqrt{\frac{d_{NTF}^3 \cdot k_{1B}}{n_B \cdot e_M \cdot k_{1S}}}$$

d_{NTF} = Diameter of the nozzle stock [mm] defined in 9.3.1

k_{1S} = Material factor k1 for the steel used for the stock

k_{1B} = Material factor k1 for the steel used for the bolts

e_M = Mean distance [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 $d_{NTF} \geq 75$ 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 ($0{,}25 \cdot d_{NT} x \cdot 0{,}10 \cdot d_{NT}$) [mm^2], where d_{NT} is defined in 9.3.1, 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 $1{,}2.d_B$.

9.5.2 Thickness of coupling flange

The thickness of the coupling flange is to be not less than the value obtained [mm] from the following formula:

$$t_P = d_B \cdot \sqrt{\frac{k_{1F}}{k_{1B}}}$$

d_B = Bolt diameter [mm] defined in 9.5.1

k_{1B} = Material factor k_1 for the steel used for the bolts

k_{1F} = Material factor k_1 for the steel used for the coupling flange

9.5.3 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:

$\Delta_0 \le \Delta_E \le \Delta 1$

Δ_0 = the greater of:

– $$6{,}2 \cdot \frac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot d_M \cdot t_S \cdot \mu_A \cdot \beta}$$

– $$16 \cdot \frac{M_{TR} \cdot \eta \cdot \gamma}{c \cdot t_S^2 \cdot \beta} \cdot \sqrt{\frac{d_{NTF}^6 - d_{NT}^6}{d_{NT}^6}}$$

d_{NTF}, d_{NT} = Nozzle stock diameter [mm] to be obtained from the formula in 9.3.1, considering k1 = 1

η, c, β, d_M, d_E, μ_A, μ, γ = defined in 5.2.3

t_S, d_U, d_0 = Defined in Fig. 10.2

R_{eH} = Defined in 2.4.3

9.5.4 Locking device

A suitable locking device is to be provided to prevent the accidental loosening of nuts.

10. Azimuth propulsion system

10.1 General

10.1.1 Arrangement

The azimuth propulsion system is constituted by the following sub-systems (see Fig. 10.9):

– Steering unit

– Bearing

– Hull supports

– Rudder part of the system

– Pod, which contains the electric motor in the case of a podded propulsion system

10.1.2 Application

The following requirements 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 Section 12, E.

10.1.3 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 **TL** for azimuth propulsion systems during manoeuvres, provided that the orientation values together with the relevant speed values are submitted to **TL** for review.

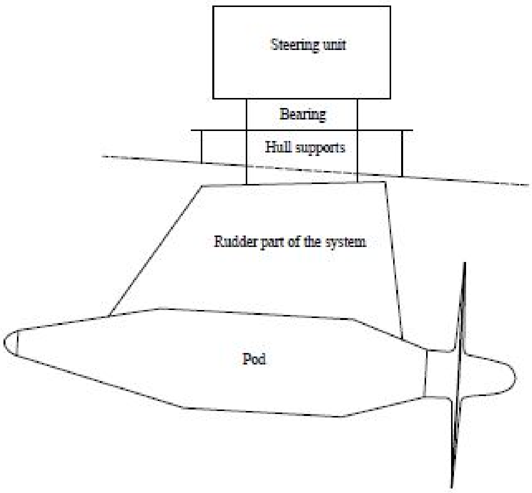


Fig. 10.9 Azimuth propulsion system

10.2 Arrangement

10.2.1 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 **TL** for review. The scantlings of the supports and the maximum loads which act on the supports are to be specified in these drawings.

10.2.2 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.

10.3 Primary supporting members

10.3.1 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 10.3.2

The direct calculation analyses (structural model, load and stress calculation, strength checks) carried out by the designer are to be submitted to TL for information.

10.3.2 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 10.1.3)

– 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

10.3.3 Strength check

It is to be checked that the Von Mises equivalent stress σ_E in primary supporting members, calculated [N/mm^2] for the load cases defined in 10.3.2, is in compliance with the following formula:

$$\sigma_E \le \sigma_{ALL}$$

σ_{ALL} = Allowable stress [N/mm^2] to be taken equal to the lesser of the following values:

– $0{,}275 \cdot R_m$

– $0{,}55 \cdot R_{eH}$

R_m = Tensile strength [N/mm^2] of the material, defined in Section 5, A.2.1

R_{eH} = Minimum yield stress [N/mm^2] of the material, defined in Section 5, A.2.1

10.4 Hull supports of the azimuth propulsion system

10.4.1 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 10.3.1.

10.4.2 Loads

The loads to be considered in the direct calculation of the hull supports of the azimuth propulsion system are those specified in 10.3.2.

10.4.3 Strength check

It is to be checked that the Von Mises equivalent stress σ_E in hull supports [N/mm^2] calculated for the load cases defined in 10.3.2, is in compliance with the following formula:

$$\sigma_E \leq \sigma_{ALL}$$

σ_{ALL} = Allowable stress [N/mm^2] equal to:

σ_{ALL} = 65 / k

k = Material factor, defined in Section 5, A.2.4

Values of σ_E greater than σ_{ALL} may be accepted by **TL** on a case-by-case basis, depending on the localisation of σ_E and on the type of direct calculation analysis.

B. Bulwarks and Guard Rails

1. General

1.1 The following requirements apply to the arrangement and scantling of bulwarks and guard rails provided at the boundaries of the main deck and superstructure deck.

2. Bulwark

On all cargo vessels, except pushed barges, bulwarks are to be fitted in way of the fore and aft ship, extending from the stem to the forward end of the foremost hatchway (forward cargo tank on tankers) and from the stern to the forward end of the aft deckhouse.

Between these two areas, a foot guard is to be fitted which is to rise at least 50 mm above the weather deck.

2.1 Height

2.1.1 Cargo carriers

The bulwark is to be at least 700 mm high. This may be required to be increased in way of the stem.

2.1.2 Passenger vessels

On passenger vessels, the bulwarks or guard rails are to be at least 1000 mm high on the decks open to passengers. In way of the after deckhouse, a similar height is to be arranged.

Openings and equipment for embarking or disembarking, and also openings for loading or unloading, shall be such that they can be secured.

2.2 Thickness

The bulwark gross thickness [mm] is not to be less than:

– $L \leq 30$ m: t = 4

– 30 m < $L \leq 90$ m: t = 5

– L > 90 m: t = 6

2.2.1 Bulwarks are to be aligned with the beam located below or connected to them by means of local transverse stiffeners.

Plate bulwarks are to be supported either by stays or plate brackets spaced not more than 2 m apart.

2.2.2 At its upper part, bulwarks are to be fitted with an efficient section acting as a handrail and supported by means of stays located, as far as practicable, in way of the beams.

3. Guard rails

In general, the guard rails have to be built in compliance with EN 711, as amended.

In case the bulwark height is less than the required guard rail height, a guard rail is to be placed on top of the bulwark.

Alternative guard rail designs and railing fillings made of glass may be used on the basis of individual examination.

C. Propeller Shaft Brackets

1. Symbols

F_C = force [kN]

$$= \left(\frac{2 \cdot \pi \cdot N}{60}\right)^2 \cdot R_P \cdot m$$

m = Mass of a propeller blade [t]

N = Number of revolutions per minute of the propeller

R_P = Distance [m] of the centre of gravity of a blade in relation to the rotation axis of the propeller

σ_{ALL} = Allowable stress [N/mm^2]:

= 70

w_A = Section modulus [cm^3] of the arm at the level of the connection to the hull with respect to a transversal axis

A = Sectional area [cm^2] of the arm

A_S = Shear sectional area [cm^2] of the arm

d_P = Propeller shaft diameter [mm] measured inside the liner, if any

2. General

2.1 Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

2.2 Strength check

2.2.1 General

The strength check is to be carried out according to 3., 4. or 5.

2.2.2 Vibration analysis

A vibration analysis according to Section 12, B.5. is recommended to be performed for single-arm propeller shaft brackets.

3. Double arm propeller shaft brackets

3.1 General

3.1.1 Both arms of detached propeller brackets are to form an angle α to each other that 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 **TL** on a caseby-case basis.

3.1.2 Scantlings of arms

The moment in the arm [kN.m] is to be obtained from the following formula:

$$M = \frac{F_C}{\sin\alpha} \cdot \left(\frac{L}{\ell} \cdot d_1 \cdot \cos\beta + L - \ell \right)$$

α = Angle between the two arms

β = Angle defined in Fig. 10.10

d_1 = Distance [m] defined in Fig. 10.10

L, ℓ = Lengths [m] defined in Fig. 10.11

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:

$$\sqrt{(\sigma_F + \sigma_N)^2 + 3 \cdot \tau^2} \le \sigma_{ALL}$$

$$\sigma_F = \frac{M}{w_A} \cdot 10^3$$

$$\sigma_N = 10 \cdot F_C \cdot \frac{L \cdot \sin\beta}{A \cdot \ell \cdot \sin\alpha}$$

$$\tau = 10 \cdot F_C \cdot \frac{L \cdot \cos\beta}{A_S \cdot \ell \cdot \sin\alpha}$$

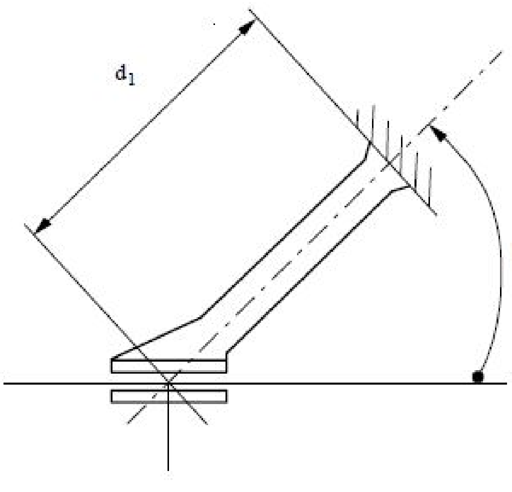


Fig. 10.10 Angle β and length d_1

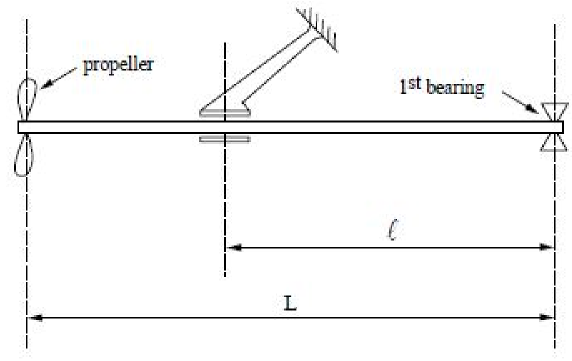


Fig. 10.11 Lengths L and ℓ

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 Section 12, B.2.6.2).

The thickness of the propeller shaft bossing is to be not less than 0,33 · d_P.

3.1.4 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.

4. Single arm propeller shaft brackets

4.1 Scantlings

4.1.1 This type of propeller shaft bracket consists of one arm.

4.1.2 Scantlings of arms

The moment in case of a vertical single arm [kN.m] is to be obtained from the following formula:

$$M = d_2 \cdot F_C \cdot \frac{L}{\ell}$$

d_2 = Length of the arm [m] measured between the propeller shaft axis and the hull

L, ℓ = Lengths [m] defined in Fig. 10.11

It is to be checked that the bending stress σ_F and the shear stress τ are in compliance with the following formula:

$$\sqrt{\sigma_F^2 + 3\tau^2} \leq \sigma_{ALL}$$

$$\sigma_F = \frac{M}{w_A} \cdot 10^3$$

$$\tau = 10 \cdot F_C \cdot \frac{L}{A_S \cdot \ell}$$

4.1.3 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 Section 12, B.2.6.2).

The thickness of the propeller shaft bossing is to be not less than 0,33 . d_P.

4.1.4 Bracket arm attachments

The connection of bracket arms to the hull structure is to comply with 3.1.4.

5. Bossed propeller shaft brackets

5.1 General

Where bossed propeller shaft brackets are fitted, their scantlings are to be considered by TL on a case-bycase basis.

5.2 Scantling of the boss

The length of the boss is to be not less than the length of the aft sterntube bearing bushes (see Section 12, B.2.6).

The thickness of the boss [mm] is to be not less than 0,33 d_P.

The aft end of the bossing is to be adequately supported.

5.3 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.

5.4 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

D. Equipment

1. Symbols

P = Required bow anchor weight [kg]

P_i = Increased required bow anchor weight [kg]

L_{OA} = Length over all of the vessel [m]

B = Breadth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

R = Minimum breaking load of anchor chain cable [kN]

R_S = Minimum breaking load of mooring cables [kN]

2. General

2.1 General requirements

2.1.1 The following requirements provide the quipment in anchors, chain cables and ropes for ranges of navigation **I (0)**, **I (0,6)**, **I (1,2)** and **I (2)** defined in Section 2.

2.1.2 The towline and the mooring lines are given as a guidance, but are not required as a condition of Classification.

2.1.3 Vessels built under TL's supervision and which are to have the character + stated in their certificate and in the register book have to be equipped with anchors and chain cables complying with TL's Rules for Materials and Welding and having been tested on approved machines in the presence of a Surveyor.

2.1.4 The required equipment of anchors, chain cables, ropes and cables of the vessels trading on the inland waterways has to be determined according to 3. to 5.

2.1.5 **T**L, taking into account the conditions on the inland water concerned, may consent to a reduction in equipment for vessel intended for use only in a certain area of inland water provided that a note of this river system or inland water is appended to the Character of Classification.

2.1.6 Barges to be carried aboard sea going ships

Barges to be carried aboard sea going ships are to be exempted from the anchor equipment requirements.

3. Anchors

3.1 General

3.1.1 Anchors shall be of an approved type.

3.1.2 Cast iron anchors shall not be permitted.

3.1.3 The weight of the anchors shall stand out in relief in a durable manner.

3.1.4 Anchors having a weight in excess of 50 kg shall be equipped with windlasses.

3.2 Bow anchors

3.2.1 Cargo carriers

The total weight P of the bow anchors of cargo carriers shall be calculated by the following formula:

$$P = k \cdot B \cdot T$$

$$k = c \cdot \left(\frac{L_{OA}}{8 \cdot B}\right)^{0,5}$$

= c for pushed barges

c = Coefficient defined in Table 10.5.

Table 10.5 Coefficient c

Deadweight	Coefficient
≤ 400 t	45
> 400 t ≤ 650 t	55
> 650 t ≤ 1000 t	65
> 1000 t	70

3.2.2 Anchors for 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 weight P is obtained from the following formula:

$$P = k \cdot B \cdot T$$

k = Coefficient corresponding to 3.2.1 but where, in order to obtain the value of the empirical coefficient c, the maximum displacement [m^3] shall be taken instead of the deadweight tonnage

3.2.3 Increased bow anchor weight

For passenger vessels and for vessels having a large windage area (container vessels) it is recommended to increase the bow anchor weight as follows:

$$P_i = P + 4 \cdot A_f$$

A_f = Transverse profile view (windage area) of the hull above waterline at the draught T [m^2]

For calculating the area A_f all superstructures, deckhouses and cargoes (e.g. containers) having a breadth greater than B/4 are to be taken into account.

3.2.4 For vessels navigating in **I (0)** and **I (0,6)**, where the current velocity is lower than 6 km/h, the anchor weights according to 3.2.1 to 3.2.3 may be reduced by 13 %.

3.3 Stern anchors

3.3.1 The vessels referred to in 3.2.1 shall be fitted with stern anchors whose total weight is equal to 25 % of the weight P calculated in accordance with that figure.

3.3.2 Vessels whose maximum length exceeds 86 m shall, however, be fitted with stern anchors whose total weight is equal to 50 % of the weight P or P_i calculated in accordance with 3.2.1 to 3.2.3.

3.3.3 Pushers

Vessels intended to propel rigid convoys not more than 86 m in length shall be fitted with stern anchors whose total weight is equal to 25 % of the maximum weight P calculated in accordance with 3.2.1 for the largest formation considered as a nautical unit.

3.3.4 Vessels intended to propel downstream rigid convoys that are longer than 86 m shall be fitted with stern anchors whose total weight equals 50 % of the greatest weight P calculated in accordance with 3.2.1 for the largest formation considered as a nautical unit.

3.3.5 The following vessels are exempted from the stern anchor requirement:

– Vessels for which the stern anchor weight will be

Less than 150 kg

– Pushed lighters

3.4 Weight reduction

The anchor weights established in accordance with 3.2.1 to 3.3.4 may be reduced for certain special anchors. The following types of anchors have so far been recognised by **TL** as "high-holding-power anchors"; see Table 10.6.

3.5 Number of anchors

The total weight 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 hawse 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 weight of the lightest anchor should be not less than 45 % of that total weight.

Table 10.6 Recognized types of anchors

Type of anchors	Weight 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 %

4. Chain cables

4.1 General

4.1.1 Chains true to gauge size are to be used as anchor chain cables.

4.1.2 Short-link or stud-link chain cables may be used as anchor chain cables.

4.2 Minimum breaking loads

4.2.1 The minimum breaking load of chain cables shall be calculated by the formulae given in Table 10.7.

For the breaking loads of short-link chains and studlink chains, see Table 10.11 and Table 10.12, respectively.

4.2.2 Where the anchors have a weight greater than that required in 3.2.1 to 3.3.4, the breaking load of the anchor chain cable shall be determined as a function of the actual anchor weight.

Table 10.7 Minimum breaking loads R of chain cables

Anchor weight [kg]	R [kN]
≤ 500	R= 0,35 P'
> 500 and ≤ 2000	$R = \left(0{,}35 - \frac{P'-500}{15000}\right)P'$
> 2000	R= 0,25 P'
P' = theoretical weight of each anchor determined in accordance with 3.2, 3.3 and 3.5	

4.2.3 The attachments between anchor and chain shall withstand a tensile load 20 % higher than the tensile strength of the corresponding chain.

4.3 Length of chain cables

4.3.1 Bow anchor chain cables

For the minimum length of bow anchor chain cables, see Table10.8.

Table 10.8 Minimum length of bow anchor chain Cables

Overall length L_{OA} of the vessel [m]	Minimum length of chain cables [m]	
	I (0) to I (0,6)	I (1,2) to I (2)
< 30	ℓ = 40	ℓ = L_{OA} + 10
≥ 30 and ≤ 50	ℓ = L_{OA} + 10	
> 50	ℓ = 60	

4.3.2 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.

4.3.3 Steel wire ropes

In special cases steel wire ropes may be permitted instead of anchor chain cables. The wire ropes are to have at least the same breaking strength as the required anchor chain cables, but shall be 20 % longer.

5. Mooring and towing equipment

5.1 Ropes

5.1.1 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 tank vessels carrying inflammable liquids steel wire ropes only are to be used for mooring purposes.

5.1.2 Ropes and cables shall preferably be of the following type:

– 6 × 24 wires + 7 fibre cores for towing ropes and mooring lines

– 6 × 37 wires + 1 fibre core for warps

5.1.3 Pushed barges

Pushed barges are to be equipped with at least four wire ropes having a theoretical breaking load of 440 . kN instead of the towing ropes.

5.1.4 Mooring cables

It is recommended at least mooring cables as defined in Table 10.9 and Table 10.10.

Table 10.9 Mooring cables

Mooring cable	Minimum length of cable [m]
1st cable	$\ell' = MIN(\ell_1; \ell_2)$ $\ell_1 = L_{OA} + 20$ $\ell_2 = \ell_{max}$
2nd cable	$\ell'' = 2/3 \cdot \ell'$
3rd cable **(1)**	$\ell'' = 1/3.\ell'$
ℓ_{max} = 100 m **(1)** *This cable is not required on board of vessels whose L_{OA} is less than 20 m.*	

Table 10.10 Minimum breaking load R_S of mooring cables

$L_{OA} \cdot B \cdot T$	R_S [kN]
≤ 1000 m³	$R_S = 60 + \frac{L_{OA} \cdot B \cdot T}{10}$
> 1000 m³	$R_S = 150 + \frac{L_{OA} \cdot B \cdot T}{10}$

5.1.5 Towing cables

Self propelled barges and pushers that are also able to tow shall be equipped with an at least 100 m long towing cable whose tensile strength [kN] is not less than one quarter of the total power [kW] of the power plant(s).

5.1.6 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 [kN] not less than one third of the total power [kW] of the power plant(s).

5.2 Bollards

5.2.1 Every vessel has to be equipped with one double bollard each on the fore and after 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 after body on port and starboard side.

6. Hawse pipes and chain lockers

6.1 Arrangements

6.1.1 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.

6.1.2 The fore ship of the vessels shall be built in such a way that the anchors do not stick out of the side shell.

6.1.3 All mooring units and accessories, such as timbler, riding and trip stoppers, are to be securely fastened to the Surveyor's satisfaction.

6.1.4 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.

6.2 Hawse pipe scantlings

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
  $t = t_0$

t_0 = gross thickness of adjacent shell plating [mm]

Table 10.11 Breaking loads [kN], for short-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
10	20	40	28	56	40	80
13	32	63	45	90	63	125
16	50	100	71	140	100	200
18	63	125	90	180	125	250
20	80	160	110	220	160	320
23	100	200	140	280	200	400
26	125	250	180	360	250	500
28	140	280	200	400	280	560
30	180	360	250	500	360	710
33	200	400	280	560	400	800
36	250	500	360	710	500	1000
39	280	560	400	800	560	1100
42	320	630	450	900	630	1250

Table 10.12 Breaking loads [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
12,5	46	66	66	92	92	132
14	58	82	82	116	116	165
16	76	107	107	150	150	216
17,5	89	127	127	179	179	256
19	105	150	150	211	211	301
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	981	981	1400
44	538	769	769	1080	1080	1540
46	585	837	837	1170	1170	1680
48	635	908	908	1270	1270	1810

E. Cranes and Bunker Masts

1. General

1.1 Application

1.1.1 The lifting appliances are not covered by Classification. Therefore, the following rules are to be considered as recommendations. However, they are to comply with national and/or international Regulations.

1.1.2 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.

1.1.3 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.

1.2 Arrangement

It is to be possible to lower the crane boom or the derrick structure and to secure them to the vessel during the voyage.

2. Hull girder strength

2.1 General

The hull girder strength is to be checked when the lifting appliance is operated, taking into account the various loading conditions considered, through criteria to be agreed with **TL**.

3. Hull scantlings

3.1 Loads transmitted by the lifting appliances

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 **TL**.

3.2 Vessel's structures

The vessel's structures, subjected to the forces transmitted by the lifting appliances, are to be reinforced to **TL**'s satisfaction.

F. Barge Coupling Devices

1. General

1.1 Application

1.1.1 Pushed barges and pushers/self-propelled vessels intended to push other vessels are to comply with the following requirements.

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 3.1).

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 device, having a width not smaller than two thirds of its breadth.

2.2 Pushing transoms

Pushing transoms, at the stem of the pushing vessel and the stern of the barge, are to be arranged as a box securely attached to the vessel structure by means of horizontal and vertical web plates. As a rule, the box plating thickness is not to be less than 10 mm.

These boxes are to be arranged in following way:

– Exterior vertical plates: front walls with thickness not less than 18-20 mm and side walls with thickness of not less than 12 mm

– Horizontal plates: 8 mm

– Inner web plates: 8 mm

– Strengthening of the hull by means of a doubling plate of thickness not less than 10 mm

Attention is to be paid that this box is not supported by elements thinner and of 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.

3. Coupling devices

3.1 General

The coupling devices are to be fixed on deck, which is to be locally reinforced. The reinforcements are to be checked under the loads transmitted to the deck. These loads are to be indicated by the designer.

3.2 Connection force

For pushing in two positions, the horizontal load at the connection between the pusher and the barge [kN] may be obtained using the following formula:

$$R = \frac{0{,}266 \cdot P \cdot L}{B}$$

L = Length [m] of the pusher

B = Breadth [m] of the pusher

P = Total break horse power [kW] of the propelling installation

3.3 Cables

3.3.1 Types

The cables are recommended to be one of the following types:

– 1370 N/mm^2 steel, 114 wires (6 × 19) with 6 strands and central fibre or metal core, for breaking loads of less than 147 kN

– 1370 N/mm^2 steel, 144 wires (6 × 24) with 6 strands and 7 fibre cores, for breaking loads between 147 kN and 490 kN included

– 1570 N/mm^2 steel, 222 wires (6 × 37) with 6 strands and central fibre core, for breaking loads greater than 490 kN

The cables are to be joined at their end or equipped with a sleeve.

3.4 Bollards

3.4.1 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.

3.4.2 Diameter

The diameter of the bollards is to be not less than 15 times the diameter of the cable.

3.4.3 Spacing

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.

SECTION 11

HULL DESIGN and CONSTRUCTION - CONSTRUCTION and TESTING

A. Welding and Weld Connections

1. General

1.1 Application

1.1.1 The following requirements apply for the preparation, execution and inspection of welded connections in new construction, conversion or repair in hull structures.

If no separate requirements and remarks for welding in the individual areas as mentioned before are specified in this Rule, the requirements and conditions have to comply with the applicable requirements of **TL**.

The general requirements relevant to fabrication by welding and qualification of welding procedures are given in the relevant sections of **TL** Rules for Welding.

1.1.2 Weld connections are to be executed according to the reviewed/approved plans. A detail not specifically represented in the plans is, if any, to comply with the applicable requirements.

All materials shall be of proven weldability. They shall be chosen in accordance with the intended application and the conditions of service. Their properties shall be documented to the specified extent by test certificates.

1.1.3 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.

1.1.4 The range of approval for welding applied by the Building Yard is to be submitted to **TL** and applies to all constructions.

1.1.5 The adoption of welding procedures is dependent on their previous qualification by **TL**. In addition, individual builders are to hold an authorization by **TL** to use these procedures, employing welders qualified by **TL**.

The Building Yards and the companies, including branches and suppliers, which perform welding Works within the scope of these Rules, have to demonstrate

the fulfilment of the welding technical quality requirements according to **TL** Rules. The welding technical quality requirements can be effected by evidence of fulfilment according to EN 729 / ISO 3834 in connection with a quality assurance system according to EN 29000 / ISO 9000.

1.2 Base material

1.2.1 The following requirements apply for the welding of hull structural steels or aluminium alloys of the types considered in Section 5, A. or other types accepted as equivalent by **TL**.

Materials to be used according to 1.1 are to be tested in compliance with the applicable provisions. Quality and testing requirements for materials covered here are outlined in **TL** Rules for Materials.

1.2.2 The service temperature is intended to be the ambient temperature, unless otherwise stated.

1.3 Welding consumables and procedures

1.3.1 Approval of welding consumables and procedures

Welding consumables and welding procedures adopted are to be approved by **TL**.

The requirements for the approval of welding consumables and welding procedures for the individual users are given in **TL** Rules for Welding. The approval of the standard welding procedures is not required in the case of manual metal arc welding with approved welding consumables and auxiliaries for the steel grades A to D, except in the case of one side welding and welding in position vertical down (PG).

Standard welding procedures are: shielded metal-arc welding (SMAW) process no.111, metal-arc active gas welding (GMAW) process no.135, fluxed-cored wire metal-arc welding with active gas shield (FCAW) process no.136, submerged arc welding with wire electrode (SAW) process no.121 and tungsten inert gas arc welding (TIG) process no.141.

Note

Welding processes according to ISO 4063 and welding positions according to ISO 6947.

1.3.2 Consumables

For welding of hull structural steels, the minimum consumable grades to be adopted are specified in Table 11.1 depending on the steel grade.

It is recommended to use consumables for manual or semiautomatic welding (covered electrodes, fluxcored and fluxcoated wires) of higher strength hull structural steels which are at least of hydrogencontrolled grade H15. Where the carbon equivalent C_{eq} is not more than 0,40 % and the thickness is below 50 mm, tested and approved welding consumables by **TL** according to Table 11.1 shall be used.

Especially, welding consumables with hydrogencontrolled grade H15 and H10 shall be used for welding hull steel forgings and castings of respectively ordinary strength level and higher strength level.

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-baking, ...) hydrogen-controlled grade.

The condition and remarks of welding consumables manufacturers have to be observed.

1.4 Personnel and equipment

1.4.1 Depending on the importance of the Building Yard, welding shops or branches shall have at least one fully qualified welding supervisor and one deputy welding supervisor, who are responsible for ensuring that the welding work is competently performed. The welding education of the welding supervisor has to be demonstrated to **TL**.

1.4.2 Welders

Manual and semi-automatic welding is to be performed by welders certified by **TL**. Welders for manual and semi-mechanized welding shall have passed a test which shall comply with the applicable **TL** Rules for Welding.

Table 11.1 Correlation of welding consumables and auxiliary materials to hull steel grades

Steel grade	Quality grades of welding consumables and auxiliary materials
A	1, 1Y, 2, 2Y, 3, 3Y
B,D	2, 2Y, 3, 3Y
AH32-AH36	2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40
DH32-DH36	
A40,D40	2Y40, 3Y40, 4Y40

Notes

- *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.*
- *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.*
- *When joining normal to higher strength structural steel, consumables of the lowest acceptable grade for either material being joined may be used. When joining steels of the same strength level but of different toughness grade, consumables of the lowest acceptable grade for either material being joined may be used.*
- *It is recommended for welding of plates with thickness over 50 mm and up to 70 mm to use one quality grade higher and for welding of plates with thickness over 70 mm to use two quality grades higher.*

1.4.3 Automatic welding operators

Operators of fully mechanized or automatic welding equipment and of welding robots shall have been trained in the use of the equipment. They shall also be capable of setting or programming and operating the equipment in such a way that the required weld quality is achieved. The qualification of such personnel shall have passed a test which shall comply with the applicable **TL** Rules for Welding.

1.4.4 Organisation

The internal organisation of the Building Yard, is to be such as to ensure compliance with the requirements in 1.4.2 and 1.4.3 and to provide for assistance and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

1.4.5 NDT operators

Non-destructive tests are to be carried out by qualified personnel, certified by **TL**, or by recognised bodies in compliance with appropriate standards.

The qualifications are to be appropriate to the specific applications.

1.4.6 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 **TL** calibrated measuring instruments, enabling easy and accurate reading, and adequate devices for easy regulation and regular feed.

1.5 Documentation to be submitted

1.5.1 The structural plans to be submitted for review/approval according to Section 4, A., 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.

1.5.2 A plan showing the location of the various steel types is to be submitted at least for outer shell, deck and bulkhead structures.

1.6 Design

1.6.1 General

For the various structural details typical of welded construction in shipbuilding and not dealt with in the following, the rules of good practice, recognised standards and past experience are to apply as agreed by **TL**.

1.6.2 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 **TL** on a case-by-case basis; tests as deemed necessary (for example, transverse impact tests) may be required by **TL**.

1.6.3 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.

1.6.4 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.

1.6.5 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 [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. 11.1. 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.

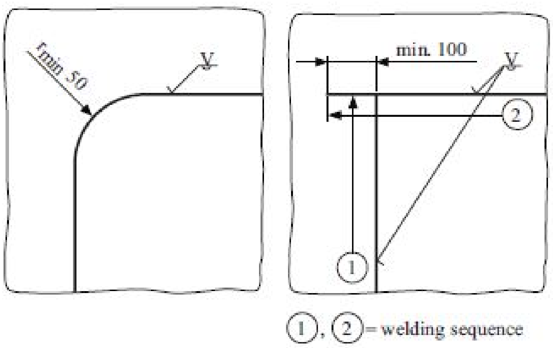


Fig. 11.1 Corners of socket weldments

2. Type of connections and preparation

2.1 General

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 **TL**, are adopted.

Connections different from the above may be accepted by **TL** on a case-by-case basis; in such cases, the relevant detail and workmanship specifications are to be approved by **TL**.

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. 11.2):

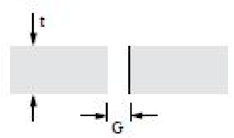
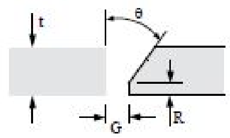
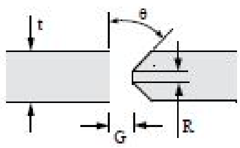
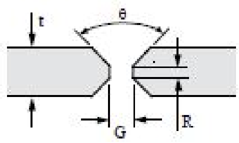
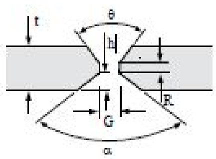
- 3 mm if $t_1 \leq 10$ mm
- 4 mm if $t_1 > 10$ mm,

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.

Table 11.2 Typical butt weld plate edge preparation (manual welding) - See Note

Detail	Standard
Square butt 	t ≤ 5 mm G= 3 mm
Single bevel butt 	t > 5 mm G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°
Double bevel butt 	t > 19 mm G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°
Double vee butt, uniform bevels 	G ≤ 3 mm R ≤ 3 mm 50° ≤ θ ≤ 70°
Double vee butt, non-uniform bevels 	G ≤ 3 mm R ≤ 3 mm 6 ≤ h ≤ t/3 mm θ = 50° α = 90°
Note *Different plate edge preparation may be accepted or approved by **TL** on the basis of an appropriate welding procedure specification.*	

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.

2.2.3 Butt welding edge preparation

Typical butt weld plate edge preparation for manual welding is specified in Table 11.2 and Table 11.3.

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 **TL**.

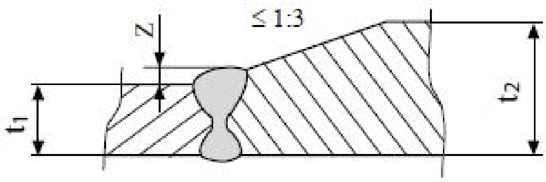


Fig. 11.2 Transition between different component dimensions

2.2.5 Section, bulbs and flat bars

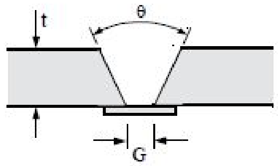
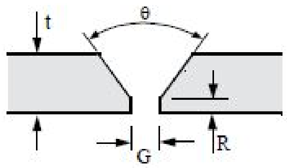
When lengths of longitudinals of the shell plating and strength deck within 0,6 . L amidships, or elements in general subject to high stresses, are to be connected together by butt joints, these are to be full penetration.

Other solutions may be adopted if deemed acceptable by **TL** 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 **TL**.

Welding of bulbs without a doubler is to be performed by welders specifically certified by **TL** for such type of welding.

Table 11.3 Typical butt weld plate edge preparation (manual welding) - See Note

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 *Different plate edge preparation may be accepted or approved by **TL** on the basis of an appropriate welding procedure specification.*	

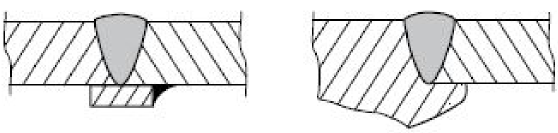


Fig. 11.3 Butt welding on permanent backing

2.3 Fillet welding

2.3.1 General

In general, ordinary fillet welding (without bevel) may be adopted for T connections of the various simple and composite structural elements, where they are subjected to low stresses (in general not exceeding 30 N/mm^2) and adequate precautions are taken to prevent the possibility of local laminations of the element against which the T web is welded.

Where this is not the case, partial or full T penetration welding according to 2.4 is to be adopted. This applies particularly to members over 12 mm in thickness constituting the whole or part of the engine seatings.

Further the special requirements in the different application range of **TL** have to be observed.

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.

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
- Where end brackets are fitted, in way of brackets and at least 50 mm beyond the bracket toes
- 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 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 [mm] of an intermittent weld, shown in:

- Fig. 11.4 for chain welding
- Fig. 11.5 for scallop welding
- Fig. 11.6 for staggered welding,

are to be such that:

$$\frac{p}{d} \le \varphi$$

where the coefficient φ is defined in Table 11.4 and Table 11.5 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.

In addition, the following limitations are to be complied with:

- chain welding (see Fig. 11.4):

  $d \ge 75$ mm
  $p - d \le 200$ mm

- scallop welding (see Fig. 11.5):

  $d \ge 75$ mm
  $p - d \le 25\ t$ and $p - d \le 150$ mm,

  where t is the lesser thickness of parts to be welded $v \le 0{,}25\ b$, without being greater than 75 mm

- staggered welding (see Fig. 11.6):

  $d \ge 75$ mm
  $p - 2\ d \le 300$ mm
  $p \le 2\ d$ for connections subjected to high alternate stresses.

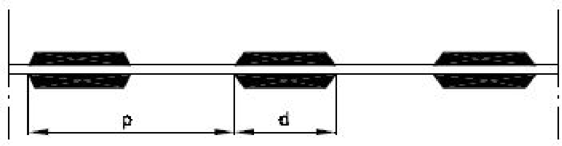


Fig. 11.4 Intermittent chain welding

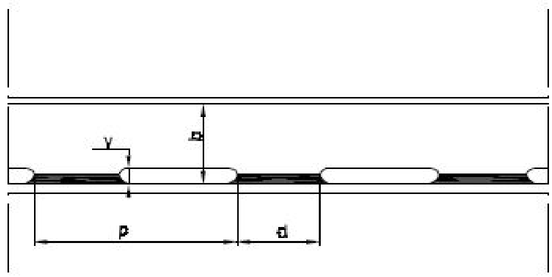


Fig. 11.5 Intermittent scallop welding

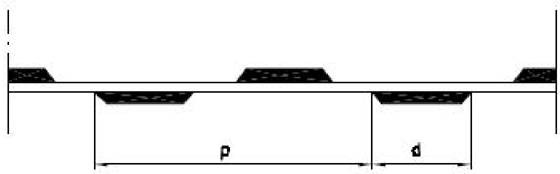


Fig. 11.6 Intermittent staggered welding

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 throat thickness of fillet weld T connections is to be obtained [mm] from the following formula:

$$t_T = w_F \cdot t \cdot \frac{p}{d}$$

w_F = welding factor, defined in Table 11.4 for the various hull structural connections; for connections of primary supporting members belonging to single skin structures and not mentioned in Table 11.4, wF is defined in Table 11.5

t = actual gross thickness [mm] of the structural element which constitutes the web of the T connection

p, d = spacing and length [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:

$$t_{T-min} = \sqrt{\frac{t_1 + t_2}{3}}$$

and:

- 3,0 mm, for $t_1 < 6$ mm
  3,5 mm, for $t_1 \geq 6$ mm

t_1, t_2 = Tthicknesses 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 2.3.8. 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 **TL**.

The throat thickness may be required by **TL** 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 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:

$$t_{TC} = t_T \cdot \frac{\varepsilon}{\lambda}$$

t_T = Throat thickness defined in 2.3.5

ε, λ = Dimensions [mm] to be taken as shown in:

- Fig. 11.7 for continuous welding
- Fig. 11.8 for intermittent scallop welding

2.3.7 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 $0{,}35 \cdot t_W$, where t_W is the web gross thickness [mm].

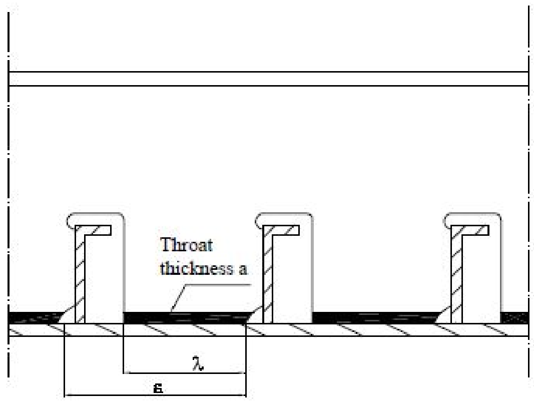


Fig. 11.7 Continuous fillet welding between cutouts

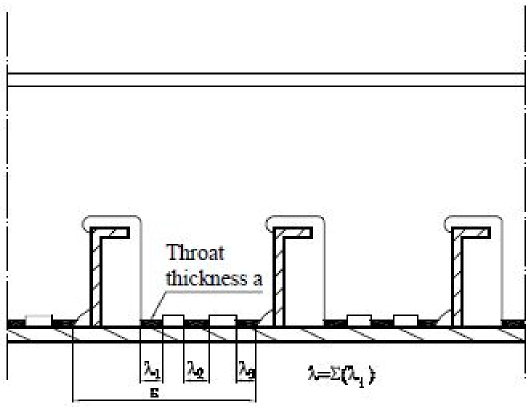


Fig. 11.8 Intermittent scallop fillet welding between cut-outs

2.3.8 Throat thickness of deep penetration filet 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 **TL**. However, this reduction may not be greater than 1,5 mm.

The same reduction applies also for semi-automatic procedures.

The conditions of welding in down hand position (PG) have to comply with the applicable **TL** Rules for Welding.

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 **TL**.

Typical edge preparations are indicated in:

- For partial penetration welds: Fig. 11.9 and Fig. 11.10, in which f [mm] is to be taken between 3 mm and t/3, and α between 45° and 60°

- For full penetration welds: Fig. 11.11 and Fig. 11.12, in which f [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.

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 **TL** 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 **TL** 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.

Table 11.4 Welding factors w_F and coefficient φ for the various hull structural connections

Hull area	Connection			W_F (1)	φ (2) (3)		
	of	to			CH	SC	ST
General, unless otherwise specified in the table	watertight plates	boundaries		0,35			
	webs of ordinary stiffeners	plating		0,13	3,5	3,0	4,6
		face plate of fabricated stiffeners	at ends **(4)**	0,13			
			elsewhere	0,13	3,5	3,0	4,6
Bottom and double bottom	longitudinal ordinary stiffeners	bottom and inner bottom plating		0,13	3,5	3,0	4,6
	centre girder	keel		0,40			
		inner bottom plating		0,20	2,2	2,2	
	side girders	bottom and inner bottom plating		0,13	3,5	3,0	4,6
		floors (interrupted girders)		0,20	2,2		
	floors	bottom and inner bottom plating	İn general	0,13	3,5	3,0	4,6
			at ends (20 % of span) for longitudinally framed double bottom	0,25	1,8		
		inner bottom plating in way of brackets of primary supporting members		0,25	1,8		
		girders (interrupted floors)		0,20	2,2		
		side girders in way of hopper tanks		0,35			
	partial side girders	floors		0,25	1,8		
	web stiffeners	floor and girder webs		0,13	3,5	3,0	4,6
Side and inner side	ordinary stiffeners	side and inner side plating		0,13			
	girders and web frames in double hull vessels	side and inner side plating		0,35			
Deck	strength deck **(5)**	side plating		w_F = 0,45 if t ≤ 15 mm Partial penetration welding if t > 5 mm			
	non-watertight decks	side plating		0,20	2,2		
	ordinary stiffeners and intercostal girders	deck plating		0,13	3,5	3,0	4,6
	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
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	
			others	0,13	3,5	3,0	4,6
	ordinary stiffeners	bulkhead plating	in general **(6)**	0,13	3,5	3,0	4,6
			at ends (25 % of span), where no end brackets are fitted	0,35	2,2		

Table 11.4 Welding factors w_F and coefficient φ for the various hull structural connections -continued-

Hull area	Connection			W_F (1)	φ (2) (3)		
	of	to			CH	SC	ST
Structures located forward of 0,75 L from the AE **(7)**	bottom longitudinal ordinary stiffeners	bottom plating		0,20	1,8		
	floors and girders	bottom and inner bottom plating		0,25			
	side frames in panting area	side plating		0,20			
	webs of side girders in single side skin structures	side plating and face plate	A < 65 cm^2 **(8)**	0,25			
			A ≥ 65 cm^2 **(8)**	See Table 11.5			
Aft peak **(7)**	internal structures	each other		0,20			
	side ordinary stiffeners	side plating		0,20			
	floors	bottom and inner bottom plating		0,20			
Machinery space **(7)**	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	0,20	1,8	1,8	
	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	
	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	
	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	
Superstructures 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
	ordinary stiffeners	external and internal bulkhead plating		0,13	3,5	3,0	4,6
Hatch covers	ordinary stiffener	plating		0,13	3,5	3,0	4,6
Pillars	elements composing the pillar section	each other (fabricated pillars)		0,13			
	pillars	deck	pillars in compression	0,35			
			pillars in tension	full penetration welding			
Ventilators	coamings	deck		0,35			
Rudders	horizontal and vertical webs directly connected to solid parts	each other		0,45			
	other webs	each other		0,20		2,2	
	Webs	plating	in general	0,20		2,2	
			top and bottom plates of rudder plating	0,35			
		solid parts or rudder stock		According to Section 10, A.7.3 or A.7.4			

Table 11.4 Welding factors w_F and coefficient φ for the various hull structural connections -continue

Hull area	Connection		W_F (1)	φ (2) (3)		
	of	to		CH	SC	ST

(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) *See 3.5.*
(5) *Fillet weld of 5 mm is acceptable for vessels of less than 90 m in length if thicknesses of strength deck and shell plating are less than 10 mm and if shell plating extends over the strength deck by more than 50 mm.*
(6) *In tanks intended for the carriage of ballast or fresh water, continuous welding with wF = 0,35 is to be adopted.*
(7) *For connections not mentioned, the requirements for the central part apply.*
(8) *A is the face plate sectional area of the side girders [cm2].*

Table 11.5 Welding factors w_F and coefficient φ for connections of primary supporting members

Primary supporting member	Connection			W_F (1)	φ (2) (3)		
	of	to			CH	SC	ST
General **(4)**	web, where A < 65 cm^2	plating and face plate	at ends	0,20			
			elsewhere	0,15	3,0	3,0	
	web, where A ≥ 65 cm^2	plating		0,35			
		face plate	at ends	0,35			
			elsewhere	0,25	1,8	1,8	
	end brackets	face plate		0,35			
In tanks Where A < 65 cm^2 **(5)**	web	plating	at ends	0,25			
			elsewhere	0,20	2,2	2,2	
		face plate	at ends	0,20			
			elsewhere	0,15	3,0	3,0	
	end brackets	face plate		0,35			
In tanks Where A ≥ 65 cm^2	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.*

Notes
- *A is the face plate sectional area of the primary supporting member [cm2].*
- *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.*

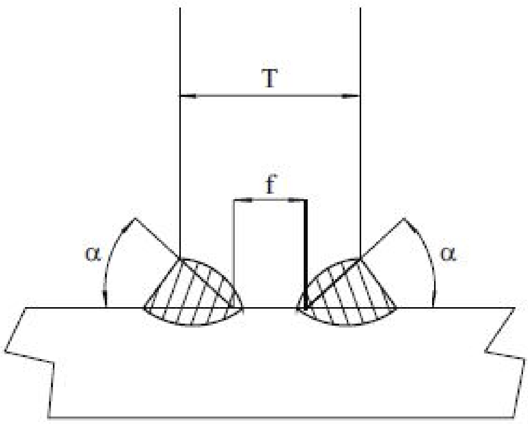


Fig. 11.9 Partial penetration weld

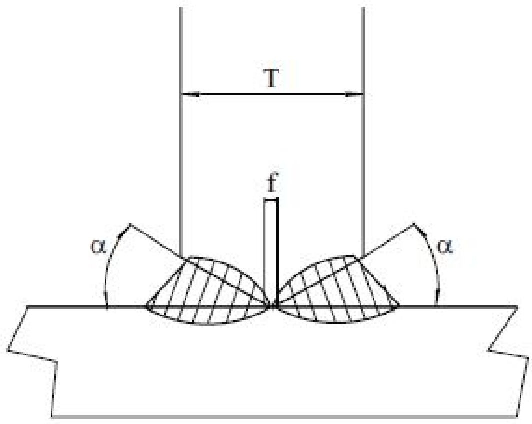


Fig. 11.11 Full penetration weld

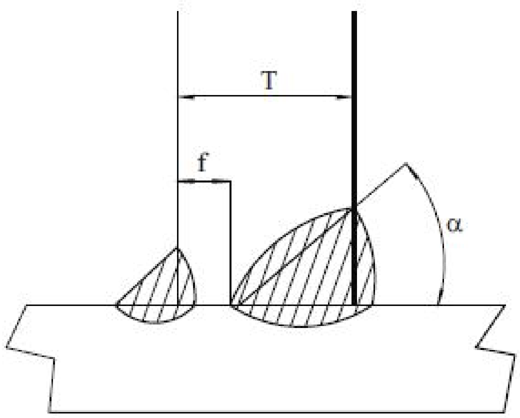


Fig. 11.10 Partial penetration weld

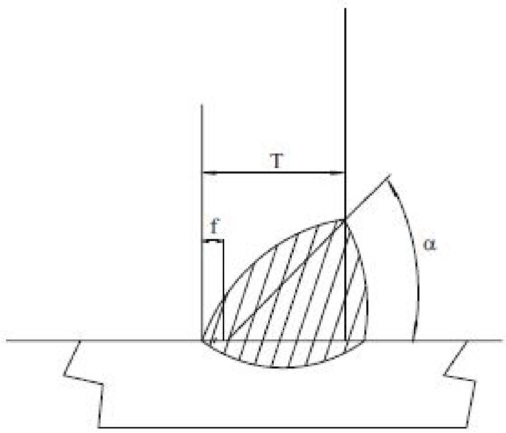


Fig. 11.12 Full penetration weld

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 Table 11.6.

2.6 Slot welding

2.6.1 General

Slot welding may be adopted in very specific cases subject to the special agreement of **TL**, e.g. for doublers according to Section 5, B.2.1.

In general, slot welding of doublers on the outer shell and strength deck is not permitted within 0,6 . L amidships. Beyond this zone, slot welding may be accepted by **TL** 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 Table 11.6.

The distance between two consecutive slot welds is to be not greater than a value which is defined on a caseby-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

Plug welding may be adopted only when accepted by **TL** on a case-by-case basis, according to specifically defined criteria. Typical details are given in Table 11.6.

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 **TL** on a case-by-case basis.

3.2 Struts connecting ordinary stiffeners

In case of a strut connected by lap joint to the ordinary stiffener, the throat thickness of the weld is to be obtained [mm] from the following formula:

$$t_T = \frac{\eta \cdot F}{n_W \cdot \ell_W \cdot \tau} \cdot 10^3$$

F = Maximum force transmitted by the strut [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 [mm]

τ = Permissible shear stress, to be taken equal to 100 N/mm^2

3.3 Connection between propeller post and propeller shaft bossing

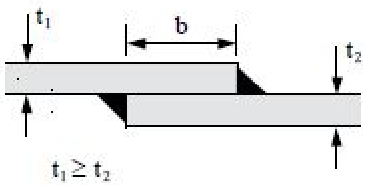
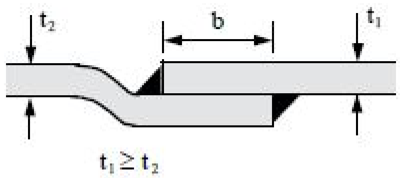
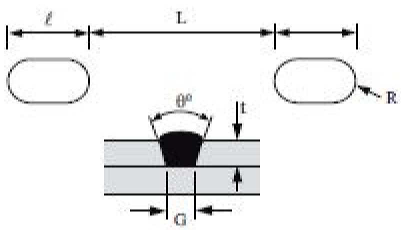
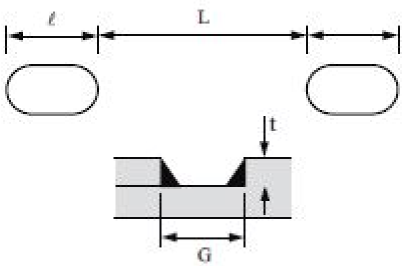
Fabricated propeller posts are to be welded with full penetration welding to the propeller shaft bossing.

3.4 Bar stem connections

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.

Table 11.6 Typical lap joint, plug and slot welding (manual welding)

Detail	Standard		Remark
Fillet weld in lap joint  	$b = 2 \cdot t_2 + 25$ mm		location of lap joint to be approved by **TL**
Fillet weld in joggled lap joint  	$b \geq 2 \cdot t_2 + 25$ mm		
Plug welding  	- $t \leq 12$ mm $\ell = 60$ mm $R = 6$ mm $40° \leq \theta \leq 50°$ $G = 12$ mm $L > 2 \cdot \ell$	- $12 \text{ mm} < t \leq 25$ mm $\ell = 80$ mm $R = 0{,}5 \cdot t$ [mm] $\theta = 30°$ $G = t$ [mm] $L > 2\,\ell$	
Slot welding  	- $t \leq 12$ mm $G = 20$ mm $\ell = 80$ mm $2 \cdot \ell \leq L \leq 3 \cdot \ell$, max 250 mm	- $t > 12$ mm $G = 2 \cdot t$ $\ell = 100$ mm $2 \cdot \ell \leq L \leq 3 \cdot \ell$, max 250 mm	

3.5 Welds at the ends of structural members

3.5.1 As shown in Fig. 11.13, 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 stifffener, subject to a maximum of 300 mm and minimum of 75 mm.

3.5.2 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.

3.5.3 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.

3.5.4 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.

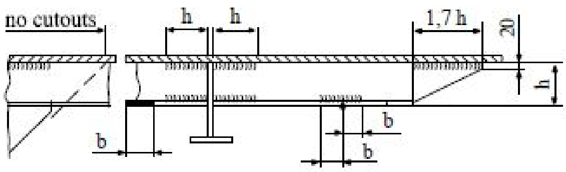


Fig. 11.13 Welds at the ends of girders and stiffeners

3.6 Joints between section ends and plates

3.6.1 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. 11.14.

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 shall be increased in the ratio t_1/t.

3.6.2 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 shall be continuous on both sides and shall meet at the ends.

The necessary 'a' dimension is to be calculated in accordance with 4.7 but need not exceed 0,6.t. The fillet weld throat thickness shall not be less than the minimum specified in 2.3.5.

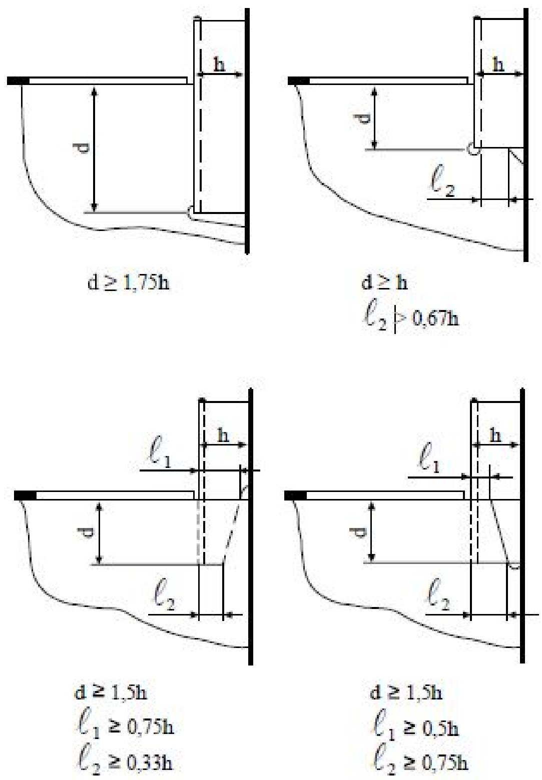


Fig. 11.14 Joints between section ends and plates

3.7 Welded joint between wale plate (sheerstrake) and side plating

If the difference in thickness between the wale plate and the side plating is at least 5 mm but not more than 10 mm, the longitudinal seam may take the form of a partial-penetration single-bevel butt weld with fillet, as shown in

Fig. 11.15. Where the difference in thickness exceeds 10 mm, the proud edge is to be bevelled at an angle ≤ 45°.

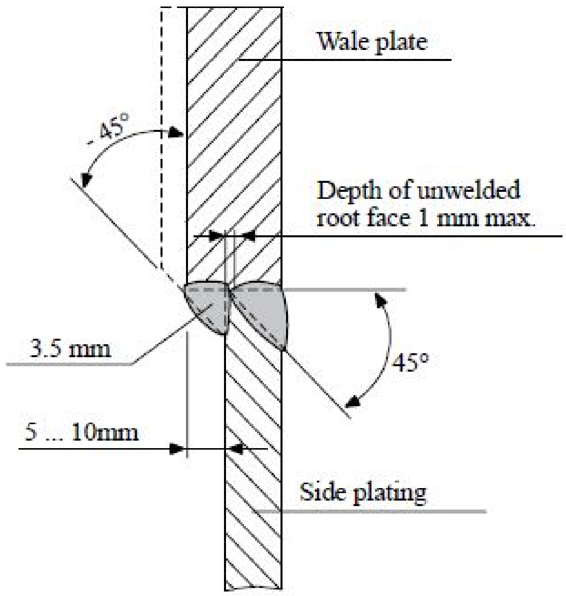


Fig.11.15 Welded joint between wale plate and side plating

3.8 Welded shaft bracket joints

3.8.1 Unless cast in one piece and provided with integrally cast welding flanges (see Fig. 11.16), strut barrel and struts are to be connected to each other and to the shell plating in the manner shown in Fig. 11.17.

3.8.2 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 shall be provided with integrally forged or cast welding flanges in the manner shown in Fig. 11.16.

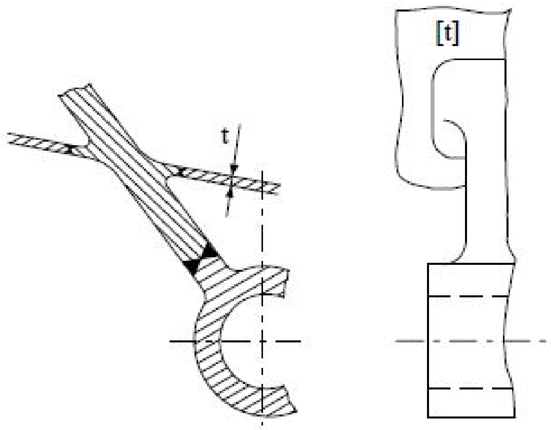
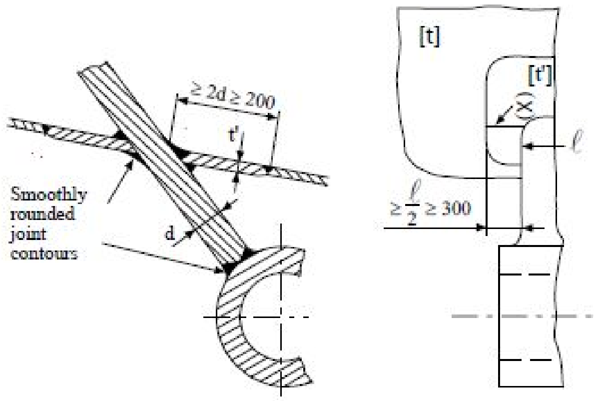


Fig. 11.16 Shaft bracket with integrally cast welding flanges

3.9 Rudder coupling flanges

3.9.1 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. 11.18).



t = shell plating thickness

t' = d/3 + 5 mm, where d < 50 mm

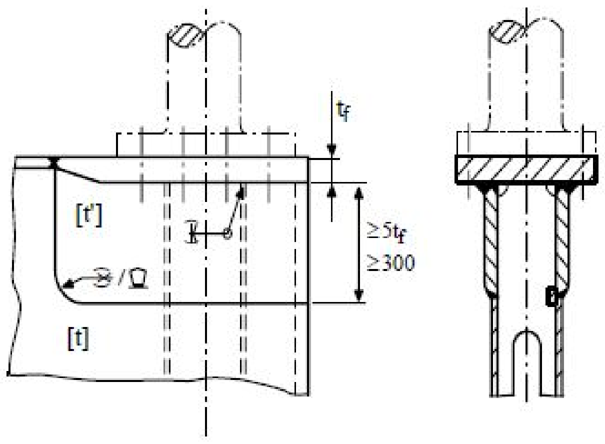
= $3 \cdot d^{0,5}$ mm, where d ≥ 50 mm

Fig. 11.17 Shaft bracket without integrally cast welding flanges

3.9.2 Allowance shall be made for the reduced strength of the coupling flange in the thickness direction (see Note). 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 :

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.



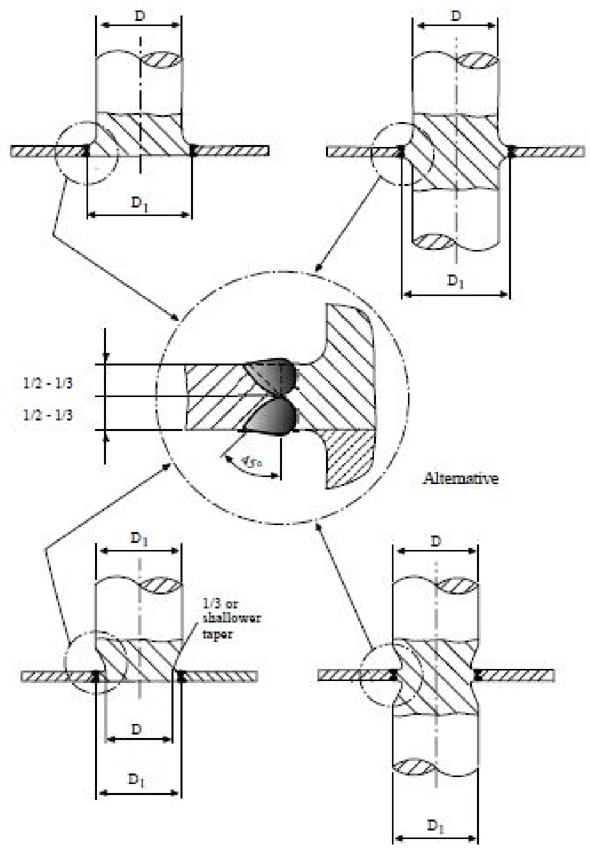
t = rudder plating thickness [mm]
t_f = actual flange thickness [mm]
t' = 1,25 t

Fig. 11.18 Horizontal rudder coupling flanges

3.10 Welded joints between rudder stock and rudder body

Where rudder stocks are welded into the rudder body, a thickened collar of the type shown in Fig. 11.19 shall 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 doublebevel 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.



D_1 = 1,1 · D without being less than D + 20 mm
$D_{1\,min}$ = D + 10 mm (applies only to alternative solution)
D = rudder stock diameter [mm]

Fig. 11.19 Rudder stock welded to rudder body

4. Direct calculation of fillet welds

4.1 General

4.1.1 As an alternative to the determination of the necessary fillet weld throat thicknesses in accordance with 2.3, a mathematical calculation may be performed, e.g. in order to optimize the weld thicknesses in relation to the loads. In the following a general stress analysis for mainly static loads is described. 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 **TL** Rules is to be submitted where necessary.

4.1.2 Definitions

For the purposes of calculation, the following stresses in a fillet weld are defined (see also Fig. 11.20):

$\sigma_{\perp}$ = Normal stress perpendicular to direction of seam

$\tau_{\perp}$ = Shear stress perpendicular to direction of seam

$\tau_{\parallel}$ = Shear stress parallel to seam

Normal stresses parallel to the seam are disregarded in the calculation.

The calculated weld seam area is (a.ℓ).

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:

$$\sigma_v = \sqrt{\sigma_1^2 + \tau_1^2 + \tau_{''}^2}$$

Fillet welds are to be so dimensioned that the stresses determined by the formulae do not exceed the permissible stresses stated in Table 11.7.

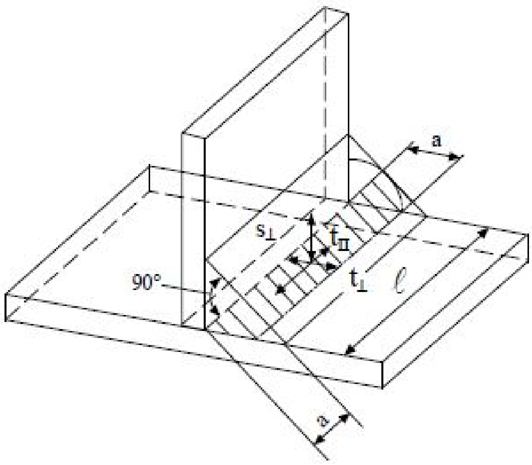


Fig. 11.20 Definition

4.2 Fillet welds stressed by normal and shear forces

Flank and frontal welds are regarded as being equal for the purposes of stress analysis. In view of this, normal and shear stresses [N/mm^2] are calculated as follows:

$$\sigma = \tau = \frac{P}{\sum a \cdot \ell}$$

a, ℓ = Thickness and length [mm] of the fillet weld

P = Force acting on the weld joint [N].

- For a joint as shown in Fig. 11.21, this produces:

- Stresses in frontal fillet welds [N/mm^2]:

$$\tau_1 = \frac{P_1}{2 \cdot a \cdot (\ell_1 + \ell_2)}$$

$$\tau_{''} = \frac{P_2}{2 \cdot a \cdot (\ell_1 + \ell_2)} \pm \frac{P_2 \cdot e}{2 \cdot a \cdot F_t}$$

- Stresses in flank fillet welds:

$$\tau_1 = \frac{P_2}{2 \cdot a \cdot (\ell_1 + \ell_2)}$$

$$\tau_{''} = \frac{P_1}{2 \cdot a \cdot (\ell_1 + \ell_2)} \pm \frac{P_2 \cdot e}{2 \cdot a \cdot F_t}$$

F_t = parameter [mm^2] equal to:

= $(\ell_2 + a).(\ell_1 + a)$

P_1, P_2 = forces [N]

a_1, ℓ_1, ℓ_2 = weld joint dimensions [mm]

- Equivalent stresses for frontal and flank fillet welds:

$$\sigma_v = \sqrt{\sigma_{'}^2 + \tau_{''}^2} \le \sigma_{Vzul}$$

- For a joint as shown in Fig. 11.22, this produces:

$$\tau_1 = \frac{P_2}{2 \cdot \ell \cdot a} + \frac{3 \cdot P_1 \cdot e}{\ell^2 \cdot a}$$

$$\tau_{''} = \frac{P_1}{2 \cdot \ell \cdot a}$$

- Equivalent stress:

$$\sigma_v = \sqrt{\sigma_{'}^2 + \tau_{''}^2} \le \sigma_{Vzul}$$

where σ_{Vzul} is given in Table 11.7.

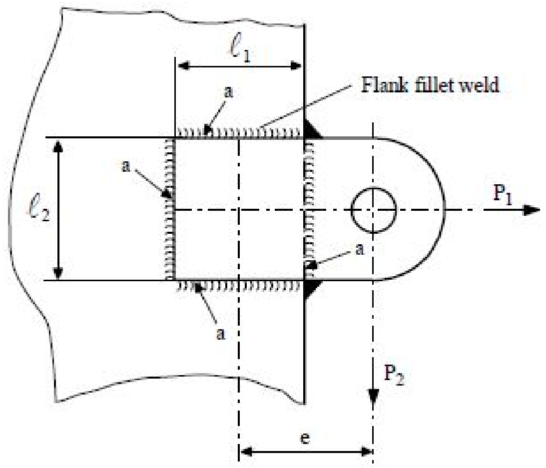


Fig. 11.21 Fillet welds stressed by normal and shear forces

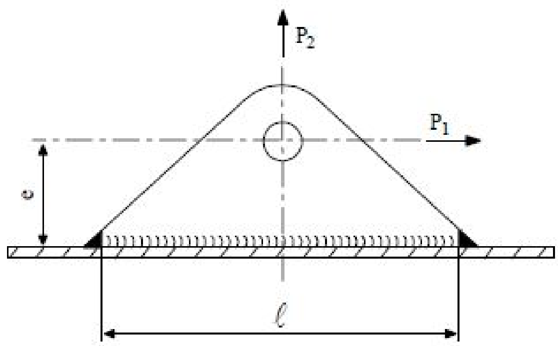


Fig. 11.22 Fillet welds stressed by normal and shear forces

Table 11.7 Permissible stresses in fillet welded joint

Material		**R_{eH} or $R_{p0,2}$ [N/mm^2]**	**Permissible stresses equivalent stress, shear stress $\sigma_{V\,zul}$, τ_{zul} [N/mm^2]**
Normal hull structural steel	A, B, D **(1)**	235	115
Higher tensile hull structural steel	AH 32 / DH 32	315	145
	AH 36 / DH 36 **(2)**	355	160
High tensile steel	St E 460	460	200
	St E 690	685	290
Austenitic stainles steels	1.4306/304L	180	110
	1.4404/316L	190	
	1.4435/316L	190	
	1.4438/317L	195	
	1.4541/321	205	
	1.4571/316 Ti	214	
Aluminium alloys	Al Mg 3	80 **(3)**	35 **(5)**
	Al Mg 4,5	125 **(3)**	56 **(6)**
	Al Mg Si 0,5	65 **(4)**	30 **(7)**
	Al Mg Si 1	11 **(4)**	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*

4.3 Fillet welds stressed by bending moments and shear forces

The stresses at the fixing point of a girder (a cantilever beam is given as an example in Fig. 11.23) are calculated as follows:

a) Normal stress due to bending [N/mm²]:

$$\sigma\perp(z)=\frac{M}{J_s}\cdot z$$

$$\sigma_{\perp\max}=\frac{M}{J_s}\cdot e_u \quad \text{for } e_u>e_0$$

$$\sigma_{\perp\max}=\frac{M}{J_s}\cdot e_o \quad \text{for } e_u<e_0$$

b) Shear stress due to shear force [N/mm²]:

$$\tau''_{(z)}=\frac{Q\cdot S_s\cdot(z)}{10\cdot J_s\cdot\sum a}$$

$$\tau''_{max}=\frac{Q\cdot S_{smax}}{20\cdot J_s\cdot a}$$

c) Equivalent stress:

It has to be proved that neither $\tau_\perp$ max in the region of the flange nor $\tau_{\parallel max}$ in the region of the neutral axis nor the equivalent stress σ_V exceed the permitted limits given in Table 11.7 at any given point. The equivalent stress σ_V should always be calculated at the web-flange connection.

$$\sigma_v=\sqrt{\sigma_\perp^2+\tau''^2}$$

M = Bending moment at the point of the welded joint [N.m]

Q = Shear force at the point of the welded joint [N]

J_S = Moment of inertia of the welded joint relative to the x-axis [cm4]

$S_{S(z)}$ = First moment of the connected weld section atthe point under consideration [cm³]

z = distance from the neutral axis [cm].

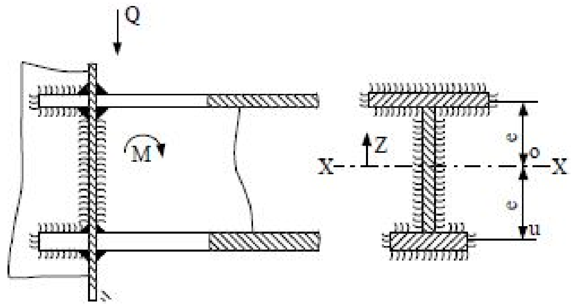


Fig. 11.23 Fillet welds stressed by bending moments and shear forces

4.4 Fillet welds stressed by bending and torsional moments and shear forces

For the normal and shear stresses [N/mm²], resulting from bending, see 4.3. Torsional stresses resulting from the torsional moment M_T are to be calculated as follows:

$$\tau_T=\frac{M_T\cdot 10^3}{2\cdot a_m\cdot A_m}$$

M_T = Torsional moment [N.m]

a_m = Mean fillet weld throat thickness [mm]

A_m = Mean area enclosed by weld seam [mm].

The equivalent stress composed of all three components (bending, shear and torsion) is calculated by the following formulae:

- where $\tau_\parallel$ and $\tau_\perp$ do not have the same direction:

$$\sigma_v=\sqrt{\sigma_\perp^2+\tau_\perp^2+\tau''^2}$$

- where $\tau_\parallel$ and $\tau_\perp$ have the same direction:

$$\sigma_v=\sqrt{\sigma_\perp^2+(\tau_\perp+\tau_T)^2}$$

4.5 Continuous fillet welded joints between web and flange of bending girders

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 [N/mm^2] is to be calculated as follows:

$$\tau_{\parallel} = \frac{Q \cdot S}{20 \cdot J \cdot 2 \cdot a}$$

Q = Shear force at the point considered [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 [cm^3]

J = Moment of inertia of the girder section [cm4]

a = Thickness of the fillet weld [mm]

The fillet weld thickness required [mm] is:

$$a_{erf} = \frac{Q \cdot S}{10 \cdot J \cdot 2 \cdot \tau_{zul}}$$

4.6 Intermittent fillet welded joints between web and flange of bending girders

The shear stress [N/mm^2] is to be calculated as follows:

$$\tau_{\parallel} = \frac{Q \cdot S \cdot \alpha}{10 \cdot J \cdot 2 \cdot a} \cdot \frac{b}{\ell}$$

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

= 1,1

The fillet weld thickness required [mm] is:

$$a_{erf} = \frac{1{,}1 \cdot Q \cdot S}{10 \cdot J \cdot \tau_{zul} \cdot 2} \cdot \frac{b}{\ell}$$

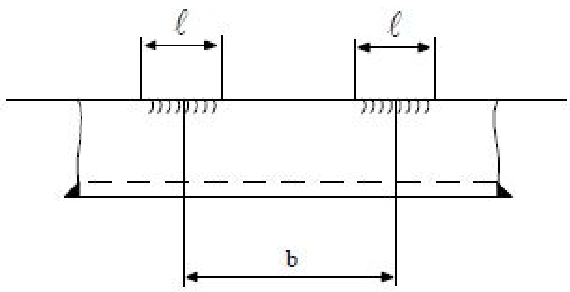


Fig. 11.24 Intermittent fillet welded joints between web and flange of bending girders

4.7 Fillet weld connections on overlapped profile joints

4.7.1 Profiles joined by means of two flank filet welds (see Fig. 11.25):

$$\tau_{\perp} = \frac{Q}{2 \cdot a \cdot d}$$

$$\tau_{\parallel} = \frac{M \cdot 10^3}{2 \cdot a \cdot c \cdot d}$$

The equivalent stress is:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2}$$

Q = Shear force to be transmitted [N]

M = Bending moment to be transmitted [N.m]

c, d, ℓ_1, ℓ_2, r = Dimensions [mm], defined in Fig. 11.25

$$c = r + \frac{3 \cdot \ell_1 - \ell_2}{4}$$

As the influence of the shear force can generally be neglected, the required fillet weld thickness [mm] is:

$$a_{erf} = \frac{M \cdot 10^3}{2 \cdot c \cdot d \cdot \tau_{zul}}$$

or

$$a_{erf} = \frac{w \cdot 10^3}{1{,}5 \cdot c \cdot d}$$

w = Section modulus of the joined profile [cm^3]

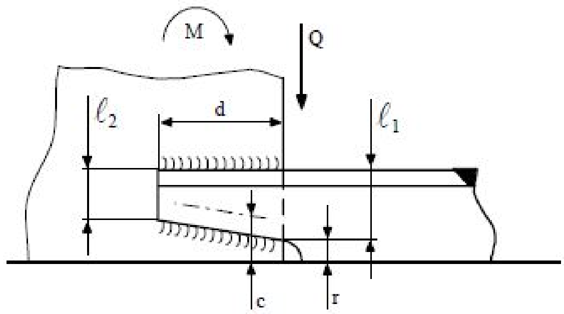


Fig. 11.25 Fillet weld connections on overlapped profile joints: case a

4.7.2 Profiles joined by means of two flank and two front fillet welds (all-round welding as shown in Fig. 11.26):

$$\tau_{\perp} = \frac{Q}{a \cdot (2 \cdot d + \ell_1 + \ell_2)}$$

$$\tau_{\parallel} = \frac{M \cdot 10^3}{a \cdot c \cdot (2 \cdot d + \ell_1 + \ell_2)}$$

The equivalent stress is:

- where $\tau_{\parallel}$ and $\tau_{\perp}$ do not have the same direction:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2}$$

- where $\tau_{\parallel}$ and $\tau_{\perp}$ have the same direction:

$$\sigma_v = \sqrt{\tau_{\perp} + \tau_{\parallel}}$$

As the influence of the shear force can generally be neglected, the required fillet weld thickness [mm] is:

$$a_{erf} = \frac{M \cdot 10^3}{2 \cdot c \cdot d \cdot \left(1 + \frac{\ell_1 + \ell_2}{2 \cdot d}\right) \cdot \tau_{zul}}$$

or

$$a_{erf} = \frac{W \cdot 10^3}{1{,}5 \cdot c \cdot d \cdot \left(1 + \frac{\ell_1 + \ell_2}{2 \cdot d}\right)}$$

c, d, ℓ_1, ℓ_2, r = Dimensions [mm] defined in Fig. 11.26

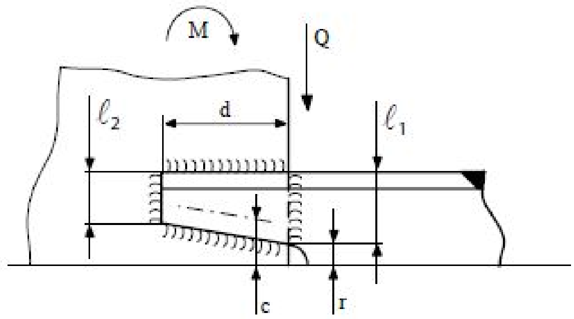


Fig. 11.26 Fillet weld connections on overlapped profile joints: case b

4.8 Bracket joints

Where profiles are joined to brackets as shown in Fig 11.27 the average shear stress [N/mm^2] is:

$$\tau = \frac{3 \cdot M \cdot 10^3}{4 \cdot a \cdot d^2} + \frac{Q}{2 \cdot a \cdot d}$$

M = Moment of constraint [N.m]

Q = Shear force [N]

d = Length of overlap [mm]

The required fillet weld thickness [mm] is to be calculated from the section modulus of the profile, w, as follows:

$$a_{erf} = \frac{w \cdot 10^3}{d^2}$$

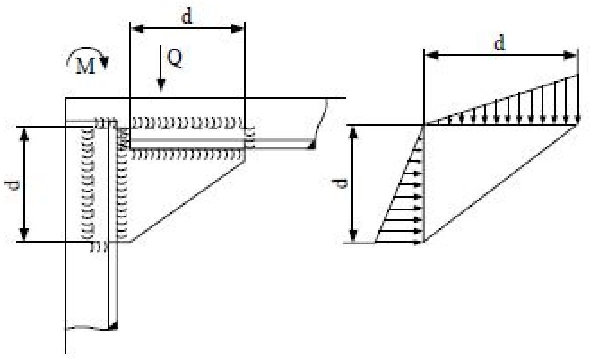


Fig. 11.27 Bracket joint with idealized stress distribution resulting from moment M and shear Q

4.9 Admissible stresses

Both, the individual and the reference stresses calculated in accordance with the formulae in 4.1.2 and 4.2 to 4.8, shall not exceed the admissible stresses as indicated in Table 11.7 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.

5. Workmanship

5.1 Welding procedures and consumables

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 weldability 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 **TL** Rules and of a quality grade standards recognized by **TL** appropriate to the base material to be welded may be used.

5.2 Welding operations

5.2.1 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.

5.2.2 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.

5.2.3 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 **TL**.

Shop primers are to be approved by **TL** for a specific type and thickness according to **TL** Rules for Welding.

5.2.4 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.

5.2.5 Gap in fillet weld T connections

In fillet weld T connections, a gap g, as shown in Fig. 11.28, 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.

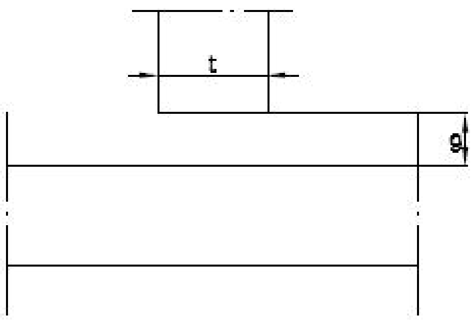


Fig. 11.28 Gap in fillet weld T connections

5.2.6 Plate misalignment in butt connections

The misalignment m, measured as shown in Fig. 11.29, between plates with the same gross thickness t is to be less than 0,15 t, without being greater than 3 mm.

5.2.7 Misalignment in cruciform connections

The misalignment m in cruciform connections, measured on the median lines as shown in Fig. 11.30, 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 AH 32 to DH 40

TL may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

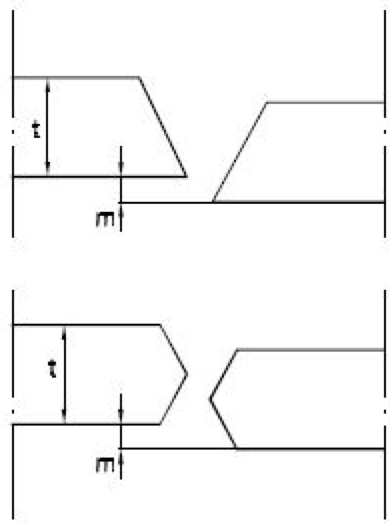


Fig. 11.29 Plate misalignment in butt connections

5.2.8 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 **TL** on a case-by-case basis.

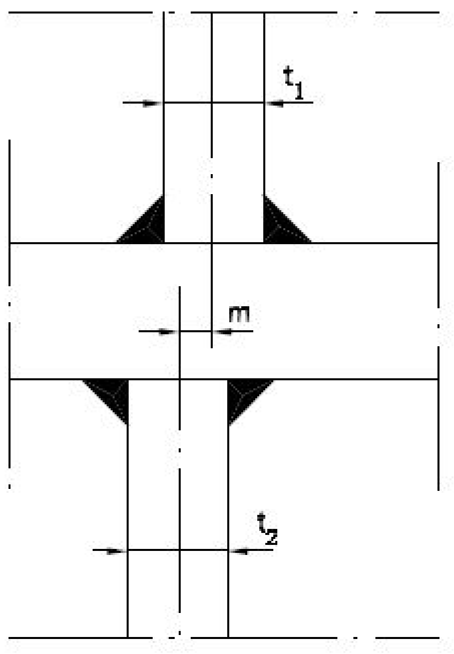


Fig. 11.30 Misalignment in cruciform connections

5.2.9 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 thickwalled 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 thickwalled 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 **TL** Rules for Material and Welding.

Suitable preheating, to be maintained during welding, and slow cooling may be required by **TL** on a caseby-case basis.

The preheating and interpass temperatures are to be shown in the welding procedures which have to be approved by **TL**.

5.2.10 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 **TL** 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.

5.2.11 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.

5.2.12 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 ÷ 620 °C, as appropriate for the type of steel.

Further specifications may be required by **TL** 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 Table 11.8.

5.3 Crossing of structural elements

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.

Table 11.8 Minimum bending radius of welding of cold formed sections

Plate thickness [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

6. Modifications and repairs during construction

6.1 General

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 **TL** on a case-by-case basis.

6.2 Gap and weld deformations

Welding by building up of gaps exceeding the required values and repairs of weld deformations may be accepted by **TL** upon special examination.

6.3 Defects

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 **TL**.

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 nondestructive 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.

6.4 Repairs on structures already welded

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 **TL** on a case-by-case basis.

7. Inspections and checks

7.1 General

7.1.1 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.

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

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

7.1.3 The manufacturer 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.

7.1.4 The necessary quality of the welds is to be proved by non-destructive tests of at least the number NP defined below, carried out at testing positions on the welded joints:

$$N_P = c_P \cdot L/3$$

N_P = Number of test positions using radiographic methods with a 480 mm film length or ultrasonic methods with 1 m long test sections

L = Rule length [m] of the vessel, defined in Section 4, A.1.2.1

c_P = Coefficient defined as

= 0,8 for transverse framing

= 1,0 for longitudinal and combined construction

7.1.5 Test schedule, evaluation of results, test reports

A test schedule shall be compiled covering the tests to be performed. This schedule shall contain details of the materials used and their thicknesses and the method to be applied. The positions at which the various tests are to be performed will be designated by the Surveyor on completion of the welded joints. This shall later be clearly specified in the test schedule. The evaluation of weld defects identified according to their nature, location, size and distribution shall take due account of the requirements applicable to the welded joints (position and loading of the weld), e.g ISO 5817 categories C. The test results shall be evaluated by the testing department and/or the welding supervisory staff.

7.2 Visual and non-destructive examinations

7.2.1 After completion of the welding operation and workshop inspection, the structure is to be presented to the Surveyor for visual examination at a suitable stage of fabrication. For this purpose, welds shall be readily accessible and shall normally be uncoated. Wherever possible, the results of non-destructive tests shall be presented at this juncture.

7.2.2 Non-destructive examinations are to be carried out with appropriate methods and techniques suitable for the individual applications, to be agreed with **TL**.

7.2.3 Radiographic examinations are to be carried out on the welded connections of the hull in accordance with 7.3. The Surveyor is to be informed when these examinations are performed. The results are to be made available to **TL**.

7.2.4 **TL** may allow radiographic examinations to be replaced by ultrasonic examinations.

7.2.5 When the visual or non-destructive examinations reveal the presence of unacceptable indications, the relevant connection is to be repaired to sound metal for an extent and according to a procedure agreed with the Surveyor. The repaired zone is then to be submitted to nondestructive 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.

7.2.6 Ultrasonic and magnetic particle examinations may also be required by the Surveyor in specific cases to verify the quality of the base material.

7.3 Radiographic inspection

7.3.1 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 7.3.2 to 7.3.5 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 **TL** 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 7.3.2 to 7.3.5.

7.3.2 As far as automatic welding of the panels butt welds during the premanufacturing stage is concerned, the Building Yard is to carry out random nondestructive testing of the welds (radiographic or ultrasonic inspection) in order to ascertain the regularity and the constancy of the welding inspection.

7.3.3 In the midship area, radiographies are to be taken at the joining butts of panels.

Each radiography is situated in a butt joint at a crossshaped 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; furthermore, in the same section, on average of two radiographies is to be taken on all the butts of bottom, deck and side shell platings. 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

Moreover, a radiographic inspection is to be taken at random of the weldings of the bilge keel and of intermediate flat.

7.3.4 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
- to take 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.

7.3.5 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.

B. Protection of Hull Metallic Structures

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

t = Thickness [mm]

2. Corrosion protection

2.1 Protection by coating

2.1.1 All areas endangered by corrosion are to be protected by a suitable corrosion protective coating.

2.1.2 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.

2.2 Cathodic protection

2.2.1 Ballast water tanks or other internal spaces endangered by corrosion due to brackish or harbour water need to be protected by sacrificial anodes.

2.2.2 Uncoated stainless steels are not protected cathodically if they are suitable for withstanding the corrosion stress.

Coated stainless steels shall be cathodically protected in the submerged zone.

2.2.3 Details concerning the type of anodes used and their location and attachment to the structure are to be submitted to **TL** for review/approval.

2.3 Protection against galvanic corrosion

Suitable protection measures shall take place, where the danger of galvanic corrosion exists.

3. Protection of bottom by ceiling

3.1 General

3.1.1 In single bottom vessels, ceiling is to be laid on the floors from side to side up to the upper bilge.

3.1.2 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 Section 14, A.4.4 and Section 14, B.4.4

3.2 Arrangement

3.2.1 Planks forming ceiling over the bilges and on the inner bottom are to be easily removable to permit access for maintenance.

3.2.2 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.

3.2.3 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.

3.2.4 The Building Yard is to take care that the attachment of ceiling does not affect the tightness of the inner bottom.

3.2.5 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.

3.3 Scantling

3.3.1 The thickness of ceiling boards 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:

  $t = 50$

  $= 0{,}45.s.(L + 160)$

- Other vessels:

  $t = 25$

  $= 0{,}3.s.(L + 160)$

s being the floor spacing [m].

Where the floor spacing is large, the thicknesses may be considered by **TL** on a case-by-case basis.

Under cargo hatchways, the thickness of ceiling is to be increased by 15 mm.

3.3.2 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.

4. Protection of decks by wood sheathing

4.1 Deck not entirely plated

4.1.1 The wood used for sheathing is to be of good

quality dry teak or pine, without sapwood or knots. The sheathing thickness is not to be less than:

- teak $t = (L + 55)/3 \geq 40$
- pine $t = (L + 100)/3$

4.1.2 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.

4.1.3 Wooden decks are to be carefully caulked, to the satisfaction of the Surveyor.

4.2 Wood sheathed plate deck

4.2.1 As far as practicable, plate decks above passenger or crew cabins are to be sheathed with wood planks.

4.2.2 The plank thickness is not to be less than 40 mm nor than:

- teak $t = (L + 40)/3$
- pine $t = (L + 85)/3$

C. Testing

1. Symbols

p = maximum design pressure [kPa]

p_{S1} = leak test pressure [kPa]:

= MIN (10; p)

p_{S2} = leak test pressure [kPa]:

= MIN (15; p)

2. General

2.1 Application

2.1.1 The following requirements determine the testing conditions for: IACS

- gravity tanks, including independent tanks of 5 m^3 or more in capacity
- watertight or weathertight structures

The purpose of these tests is to check the tightness and/or the strength of structural elements.

2.1.2 Tests are to be carried out in the presence of the Surveyor at a stage sufficiently close to completion so that any subsequent work would not impair the strength and tightness of the structure.

In particular, tests are to be carried out after air vents and sounding pipes are fitted.

2.2 Definitions

2.2.1 Shop primer

Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

2.2.2 Protective coating

Protective coating is a final coating protecting the structure from corrosion.

2.2.3 Structural testing

Structural testing is a hydrostatic test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible (for example when it is difficult, in practice, to apply the required head at the top of the tank), hydropneumatic testing may be carried out instead.

Structural testing is to be carried out according to 3.2.

2.2.4 Hydropneumatic testing

Hydropneumatic testing is a combination of hydrostatic and air testing, consisting in filling the tank to the top with water and applying an additional air pressure.

Hydropneumatic testing is to be carried out according to 3.3.

2.2.5 Leak testing

Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.

Leak testing is to be carried out according to 3.4.

2.2.6 Hose testing

Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and of other components which contribute to the watertight or weathertight integrity of the hull.

Hose testing is to be carried out according to 3.5.

2.2.7 Sister vessel

See Section 1, A.1.2.20.

3. Watertight compartments

3.1 General

3.1.1 The requirements in 3.1 to 3.6 intend generally to verify the adequacy of the structural design of gravity tanks, excluding independent tanks of less than 5 m^3 in capacity, based on the loading conditions which prevailed when determining the tank structure scantlings.

3.1.2 General requirements for testing of watertight compartments are given in Table 11.9, in which the types of testing referred to are defined in 2.2.

3.2 Structural testing

3.2.1 Structural testing may be carried out before or after launching.

3.2.2 Structural testing may be carried out after application of the shop primer.

3.2.3 Structural testing may be carried out after the protective coating has been applied, provided that one of the following two conditions is satisfied:

- All the welds are completed and carefully inspected visually to the satisfaction of the Surveyor prior to the application of the protective coating

- Leak testing is carried out prior to the application of the protective coating In the absence of leak testing, protective coating is to be applied after the structural testing of:

- All erection welds, both manual and automatic

- All manual fillet weld connections on tank boundaries and manual penetration welds

3.3 Hydropneumatic testing

When a hydropneumatic testing is performed, the conditions are to simulate, as far as practicable, the actual loading of the tank.

The value of the additional air pressure is at the discretion of **TL**, but is to be at least as defined in 3.4.2 for leak testing.

The same safety precautions as for leak testing (see 3.4.2) are to be adopted.

3.4 Leak testing

3.4.1 An efficient indicating liquid, such as a soapy water solution, is to be applied to the welds.

3.4.2 Where leak testing is carried out in accordance with Table 11.9, an air pressure p_{S1} is to be applied during the test.

Prior to inspection, it is recommended that the air pressure in the tank should be raised to p_{S2} and kept at this level for approximately 1 hour to reach a stabilised state, with a minimum number of personnel in the vicinity of the tank, and then lowered to the test pressure.

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The test may be conducted after the pressure has reached a stabilised state at p_{S2}, without lowering the pressure, provided **TL** is satisfied of the safety of the personnel involved in the test.

3.4.3 A U-tube filled with water up to a height corresponding to the test pressure is to be fitted to avoid overpressure of the compartment tested and verify the test pressure.

The U-tube is to have a cross-section larger than that of the pipe supplying air.

In addition, the test pressure is also to be verified by means of one master pressure gauge.

Alternative means which are considered to be equivalently reliable may be accepted at the discretion of the Surveyor.

3.4.4 Leak testing is to be carried out, prior to the application of a protective coating, on all fillet weld connections on tank boundaries, and penetration and erection welds on tank boundaries excepting welds made by automatic processes.

Selected locations of automatic erection welds and preerection manual or automatic welds may be required to be similarly tested to the satisfaction of the Surveyor, taking into account the quality control procedures operating in the Building Yard.

For other welds, leak testing may be carried out after the protective coating has been applied, provided that such welds have been carefully inspected visually to the satisfaction of the Surveyor.

3.4.5 Any other recognised method may be accepted to the satisfaction of the Surveyor.

3.5 Hose testing

When hose testing is required to verify the tightness of the structures, as defined in Table 11.9, the minimum pressure in the hose, at least equal to 200 kPa, is to be applied at a maximum distance of 1,5 m.

The nozzle diameter is to be not less than 12 mm.

3.6 Other testing methods

Other testing methods may be accepted, at the discretion of **TL**, based upon equivalency considerations. As far as applicable, **TL** reserves the right, on the request of the Prospective Owner or the Building Yard to accept any other equivalent testing methods as defined in other Society's Rules.

Referring to the testing of tanks, this may in particular be effected by a combination of a leak test by means of air pressure and an operational test by means of water or of the liquid for which the tanks are intended to be used. The operational test may be carried out when the vessel is afloat or during the trial trip. For all tanks the proper functioning of filling and suction lines and of the valves as well as the functioning and tightness of the vent, sounding and overflow pipes is to be tested.

4. Miscellaneous

4.1 Doors in bulkheads above the bulkhead deck

Doors are to be designed and constructed as weathertight doors and, after installation, subjected to a hose test from each side for weathertightness.

4.2 Steering nozzles

Upon completion of manufacture, the nozzle is to be subjected to a leak test.

Table 11.9 Watertight compartments - General testing requirements

Compartment or structure to be tested	Type of testing	Structural test pressure	Remarks
Double bottom tanks	Structural testing **(1)**	Head of water up to the top of overflow, at least 1,0 m above tank top	Tank boundaries tested from at least one side
Double side tanks	Structural testing **(1)**	Head of water up to the top of overflow, at least 1,0 m above tank top	Tank boundaries tested from at least one side
Tank bulkheads, deep tanks	Structural testing **(1)**	The greater of the following **(2)**: - head of water up to the top of overflow, at least 1, 0 m above tank top - testing pressure defined in Section 5, D., Table 5.13	Tank boundaries tested from at least one side
Fuel oil bunkers	Structural testing		
Fore and aft peak tanks used as tanks	Structural testing	Head of water up to the top of overflow, at least 1,0 m above tank top	Test of the after peak carried out after the sterntube has been fitted
Fore peak not used as tank	Structural testing	Head of water up to bulkhead deck	
Aft peak not used as tank	Leak testing		
Cofferdams	Structural testing **(3)**	Head of water up to the top of overflow, at least 1,0 m above cofferdam top	
Watertight bulkheads	Hose testing **(4)**		
Watertight doors below freeboard or bulkhead deck **(5)**	Structural testing	Head of water up to bulkhead deck	Test to be carried out before the vessel is put into service, either before or after the door is fitted on board
Double plate rudders	Leak testing		
Shaft tunnel clear of deep tanks	Hose testing		
Shell doors	Hose testing		
Weathertight hatch covers and closing appliances	Hose testing		
Chain locker (if aft of collision bulkhead)	Structural testing	Head of water up to the top	
Independent tanks not used as cargo tanks	Structural testing	Head of water up to the top of overflow, but not less than 2,4 m	

(1) *Hydropneumatic or leak testing may be accepted under the conditions specified in 3.3 and 3.4.*

(2) *Where applicable, the highest point of the tank is to be measured to deck and excluding hatches. In holds for liquid cargo or ballast with large hatch covers, the highest point of tanks is to be taken at the top of the hatch.*

(3) *Hydropneumatic or leak testing may be accepted under the conditions specified in 3.3 and 3.4, respectively, when, at the* ***TL****'s discretion, it is considered significant also in relation to the construction techniques and the welding procedures adopted.*

(4) *When a hose test cannot be performed without damaging possible outfitting (machinery, cables, switchboards, insulation, etc...) already installed, it may be replaced, at the* ***TL****'s discretion, by a careful visual inspection of all the crossings and welded joints. Where necessary, a dye penetrant test or ultrasonic leak test may be required.*

(5) *The means of closure are to be subjected to a hose test after fitting on board.*

SECTION 12

MACHINERY and SYSTEMS

A. General Requirements

1. General

1.1 Application

1.1.1 This Section applies to the design, construction, installation, tests and trials of main propulsion and essential (needed for navigation) auxiliary machinery systems and associated equipment, boilers and pressure vessels and piping systems installed on board classed inland navigation vessels, as indicated in each Subsection (A. to I.) of this Section.

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in Additional Requirements for Notations, 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 parts of this Section are to be submitted to **TL** for review/approval.

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.

Engines and their ancillaries shall be designed, built and installed in accordance with best practice.

2.2 Materials, welding and testing

2.2.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of the **TL** Rules for Materials and Welding and those given in the other parts of this Section. 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 **TL** in accordance with the **TL** Rules for Welding.

References to welding procedures adopted are to be clearly indicated on the plans submitted for review/ approval.

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.

2.3 Vibrations

Special consideration (see B.5.) 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

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 Table 12.1. 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 12.1 Permanent inclination of vessels

Installations, components	**Angle of inclination [°] (1)**	
	Athwartship	**For 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*

2.5 Ambient conditions

Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Table 12.2, unless otherwise specified.

Table 12.2 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 **TL** in the case of vessels intended for restricted service.*

2.6 Approved fuels

2.6.1 The flash point of liquid fuels for the operation of machinery and boiler installations shall be above 55 °C.

2.6.2 Liquid fuel is to be carried in oiltight tanks which shall either form part of the hull or be solidly connected with the vessel's hull.

2.7 Power of machinery

Unless otherwise stated in this Section, 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

2.8 Astern power

Sufficient power for going astern is to be provided to secure proper control of the vessel in all normal circumstances.

The main propulsion machinery is to be capable of maintaining in free route astern at least 70 % of the maximum ahead revolutions for a period of at least 10 min.

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 I.3.2).

2.9 Safety devices

2.9.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2.9.2 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.

2.9.3 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.

TL may permit provisions for overriding automatic shut-off devices.

3. Arrangement and installation on board

3.1 General

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.

Engines shall be installed and fitted in such a way as to be adequately accessible for operation and maintenance, and shall not endanger the persons assigned to those tasks. It shall be possible to make them secure against unintentional starting.

3.2 Floors

Floors in engine rooms are to be metallic, divided into easily removable panels.

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.

Propulsion Plants are to be mounted and secured to their shipboard foundations in conformity with Guidelines for the Seating of Propulsion Plants.

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

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

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

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

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 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 H.

3.8 Machinery remote control, alarms and safety systems

For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems (see Section 13,M.2.7).

4. Tests and trials

4.1 Works tests

Equipment and its components are subjected to Works tests which are detailed in the relevant parts of this Section and are to be witnessed by the Surveyor.

Where such tests cannot be performed in the workshop, **TL** 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 shipboard installation. In such cases, the Surveyor is to be informed in advance and the tests are to be carried out in accordance with the provisions of the **TL** Rules for 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 parts of this Section.

4.2 Tests on board

Trials on board of machinery are detailed in I.

B. Propelling and Auxiliary Machinery

1. Symbols

N = Speed of the shaft for which the check is carried out [rev/min]

N_N = Nominal speed of the engine [rev/min]

λ = Speed ratio

= N/N_N

2. Internal combustion engines

2.1 General

2.1.1 Scope

The Rules contained in the following apply to internal combustion engines used as main propulsion units and auxiliary units.

For the purpose of these Rules, internal combustion engines are diesel engines.

2.1.2 Rated Power

Diesel engines are to be designed such that their rated power running at rated speed can be delivered as a continuous net brake power. Diesel engines are to be capable of continuous operation within power range (1) of Fig. 12.1 and of short-period operation in power range (2). The extent of the power range is to be stated by the engine manufacturer.

In determining the power of all engines used on board inland waterway vessels with unlimited range of service, the ambient conditions given in Table 12.3 are to be used.

Table 12.3 Ambient conditions

Barometric pressure	1000 mbar
Suction air temperature	- 40 °C, in general - 45 °C, in tropical zone
Relative humidity	60 %
Raw water temperature (inlet temperature of charge air coolant)	- 25 °C, in general - 32 °C, in tropical zone

Continuous power is understood to mean the net brake power which an engine is capable of delivering continuously, provided that the maintenance prescribed by the engine manufacturer is carried out, between the maintenance intervals stated by the engine manufacturer.

To verify that an engine is rated at its continuous power, it is to be demonstrated on the test bed that the engine can run at an overload power corresponding to 110 % of its rated power at corresponding speed for an uninterrupted period of 30 minutes.

After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.

Subject to the prescribed conditions, diesel engines driving electric generators shall be capable of overload operation even after installation on board.

Subject to the approval of **TL**, diesel engines for special vessels and applications may be designed for a blocked continuous power which cannot be exceeded.

For main engines, a power diagram (Fig. 12.1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

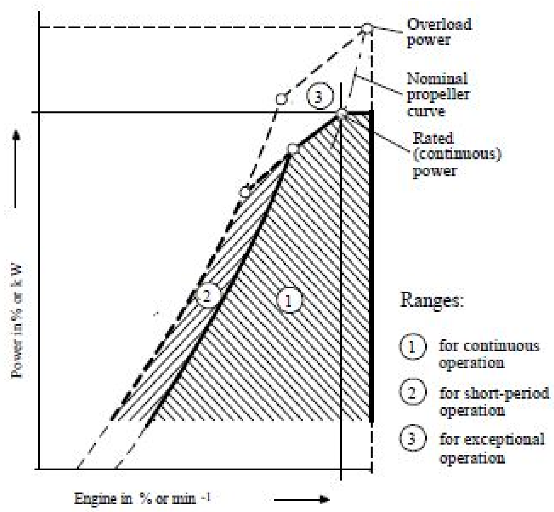


Fig. 12.1 Power/speed diagram

2.1.3 Fuels

The use of liquid fuels is subject to the Rules contained in A.2.6.

Only internal combustion engines burning liquid fuels having a flash point of more than 55 °C may be installed. The use of gaseous fuels is subject to a further design approval.

For fuel systems, see C.7.

2.1.4 Accessibility of engines

Engines are to be so arranged in the engine room that all the erection holes and inspection ports provided by the engine manufacturer for inspections and repairs are accessible or easily be made accessible (see A.3.1)

2.1.5 Installation and mounting of engines

Engines are to be mounted and secured to their shipboard foundations in conformity with Guidelines for the Seating of Propulsion Plants.

2.1.6 Documents for review/approval

For each engine type, one or three copies, as specified, of the drawings and documents listed in Table 12.4 shall, wherever applicable, be submitted for review/approval (A) or information (R).

The type specification of an internal combustion engine is defined by the following data:

- Manufacturer’s type designation
- Cylinder bore
- Stroke
- Method of injection (direct, indirect)
- Valve and injection operation (by cams or electronically controlled)
- Working cycle (4-stroke, 2-stroke)
- Method of gas exchange (naturally aspirated or supercharged)
- Rated power per cylinder at rated speed and mean effective working pressure
- Method of pressure charging (pulsating pressure system or constant pressure system)
- Charge air cooling system
- Cylinder arrangement (in-line, V-type)

Following initial approval of an engine type by **TL**, only those documents listed in Table 12.4 require to be resubmitted for examination which embody important design modifications.

2.2 Crankshaft design

2.2.1 Design methods

Crankshafts are to be designed to withstand the stresses occurring when the engine runs at rated power. Calculations are to be based on the **TL** Rules for Machinery. Other methods of calculation may be used provided that they do not result in crankshaft dimensions smaller than those specified in the most recent edition of the aforementioned **TL** Rules.

Outside the end bearings, crankshafts designed according to the **TL** Rules may be adapted to the diameter of the adjoining shaft by a generous filet (r ≥ 0,06.d) or a taper.

Design methods for application to crankshafts of special construction and to the crankshafts of engines of special type are to be agreed with **TL**.

2.2.2 Split crankshaft

Fitted bolts or equivalent fastenings are to be used for assembling split crankshafts.

2.2.3 Torsional vibration, critical speeds

See B.6.

2.3 Materials

2.3.1 Approved materials

The mechanical characteristics of materials used for the components of diesel engines shall conform to the **TL** Rules for Materials. The materials approved for the various components are shown in Table 12.6 together with their minimum required characteristics.

Materials with properties deviating from those specified may be used only with **TL** consent.

2.3.2 Testing of materials

For the following components:

- Crankshaft
- Crankshaft coupling flange (non-integral) for main power transmission
- Crankshaft coupling bolts
- Connecting rods

Evidence is to be supplied that the materials used meet the requirements of the **TL** Rules for Materials. This evidence may take the form of a manufacturer's acceptance certificate.

In addition, crankshafts and connecting rods are to be subjected to non-destructive crack tests at the works and the results placed on record.

Where there is reason to doubt the satisfactory nature of an engine component, further additional tests according to recognized procedures may be stipulated.

2.4 Tests and trials

2.4.1 Pressure tests

Appointed components of internal combustion engines are to be subjected at the works to pressure tests at the test pressures indicated in Table 12.5 or to equivalent tests.

2.4.2 Test bed trials

In general, engines are to be subjected under **TL** supervision to a test bed trial of the scope stated below. Exceptions to this require the agreement of **TL**.

Main engines for direct propeller drive:

a) 100 % power (rated power)
at rated speed n_0: 60 minutes

b) 100 % power
at n = 1,032.n_0: 30 minutes

c) 90 %, 75 %, 50 % and 25 % power in accordance with the nominal propeller curve.
In each case the measurements shall not be carried out until the steady operating condition has been achieved.

d) Starting and reversing manoeuvres

e) Test of governor and independent overspeed protection device

f) Test of engine shut-down devices

For main engines for indirect propeller devices, the test is to be performed at rated speed with a constant governor setting under conditions of:

a) 100 % power
(rated power): 60 minutes

b) 110 % power: 30 minutes

c) 75 %, 50 % and 25 % power and idle run

In each case the measurements shall not be carried out until the steady operating condition has been achieved.

d) Start-up tests

For auxiliary driving engines and engines driving electric generators, tests are to be performed in accordance with the above paragraph (main engines for indirect propeller devices). The manufacturer's test bed reports are acceptable for auxiliary driving engines rated at ≤ 220 kW.

Table 12.4 Documents for review

No.	A/R	Description	Quantity	Remarks
1	R	Details required on **TL** forms when applying for review/approval of a internal combustion engine	3	
2	R	Engine transverse cross section	3	
3	R	Engine longitudinal section	3	
4	R	Bedplate or crankcase	1	
5	R	Engine block	1	
6	R	Tie rod	1	
7	R	Cylinder cover assembly	1	
8	R	Cylinder liner	1	**(1)**
9	A	Crankshaft details, for each number of cylinders	3	
10	A	Crankshaft assembly, for each number of cylinders	3	
11	A	Counterweights including fastening bolts	3	
12	A	Connecting rod, details	3	
13	R	Connecting rod assembly	3	**(1)**
14	R	Piston assembly	1	
15	R	Camshaft drive assembly	1	
16	A	Material specifications of main components	3	
17	A	Arrangement of foundation bolts (for main engines only)	3	
18	A	Schematic diagram of engine control and safety system	3	
19	R	Shielding and insulation of exhaust pipes - assembly	1	
20	A	Shielding of high-pressure fuel pipes - assembly	3	**(2)**
21	A	Arrangement of crankcase explosion relief valves	3	**(3)**
22	R	Operation and service manuals	1	

(1) *Only necessary if sufficient details are not shown on the transverse cross section and longitudinal section*

(2) *For attended engine: only engines with a cylinder bore of ≥ 250 mm*

(3) *Only for engines with a cylinder diameter of > 200 mm, or a crankcase volume exceeding 0,6 m^3*

2.5 Safety devices

2.5.1 Speed control and engine protection against overspeed

a) Main and auxiliary engines

Each diesel engine not used to drive an electric generator shall be equipped with a speed governor or regulator so adjusted that the engine speed cannot exceed the rated speed by more than 15 %.

In addition to governor, each main engine with a rated power of 220 kW or over which can be declutched in service or which drives a variable pitch propeller shall be fitted with an additional overspeed device so adjusted that the engine speed cannot exceed the rated speed by more than 20 %.

Equivalent equipment may be approved by **TL**.

b) Engine driving electric generators

Each diesel engine used to drive an electric generator shall be fitted with a governor which, in the event of the sudden complete removal of the load, prevents any transient speed variation (δ_{rs}) in excess of 10 % of the rated speed. The permanent speed variation (δ_r) may not exceed 5 %.

In the case when a step load equivalent to the rated output of the generator is switched off, a transient speed variation in excess of 10 % of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by next passage.

In addition to the governor, each diesel engine with a rated power of 220 kW or over shall be equipped with an overspeed protection device independent of the normal governor which prevents the engine speed from exceeding the rated speed by more than 15 %.

Unless other requirements have been agreed with **TL** regarding the connection of loads, the speed variations specified above shall not be exceeded when the engine, running on no-load, is suddenly loaded to 50 % of its rated power followed by the remaining 50 %.

Generating sets of different capacities operating in parallel are required to run within the limits specified in B.6.

The speed shall be stabilized within five seconds, inside the permissible range specified for the permanent speed variation δ_r.

Generator sets which are installed to serve stand-by circuits shall satisfy these requirements even when the engine is cold. The start-up and loading sequence is to be concluded in about 45 seconds.

Emergency generator sets shall satisfy the above governor conditions even when their total consumer load is applied suddenly.

The governors of the engines mentioned above shall enable the rated speed to be adjusted over the entire power range with a maximum deviation of 5 %.

The rate of speed variation of the adjusting mechanisms shall permit satisfactory synchronization in a sufficiently short time. The speed characteristic should be as linear as possible over the whole power range. The permanent deviation from the theoretical linearity of the speed characteristic may, in the case of generating sets intended for parallel operation, in no range exceed 1 % of the rated speed.

Notes :

- *The rated power and the corresponding rated speed relate to the conditions under which the engines are operated in the system concerned.*

- *Additional overspeed protection device means a system all of whose component parts, including the drive, function independently of the governor.*

c) Use of electrical/electronic governors

The electrical/ electronic governors used shall have been type-tested by **TL**.

In the case of engines with electrical starters, the governor may be supplied direct from the starter battery allocated to each engine.

For each engine without an electric starter, the governor shall be supplied from the floating shipboard supply battery or from a permanently assigned battery of suitable capacity.

Arrangements are to be made to ensure that the batteries are kept charged and monitored at all times.

When an engine is taken out of service, the supply to its governor shall cut out automatically.

2.5.2 Cylinder overpressure warning device

All the cylinders of engines with a cylinder bore > 230 mm are to be fitted with cylinder overpressure control valves. The response threshold of these valves shall be set at not more than 40 % above the combustion pressure at rated power.

A warning device may be dispensed with if it is ensured by an appropriate engine design or by control functions that an increased cylinder pressure cannot create danger.

2.5.3 Crankcase airing and venting

The airing of crankcases is not allowed.

Crankcases are to be equipped with venting systems with a clear opening not larger than is strictly necessary. The crankcase vent pipes of engines having a swept volume of more than 50 dm^3 per row of cylinders are to be led into the open and protected to prevent the entry of water.

Engine with a swept volume of up to 50 dm^3 per row of cylinders are to be fitted with vent pipes which are to be covered over to prevent the entry of foreign matter and which may not terminate at hot points.

Where provision has been made for extracting the lubricating oil vapours, e.g. for monitoring the oil vapour concentration, the negative pressure in the crankcase may not exceed 2,5 mbar.

Joining together the crankcase vent pipes of two or more engines is not permitted.

2.5.4 Crankcase safety devices

Crankcase safety devices have to be type-approved in a configuration that represents the installation arrangements that will be used on an engine according to the requirements defined in Test Requirements for Mechanical Components and Equipment.

Safety valves to safeguard against overpressure in the crankcase are to be fitted to all engines with a cylinder bore of > 200 mm or a crankcase volume of > 0,6 m^3.

All other spaces communicating with the crankcase, e.g. gear or chain casings for camshafts or similar drives, are to be equipped with additional safety valves if the volume of these spaces likewise exceeds 0,6 m^3.

Engines with a cylinder bore of > 200 mm ≤ 250 mm shall be equipped with at least one safety valve at each end of the crankcase. If the crankshaft has more than 8 throws, an additional safety valve is to be fitted near the middle of the crankcase.

Engines with a cylinder bore of > 250 mm < 300 mm shall have at least one safety valve close to every second crank throw, subject to a minimum number of two.

Engines with a cylinder bore of > 300 mm shall have at least one safety valve close to each crank throw.

Each safety valve shall have a free cross sectional area of at least 45 cm^2.

The total free sectional area of the safety valves fitted to an engine to safeguard against overpressure in the crankcase may not be less than 115 $cm2/m^3$ of crankcase volume.

Notes

- *In estimating the gross volume of the crankcase,the volume of the fixed parts which it contains may be deducted.*

- *A space communicating with the crankcase via a total free cross sectional area of > 115 cm^2/m^3 of the volume need not be considered as a separate space. In calculating the total free cross sectional area, individual sections of < 45 cm^2 are to be disregarded.*

- *Each safety valve required may be replaced by not more than two safety valves of smaller cross sectional area provided that the free cross sectional area of each safety valve is not less than 45 cm^2.*

The safety devices shall take the form of flaps or valves of proven design. In service they shall be oiltight when closed and shall prevent air from flowing in into the crankcase. The gas flow caused by the response of the safety device shall be deflected in such a way as not to endanger persons standing nearby.

Safety device shall respond to as low an overpressure in the crankcase as possible (maximum 0,2 bar).

Covers of crankcase openings shall be so dimensioned as not to suffer permanent deformation due to the pressure occurring during the response of the safety equipment.

Crankcase doors and hinged inspection ports are to be equipped with appropriate latches to effectively prevent unintended closing.

A warning sign is to be mounted on the engine control platform or, if appropriate, on both sides of the engine drawing attention to the fact that the crankcase may not be opened immediately following stoppage of the hot run engine, but only after a sufficient cooling period has elapsed.

2.5.5 Safety devices in the starting air system

The following equipment is to be fitted to safeguard main starting air lines against explosions due to failure of starting valves:

a) An isolation non-return valve is to be fitted to the starting air line serving each engine.

b) Engines with cylinder bore of > 230 mm are to be equipped with flame arresters as follows:

- on directly reversible engines, in front of each start-up valve of each cylinder

- on non-reversing engines, in the main starting air line to each engine

c) Equivalent safety devices may be approved by **TL**.

2.5.6 Safety devices in the lubricating oil system

If the lubricating oil pressure falls below the minimum level specified by the engine manufacturer, thereby necessitating the immediate shutdown of the main engine, an audible and visual alarm shall be given which is clearly perceptible throughout the engine room and the control stand.

This alarm shall be clearly distinguishable from the alarm required under A.3.8.

2.6 Pipes and filters

2.6.1 General

The general engine piping system is subject to the requirements of C.

Table 12.5 Pressure tests

Component		Test pressure, p_p (1)
Cylinder cover, cooling water space		7 bar
Cylinder liner, over whole length of cooling water space		7 bar
Cylinder jacket, cooling water space		4 bar, at least 1,5 . $p_{e,zul}$
Exhaust valve, cooling water space		4 bar, at least 1,5 . $p_{e,zul}$
Piston, cooling water space (after assembly with piston rod, if applicable)		7 bar
Fuel injection system	Pump body, delivery side	1,5 · $p_{e,zul}$ or $p_{e,zul}$ + 300 bar (whichever is less)
	Valves Pipes	1,5 · $p_{e,zul}$ or $p_{e,zul}$ + 300 bar (whichever is less)
Exhaust gas turbocharger, cooling water space		4 bar, at least 1,5 · $p_{e,zul}$
Exhaust gas line, cooling water space		4 bar, at least 1,5 · $p_{e,zul}$
Main engine-driven compressor: Cylinder, cover, intercooler	Air side	1,5 · $p_{e,zul}$
Aftercooler	Water side	4 bar, at least 1,5 · $p_{e,zul}$
Cooler, both sides (charge air cooler only on water side)		4 bar, at least 1,5 · $p_{e,zul}$
Main engine-driven pumps (Oil, water, fuel and bilge pumps)		4 bar, at least 1,5 · $p_{e,zul}$
Starting and control air system		1,5 · $p_{e,zul}$ before installation

(1) *Component shall normally be hydraulically tested. Other equivalent test methods may be accepted.*

$p_{e,zul}$ = *maximum permissible working pressure of component concerned [bar]*

Table 12.6 Approved materials

Minimum required characteristics	Components
Forged steel $R_m \geq 360$ N/mm^2	Crankshafts Connecting rods Tie rods Bolts and studs
Rolled steel rounds $R_m \geq 360$ N/mm^2	Tie rods Bolts and studs
Nodular cast iron, preferably ferritic grades	Engine blocks Bedplates Cylinders covers Flyweels Valve bodies and similar parts
Lamellar cast iron $R_m \geq 200$ N/mm^2	Engine blocks Bedplates Cylinder covers Liners Flywheels
Shipbuilding steel All grade D for plates ≤ 25 mm thick	Welded bedplates Welded engine blocks
Shipbuilding steel All grade D for plates > 25 mm thick or equivalent structural steel, cast in the fully killed condition and normalized	
Weldable cast steel	Bearing transverse girders

2.6.2 Fuel lines

Only pipe connections with metal sealing surfaces or equivalent pipe connections of approved design may be used for fuel injection lines.

External high-pressure fuel delivery pipes of diesel engines, between the high-pressure fuel pumps and fuel injectors, shall be protected with a jacketed piping system capable of containing fuel from a high-pressure pipe failure. The jacketed piping system shall include a means for the collection of leakages, and arrangements shall be provided for an alarm to be given of a fuel pipe failure, except that an alarm is not required for engines with no more than two cylinders.

Jacketed piping systems need not be applied to engines on open decks operating windlasses and capstans. If pressure variations of > 20 bar occur in the fuel return lines, these are also to be shielded.

Leaking fuel is to be safely drained away at zero excess pressure. Care is to be taken to ensure that leaking fuel cannot become mixed with the engine lubricating oil.

2.6.3 Filters

a) Lubricating oil filters for main engines

Lubricating oil lines are to be fitted with lubricating oil filters located in the main oil flow on the delivery side of the pumps.

Steps are to be taken to ensure that main flow filters can be cleaned without interrupting operation. This requirement is considered to be satisfied by switch-over duplex filters, automatic filters or equivalent devices of approved design.

On main engines with a rated power of up to 220 kW, fitted with a lubricating oil line supplied from the engine oil sump, simplex filters may be fitted provided that they are equipped with a pressure alarm behind the filter and provided also that the filter can be changed during operation. For this purpose, a by-pass with manually operated shut-off valves is to be provided.

The switch positions shall be clearly recognizable.

b) Lubricating oil filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

c) Fuel filters for main engines

The supply lines to fuel-injection pumps are to be fitted with switch-over duplex filters or automatic filters.

d) Fuel filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

e) Filter arrangements

Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in immediate proximity of hot components.

Where the arrangement stated here before is unfeasible, the rotating parts and the hot components are to be sufficiently shielded.

Drip pans of suitable size are to be mounted under fuel filters. The same applies to lubricating oil filters if oil can escape when the filter is opened.

Switch-over filters with two or more filter chambers are to be fitted with devices ensuring a safe relief of pressure before opening and venting when a chamber is placed in service. Shutoff valves shall normally be used for this purpose. It shall be clearly discernible which fitler chambers are in service and which are out of operation at any time.

2.6.4 Exhaust gas lines

Exhaust gas pipes from engines are to be installed separately from each other with regard to structural fire protection.

The pipes shall be so installed that no exhaust gases can penetrate into accommodation spaces.

Account is to be taken of thermal expansion when laying out and suspending the lines.

Where exhaust gas lines discharge near water level, provisions are to be taken to prevent water from entering the engines.

Exhaust gas lines are to be insulated and/or cooled in such a way that the surface temperature cannot exceed 220 °C at any point. Insulating materials shall be noncombustible.

Exhaust gas lines are to be provided with suitable protection, e.g. sheet metal cladding or approved hard sheathing, to prevent leaking oil from seeping into the insulation.

Insulation material used in engine rooms shall be protected against the intrusion of fuel and fuel vapours.

The exhaust gas lines of main and auxiliary engines are to be fitted with efficient silencers.

For engine exhaust gas lines on tankers, see Section 16.

2.7 Starting equipment

2.7.1 Electric starting equipment

Where main engines are started electrically, one independent set of starter batteries is to be provided for each engine. The set of batteries shall enable the main engine to be started from cold.

The capacity of the starter set of batteries shall be sufficient for at least 6 start-up operations within 30 minutes without recharging.

Electrical starters for auxiliary engines are to be provided with independent batteries. The capacity of the batteries shall be sufficient for at last 3 start-up operations within 30 minutes.

Where machinery installations comprise 2 or more electrically started main engines, the starting equipment for auxiliary engines can also be supplied from the latter’s starter batteries. Separate circuits are to be installed for this purpose.

The starter batteries may only be used for starting (and possibility for preheating) as well as for monitoring equipment associated with the engine.

Arrangements are to be made to ensure that batteries are kept charged and monitored at all times.

2.7.2 Starting with compressed air

Main engines which are started with compressed air are to be equipped with at least two starting air compressors. At least one of the air compressors shall be driven independently of the main engine and shall supply at least 50 % of the total capacity required.

The total capacity of the starting air compressors is to be such that the starting air receivers can be charged to their final pressure within one hour (the receivers being at atmospheric pressure at the start of the charging operation).

Normally, compressors of equal capacity are to be installed.

If the main engine is started with compressed air, the available starting air is to be divided between at least two starting air receivers of approximately equal size which can be used independently of each other.

The total volume of the starting air receivers shall be such that it can be proved during the river trials that the quantity of air available is sufficient for at least 6 start-up operations with non-reversible main engines and at least 12 start-up operations with reversible main engines. Recharging of the starting air receivers during the execution of the start-ups is not allowed.

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.

No special starting air storage capacity needs to be provided for auxiliary engines in addition to the starting air storage capacity specified above. The same applies to pneumatically operated regulating and manoeuvring equipment and to the air requirements of typhon units.

Other consumers with a high air consumption may be connected to the starting air system only if the stipulated minimum supply of starting air for the main engines remains assured.

2.7.3 Air compressor equipment

Coolers are to be so designed that the temperature of the compressed air does not exceed 160 °C at the discharge of each stage of multi-stage compressors or 200 °C at the discharge of single-stage compressors.

Unless they are provided with open discharges, the cooling water spaces of compressors and coolers shall be fitted with safety valves or rupture discs of sufficient cross sectional area.

High-pressure stage air coolers shall not be located in the compressor cooling water space.

Every compressor stage shall be equipped with a suitable safety valve which cannot be blocked and which prevents the maximum permissible working pressure from exceeded by more than 10 % even when the delivery line has been shutoff. The setting of the safety valve shall be secured to prevent unauthorized alteration.

Each compressor stage shall be fitted with a suitable pressure gauge, the scale of which shall indicate the relevant maximum permissible working pressure.

2.8 Control equipment

2.8.1 Main engines room control platform

As a minimum requirement, the engine room control platform 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 platform 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.

See also Section 13, Table 13.16.

2.8.2 Main engines control from the bridge

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 2.8.1 is to signal faults on the bridge. Faults may be signalled in accordance with A.3.8. An indicator in the engine room and on the bridge shall show that the alarm system is operative.

2.8.3 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.

See also Section 13, Table 13.16.

2.9 Auxiliary systems

2.9.1 Lubricating oil system

General requirements relating to lubricating oil systems are contained in C.8.; for filters, see 2.6.3.

Engines whose sumps serve as oil reservoirs shall be so equipped that the oil level can be established and, if necessary, topped up during operation. Means shall be provided for completely draining the oil sump.

The combination of the oil drainage lines from the crankcases of two or more engines is not allowed.

Main lubricating oil pumps driven by the engine are to be designed to maintain the supply of lubricating oil over the entire operating range of the engine.

2.9.2 Cooling system

General requirements relating to the design of cooling water systems are contained in C.9.

Main cooling water pumps driven by the engine are to be designed to maintain the supply of cooling water over the entire operating range of the engine.

If cooling air is drawn from the engine room, the design of the cooling system is to be based on a room temperature of at least 40 °C.

The exhaust air of air-cooled engines may not cause any unacceptable heating of the spaces in which the plant is installed. The exhaust air is normally to be led to the open air through special ducts.

See also A.3.6.

Where air-cooled engines are used on tankers, Section 16 is applicable.

2.9.3 Exhaust gas turbochargers

Exhaust gas turbochargers may exhibit no critical speed ranges over the entire operating range of the engine.

The lubricating oil supply shall also be ensured during start-up and run-down of the exhaust gas turbochargers.

Even at low engine speeds, main engines shall be supplied with charge air in a manner to ensure reliable operation.

Emergency operation shall be possible in the event of the failure of an exhaust gas turbocharger.

2.9.4 Charge air cooling

Means are to be provided for regulating the temperature of the charge air within the temperature range specified by the engine manufacturer.

The charge air lines of engines with charge air coolers are to be provided with sufficient means of drainage.

2.10 Installation and mounting of engines

2.10.1 Engines are to be mounted and secured to their shipboard foundations in conformity with the **TL** Rules.

3. Main shafting

3.1 General

3.1.1 Scope

The following requirements apply to typical and proven types of main shafting. Novel designs require **TL** special approval.

Main shafts of reinforced design are additionally subject to the requirements of Section 13, Table 13.16. **TL** reserves the right to call for propeller shaft dimensions in excess of those specified in the following if the propeller arrangement results in increased bending stresses.

3.1.2 Documents for review/approval

General drawings of the entire shafting, from the main engine coupling flange to the propeller, and detail drawings of the shafts, couplings and other component parts transmitting the propelling engine torque, are each to be submitted to **TL** for review/approval. In specific cases and following prior agreement with **TL**, they can also be submitted in paper form in triplicate. The drawings shall contain all the data necessary to enable the stresses to be evaluated.

3.2 Materials

3.2.1 Approved materials

Propeller, intermediate and thrust shafts together with flanged connections and couplings are to be made of forged steel; where appropriate, couplings may also be made of cast steel or nodular cast iron with a ferritic matrix.

Rolled round steel may also be used for plain, flangeless shafts. In general, the tensile strength of steels used for shafting shall be between 400 N/mm^2 and 800 N/mm^2. However, the value of Rm used for calculating the material factor C_W defined in 3.3.2 for propeller shaft shall not be greater than 600 N/mm^2.

Where parts of the main shafting are made of material other than steel, the special consent of **TL** shall be obtained.

3.2.2 Materials testing

All materials of torque transmitting shafting components shall possess the properties specified in the **TL** Rules for Materials. This may be proven by an acceptance test certificate issued by the manufacturer.

3.3 Shaft dimensions

3.3.1 General

All parts of the shafting are to be dimensioned in accordance with the following formulas in compliance with the requirements relating to critical speeds set out in 6.

The dimensions of the shafting shall be based on the total installed power. Where the geometry of a part is such that it cannot be dimensioned in accordance with these formulas, special evidence of the mechanical strength of the part or parts concerned is to be furnished to **TL**.

3.3.2 Minimum diameter

The minimum diameter is to be determined by applying the following formula:

$$d \geq F \cdot k \cdot \sqrt[3]{\frac{P_W \cdot C_W}{n \cdot \left[1 - \left(\frac{d_i}{d_a}\right)^4\right]}} \cdot \leq d_a$$

d = Minimum required outside diameter of shaft [mm]

d_i = Diameter of the shaft bore, where present [mm]

If $d_i \leq 0{,}4 \, . \, d_a$

$$\left[1 - \left(\frac{d_i}{d_a}\right)^4\right] = 1$$

d_a = Actual outside shaft diameter [mm]

P_W = Shaft power [kW]

n = Shaft speed [rev/min]

F = Factor for the type of propulsion installation

= 90 for turbine installations, engine installations with slip couplings and electrical propulsion installations

= 94 for all other types of propulsion installations

C_W = Material factor

$$\frac{560}{R_m + 160}$$

R_m = Tensile strength of the shaft material [N/mm^2]

k = Factor for the type of shaft

= 1,0 for intermediate shafts with integral forged coupling flanges or with shrink-fitted keyless coupling flanges

= 1,10 for intermediate shafts with keyed coupling hubs. At a distance of at least 0,2.d from the end of the keyway, such shafts can be reduced to a diameter corresponding to k = 1,0

= 1,10 for intermediate shafts with radial holes with a diameter less than 0,3.d_a

= 1,10 for thrust shafts near the plain bearings on either side of the thrust collar, or near the axial bearings where an antifriction bearing design is used

= 1,15 for intermediate shafts designed as multi-splined shafts where d is the outside diameter of the splined shaft. Outside the splined section, the shafts can be reduced to a diameter corresponding to k = 1,0

= 1,20 for intermediate shafts with longitudinal slots where the length and width of the slot do not exceed 0,8 · d_a and 0,1 · d_a respectively

= 1,22 for propeller shafts from the area of the aft stern tube or shaft bracket bearing to the forward load-bearing face of the propeller boss subject to a minimum of 2,5.d, if the propeller is shrink-fitted, without key, on the tapered end of the propeller shaft using a method approved by **TL**, or if the propeller is bolted to a flange forged on the propeller shaft

= 1,26 for propeller shafts in the aft area as specified for k = 1,22, with tapered key/keyway connection

= 1,40 for propeller shafts in the area specified for k = 1,22, if the shaft inside the stern tube is lubricated with grease

= 1,15 for propeller shafts forward part outside the bearing area but inside the stern tube. The portion of the propeller shaft located forward of the stern tube can be reduced to the size of the intermediate shaft

Parts of the propeller shaft exposed to water and without effective corrosion protection shall be strengthened by 5 %.

3.4 Design

3.4.1 Changes in diameter

Changes from larger to smaller shaft diameters are to be effected by tapering or ample radiusing.

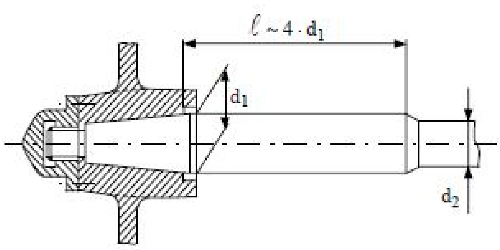


Fig. 12.2 Propeller shaft

3.4.2 Sealing

Propeller shafts running in oil or grease are to be fitted with seals of proven efficiency and approved by **TL** at the stern tube ends. The propeller boss seating is to be effectively protected against the ingress of water. The seals at the propeller can be dispensed with if the propeller shaft is made of corrosion resistant material.

Means shall be provided so that polluting lubricants do not spread into the water.

3.4.3 Shaft tapers and propeller nut threads

Keyways in the shaft taper for the propeller should be so designed that the forward end of the groove makes a gradual transition to the full shaft section. In addition, the forward end of the keyway should be spoon shaped. The edges of the keyway at the surface of the shaft taper for the propeller may not be sharp. The forward end of the keyway shall lie well within the seating of the propeller boss. Threaded holes to accommodate the securing screws for propeller keys should be located only in the aft half of the keyway (see Fig. 12.3).

Note

In Fig. 12.3 d_2 is the propeller shaft diameter.
*For most simplified designs of the keyway, the consent of **TL** will be required.*

In general, tapers for securing flange couplings should have a cone of between 1:10 and 1:20. In the case of shaft tapers for propellers, the cone shall be between 1:10 and 1:15. Where the oil injection method is used to mount the propeller on the shaft, a taper of the cone between 1:15 and 1:20 is to be preferred.

The outside diameter of the threaded end propeller retaining nut should not be less than 60 % of the calculated major taper diameter.

3.4.4 Shaft liners

Propeller shafts which are not made of corrosion resistant material are to be protected against contact with brackwater by metal liners or other liners approved by **TL** and by seals of proven efficiency at the propeller.

Metal liners, in accordance with the requirement here above, shall be made in a single piece. Only with the express consent of **TL** may particularly long liners be

made up of two parts, provided that, after fitting, the abutting edges are connected and made watertight by a method approved by **TL** and the area of the joint is subjected to special testing.

The minimum wall thickness, t [mm] of metal shaft liners in way of bearings is to be determined using the following formula:

$$t = \frac{75 \cdot d}{d + 1000}$$

d = Shaft diameter under the liner [mm]

In the case of continuous liners, the wall thickness between the bearings may be reduced to 0,75.t.

3.5 Couplings

3.5.1 The thickness of forged coupling flanges on intermediate and thrust shafts and on the forward end of the propeller shaft shall be equal at least 20 % of the Rule diameter of the shaft in question.

Where propellers are attached to a forged flange on the propeller shaft, the flange shall have a thickness equal to at least 25 % of the Rule diameter.

These flanges may not be thinner than the Rule diameter of the fitted bolts if these are based on the same tensile strength as that of the shaft material.

The radius at integrally forged flanges is to be at least 0,08.d [mm].

In 3.5.2 to 3.5.6, the following symbols are used:

A = Effective area of shrink fit seating [mm^2]

c_A = Coefficient for shrink-fitted joints

= 1,0 for gear drives and electric motors

= 1,2 for direct diesel drives

C = Conicity of shaft ends

= Difference in taper diameter/length of taper

d = Shaft diameter in area of clamp-type coupling [mm]

d_f, d_k = Diameters of fitted bolts and plain bolts [mm]

D = Diameter of pitch circle of bolts [mm]

f = Coefficient for shrink-fitted joints

$$= \left(\frac{\mu_0}{S}\right)^2 - \Theta^2$$

n = Propeller speed [rev/min]

p = Interface pressure of shrink fits [N/mm^2]

Q = Peripheral force at the mean joint diameter of a shrink-fitted joint [N]

$$= \frac{2000 \cdot T_D}{d_m}$$

T_D = Drive torque [N.m]

$$= \frac{9550 \cdot P_W}{N}$$

P_W = Shaft power [kW]

d_m = Mean joint diameter of the shrink fit [mm]

S = Safety factor against slipping of shrink fits in the shafting

= 3,0 between motor and gearing

= 2,5 for all other applications

z = Number of fitted or plain bolts

R_m = Tensile strength of fitted or plain bolt material [N/mm2]

T = Propeller thrust [N]

Θ = Half-conicity of shaft ends

= C/2

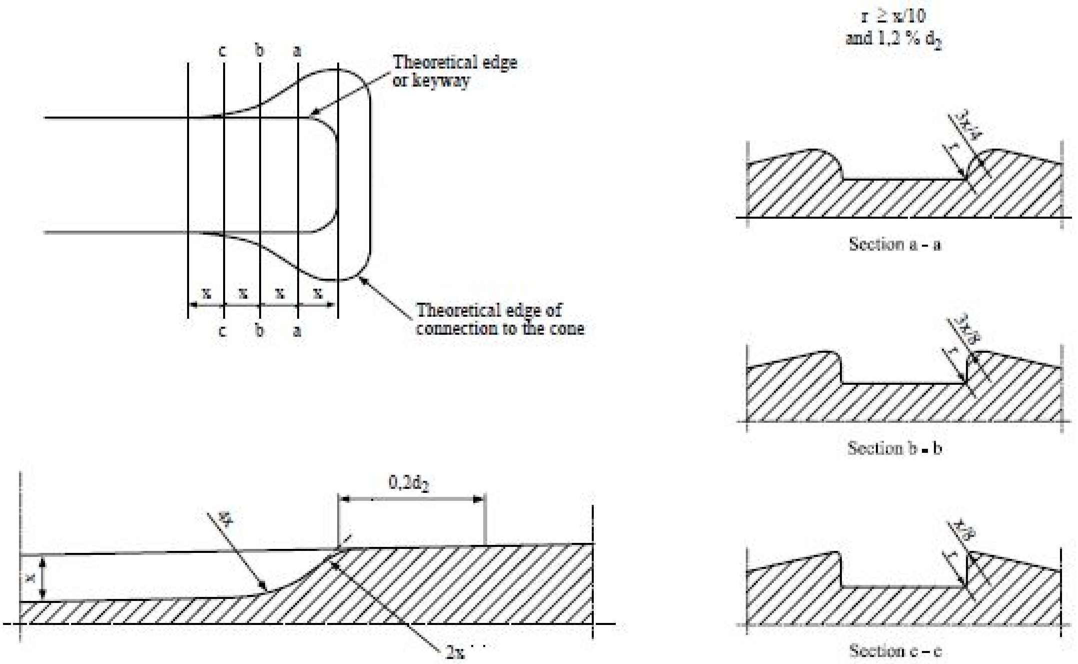


Fig. 12.3 Design of keyway in propeller shaft

μ_0 = Coefficient of static friction

= 0,15 for hydraulic shrink fits

= 0,18 for dry shrink fits

Δ_{min} = Minimum shrink interference [mm]

3.5.2 The bolts used to connect flange couplings are normally to be designed as fitted bolts. The minimum diameter df of fitted bolts at the coupling flange faces is to be determined by applying the following formula:

$$d_f = 16 \cdot \sqrt{\frac{10^6 \cdot P_W}{n \cdot z \cdot D \cdot R_m}} \quad [mm]$$

3.5.3 Where, in special circumstances, the use of fitted bolts is not feasible, **TL** may agree to the use of an equivalent frictional transmission.

3.5.4 The minimum thread root diameter dk of connecting bolts used for clamp-type couplings is to be determined using the following formula:

$$d_k = 12 \cdot \sqrt{\frac{10^6 \cdot P_W}{n \cdot z \cdot d \cdot R_m}} \quad [mm]$$

3.5.5 The shank of necked-down bolts can be designed to a minimum diameter of 0.9 times the thread root diameter. If, besides the torque, the bolted connection is also required to transmit considerable additional forces, the size of the bolts shall be increased accordingly.

3.5.6 Where shafts are coupled together without keys by shrink-fitted coupling flanges or coupling sleeves, the dimensions of these shrink fits should be such that the maximum Von Mises equivalent stress in the boss of the coupling or the bore of the coupling sleeve, based on the "go" end of the prescribed tolerance gauge, does not exceed 80 % of the yield strength of the coupling material.

The margin of safety against slipping of the joint is to be based on the "no go" ends of the prescribed tolerance gauges, and the necessary interface pressure p [N/mm^2], in the shrunk joint is to be determined as follows:

$$p = \frac{\sqrt{\theta^2 \cdot T^2 + f \cdot (c_A^2 \cdot Q^2 + T^2)} - \theta \cdot T}{A \cdot f}$$

T has to be introduced as a positive value if the propeller thrust increases the surface pressure at the taper. Change of direction of propeller thrust is to be neglected as far as power and thrust are essentially less.

T has to be introduced as a negative value if the propeller thrust reduces the surface pressure at the taper, e.g. for tractor propellers.

3.6 Shaft bearings

3.6.1 Arrangement of shaft bearings

Shaft bearings both inside and outside the stern tube are to be so disposed that, when the plant is hot and irrespective of the condition of loading of the vessel, each bearing is subjected to positive reaction forces equivalent to not less than 20 % of the weight of the shaft length carried by the bearing. By appropriate spacing of the bearings and by alignment of the shafting in relation to the coupling flange at the engine or gearing, care is to be taken to ensure that no undue transverse forces or bending moments are exerted on the crankshaft or gear shafts when the plant is hot. By spacing the bearings sufficiently far apart, steps are also to be taken to ensure that the reaction forces of line or gear shaft bearings are not appreciably affected should the alignment of one or more bearings be altered by hull deflections or by displacement or wear of the bearings themselves.

Guide values for the maximum permissible distance between bearings lmax [mm] can be determined using the following formula:

$$\ell_{max} = K_1 \cdot \sqrt{d_a}$$

K_1 = coefficient defined as:

= 450 for oil-lubricated white metal bearing

= 280 for grey cast iron, grease-lubricated stern tube bearings

= 280 - 350 for water-lubricated rubber bearings in stern tubes and shaft brackets (upper values for special designs only)

Note

Where the shaft speed exceeds 350 rev/min, it is recommended that the maximum bearing spacing in accordance with formula here below be observed in order to avoid excessive loads due to bending vibrations. In borderline cases a bending stress analysis should be made for the shafting system.

$$\ell_{max} = K_2 \cdot \sqrt{\frac{d_a}{N}}$$

K_2 = coefficient defined as:

= 8400 for oil-lubricated white metal bearings

= 5200 for grease-lubricated, grey cast iron bearings and for rubber bearings inside stern tubes and tail shaft brackets

3.6.2 Stern tube bearings

Inside the stern tube, the propeller shaft should normally be supported by two bearings. In short stern tubes, the forward bearing may be dispensed with.

Where the propeller in the stern tube runs in bearings made of rubber or plastic, the length of the after bearing should equal approximately 3 - 4 times the shaft diameter, while the length of the forward bearing should be approximately 1 - 1.5 times the shaft diameter. Where the propeller shaft inside the stern tube runs in oil-lubricated white metal bearings, the lengths of the after and forward stern tube bearings should be approximately 2 and 0.8 times the shaft diameter respectively. The length of a grease lubricated bearing is to be not less than 4.0 times the rule diameter of the shaft in way of the bearing.

Where the propeller shafts are intended to run in antifriction bearings within the stern tube, such bearings should be preferably cylindrical roller bearings with cambered rollers or bearing races and with an increased bearing clearance. The camber shall be sufficient to tolerate without adverse effects an angular deviation of 0,1 % between the shaft and the bearing axis. Self-aligning roller bearings may be used to carry the propeller shaft only if provision is made for the axial adjustment of such bearings.

Propeller shafts running in anti-friction bearings shall be fitted at the stern tube ends with seals approved by **TL** for this type of bearing.

3.6.3 Bearing lubrication

The lubrication and the matching of the materials used for journal and anti-friction bearings inside and outside the stern tube shall satisfy the requirements of marine service.

Lubricating oil or grease shall be introduced into the stern tube in such a way as to ensure a reliable supply of oil or grease to the forward and after stern tube bearings. With grease lubrication, the forward and after bearings are each to be provided with a Grease connection. Wherever possible, a grease pump driven by the shaft is to be used to secure a continuous supply of grease.

Where the shaft runs in oil within the stern tube, a header tank is to be fitted at a sufficient height above the vessel's load line. Facilities are to be provided for checking the level of oil in the tank at any time.

3.6.4 Stern tube connections

Oil-lubricated stern tubes are to be fitted with filling, testing and drainage connections as well as with a vent pipe. Connections and stern tube shall be designed to ensure that oil, infiltrated water and air can be completely expelled.

Where the propeller shaft runs in water, a flushing line is to be fitted which is to be connected to a suitable pump or another pressure system.

3.6.5 Cast resin mounting

The mounting of stern tubes and stern tube bearingsmade of cast resin and also the seating of plummer bearings on cast resin parts is to be carried out by **TL** approved companies in the presence of a **TL** Surveyor.

Only cast resins approved by **TL** may be used for seatings.

Note is to be taken of the installation instructions issued by the manufacturer of the cast resin.

3.7 Shaft locking device

To prevent dragging of a shut down propulsion unit, the shafting is to be fitted with a locking device.

3.8 Pressure tests

3.8.1 Shaft liners

Prior to fitting in the finish-machined condition, shaft liners are to be subjected to a hydraulic tightness test at 2 bar pressure.

3.8.2 Stern tubes

Prior to fitting in the finish-machined condition, cast stern tubes are to be subjected to a hydraulic tightness test at 2 bar pressure. A further tightness test is to be carried out after fitting.

For stern tubes fabricated from welded steel plates, it is sufficient to test for tightness during the pressure tests applied to the hull spaces traversed by the stern tube.

3.9 For the propulsion arrangement of passenger ships, see also Section 15, D.3.3.

4. Gears and couplings

4.1 General

4.1.1 Scope

The following requirements apply to spur, planetary and bevel gears and to all types of couplings for application in the main propulsion plant or important auxiliary machinery such as:

- Electric generator sets

- Windlasses

- Bow thruster units

- Lubricating oil, cooling water, bilge pumps, etc.

The design requirements laid down here may also be applied to the gears and couplings of auxiliary machinery other than that mentioned above, if equivalent evidence of mechanical strength is not available.

4.1.2 Application of these Rules to the auxiliary machinery couplings mentioned above may generally be limited to a basic design approval by **TL** of the particular coupling type. Regarding the design of elastic couplings for use in generator sets, reference is made to 4.7.

4.1.3 For the dimensional design of gears and couplings for vessels with reinforced design, see Section 17, A.

4.1.4 Documents for review / approval

Assembly and sectional drawings together with the necessary detail drawings and parts lists are to be submitted to **TL** for review/approval. In specific cases and following prior agreement with **TL** they can also be submitted in paper form in triplicate. They shall contain all data necessary to enable the load calculations to be checked.

4.2 Materials

4.2.1 Approved materials

a) Shafts, pinions, wheels and wheel rims of gears in the main propulsion plant should preferably be made of forged steel. Rolled steel bar may also be used for plain, flangeless shafts. Gear wheel may be of grey cast iron (see Note) or nodular cast iron or may be fabricated from welded steel or cast steel hubs.

b) Couplings in the main propulsion plant shall be made of steel, cast steel or nodular cast iron with a mostly ferritic matrix. Grey cast iron or suitable cast aluminium alloys may also be permitted for lightly stressed external components of couplings and the rotors and casings of hydraulic slip couplings.

c) The gears of important auxiliary machinery are subject to the same requirements as those specified in a) as regards the materials used. For gears intended for auxiliary machinery different to those mentioned in a), other materials may also be permitted.

d) Flexible coupling bodies for important auxiliary machinery according to a) may generally be made of grey cast iron, and for the outer coupling bodies a suitable aluminium alloy may also be used.

However, for generator sets use should only be made of coupling bodies preferably made of nodular cast iron with a mostly ferritic matrix, of steel or of cast steel, to ensure that the couplings are well able to withstand the shock torques occasioned by short circuits. **TL** reserves the right to impose similar requirements on the couplings of particular auxiliary drive units.

Note

The peripheral speed of cast iron gear wheels shall generally not exceed 60 m/s, that of cast iron coupling clamps or bowls, 40 m/s.

4.2.2 Testing of materials

All materials of torque transmitting components of gearing and couplings and the plates and steel parts of welded gear casings shall possess the properties specified in the **TL** Rules for Materials.

This may be proven by an acceptance test certificate issued by the manufacturer.

With the consent of **TL**, the tests prescribed in the **TL** Rules for Materials may be reduced if the execution of such tests is rendered impracticable by the small size of certain components or by the particular manufacturing techniques used. For such parts, proof of quality is to be furnished to **TL** by other means.

4.3 Calculation of the load bearing capacity of cylindrical and bevel gearing

4.3.1 General

The sufficient load capacity of the gear-tooth system of main and auxiliary gears in main propulsion systems of inland water vessels is to be demonstrated by load calculations according to the international standards ISO 6336 and ISO 9083 for spur gear tooth systems respectively, ISO 10300 for bevel gears.

For the design and calculation of the gears, the requirements for the design and construction of gears according to **TL** Rules for Machinery, Section 7 are applicable.

4.3.2 Application factor K_A

The application factor K_A takes into account the increase in rated torque caused by external increases in dynamic and transient load. Normally, the application factor K_A should be determined by measurements or by system analysis acceptable by **TL**.

Where a value as described above cannot be supplied, the application factor K_A is to be determined for main and auxiliary systems in accordance with Table 12.7.

Table 12.7 Application factor

System type	K_A
Main propulsion	
Diesel engine with fluid coupling or electromagnetic coupling	1,05
Diesel engine drive systems with highly flexible coupling between engine and gears	1,30
Diesel engine drive systems with other couplings than flexible	1,50
Shaft generator drives	1,50
Auxiliary propulsion	
Electric motor or diesel engine with fluid coupling or electromagnetic coupling	1,0
Diesel engine drive systems with highly flexible coupling between engine and gears	1,2
Diesel engine drive systems with other couplings than flexible	1,4
Note *For other types of systems, the factor K_A is to be stipulated separately*	

4.4 Gear shafts

4.4.1 Minimum diameter

The dimensions of shafts of reversing and reduction gears are to be calculated by applying the following formula:

$$d \geq F \cdot k \cdot \sqrt[3]{\frac{P_W}{n \cdot \left[1 - \left(\frac{d_i}{d_a}\right)^4\right]} \cdot C_W}$$

For di/da ≤ 0,3:

$$\left[1 - \left(\frac{d_i}{d_a}\right)^4\right] = 1$$

di = Diameter of shaft bore, if applicable [mm]

da = Actual shaft diameter [mm]

Pw = Driving power of shaft [kW]

N = Shaft rotational speed [rev./min]

F = Factor for the type of drive

= 90 for turbine plants, electrical drives and engines with slip couplings

= 94 for all other types of drive. **TL** reserves the right to specify higher F values if this appears necessary in view of the loading of the plant.

Cw = Material factor

$$\frac{560}{R_m + 160}$$

However, for wheel shafts, the value substituted for R_m in the formula shall not be higher than 800 N/mm^2. For pinion shafts the actual tensile strength value may generally be substituted for R_m.

k = Coefficient defined as:

= 1,10 for gear shafts

= 1,15 for gear shafts in the area of the pinion or wheel body, if this is keyed to the shaft, and for multi-spline shafts.

Higher values of k may be specified by **TL** where increased bending stresses in the shaft are liable to ocur because of the bearing arrangement, the casing design, the tooth pressure, etc.

4.5 Equipment

4.5.1 Oil level indicator

For monitoring the lubricating oil level in main and auxiliary gears, equipment shall be fitted to enable the oil level to be determined.

4.5.2 Pressure and temperature control

Temperature and pressure gauges are to be fitted to monitor the lubricating oil pressure and the lubricating oil temperature at the oil-cooler outlet before it enters the gears.

Plain journal bearings are also to be fitted with temperature indicators.

Where gears are fitted with anti-friction bearings, a temperature indicator is to be mounted at a suitable point. For gears rated up to 2000 kW, special arrangements may be agreed with **TL**.

Where vessels are equipped with automated machinery, the requirements for automation are to be complied with.

4.5.3 Lubricating oil pumps

Lubricating oil pumps driven by the gearing shall be mounted in such a way that they are accessible and can be replaced.

4.5.4 Gear casings

The casings of gears belonging to the main propulsion plant and important auxiliaries shall be fitted with removable inspection covers to enable the gears to be inspected and the thrust bearing clearance to be measured and oil sump to be cleaned.

4.5.5 Seating of gears

The seating of gears on steel or cast resin chocks is to conform to **TL** Rules for the mechanical seating of engine plants.

n the case of cast resin seatings, the thrust shall be absorbed by means of stoppers. The same applies to cast resin seatings of separate thrust bearings.

4.6 Balancing and testing

4.6.1 Balancing

Gear wheels, pinions, shafts, gear couplings and, where applicable, high-speed flexible couplings shall be assembled in a properly balanced condition.

The generally permissible residual imbalance U [kg . mm] per balancing plane of gears for which static or dynamic balancing is rendered necessary by the method of manufacture and by the operating and loading conditions can be determined by applying the formula:

$$U = \frac{9{,}6\, Q \cdot G}{z \cdot N}$$

G = Mass of body to be balanced [kg]

N = Operating rotational speed [rev./min] of body to be balanced

z = Number of balancing planes

Q = Degree of balance

= 6,3, for gear shafts, pinions and coupling members for engine gears

= 2,5, for torsion shafts and gear couplings, pinions and gear wheels belonging to turbine transmissions

4.6.2 Testing in the manufacturer's works

When the testing of material and component tests have been carried out, gearing systems for the main propulsion plant and for important auxiliaries are to be presented to **TL** for final inspection and operational testing in the manufacturer's works. The final inspection is to be combined with a trial run lasting several hours under part or full-load conditions, on which occasion the tooth clearance and contact pattern are to be checked. In the case of a trial at full-load conditions, any necessary running-in of the gears shall have been completed beforehand. Where no test facilities are available for the operational and on-load testing of large gear trains, these tests may also be performed on board vessel on the occasion of the sea trials.

Tightness tests are to be performed on those components to which such testing is appropriate.

Reductions in scope of tests require the consent of **TL**.

4.7 Design and construction of couplings

For the design and construction of couplings in main and auxiliary propulsion systems, such as tooth couplings, flexible couplings, etc., **TL** Rules and requirements for the design and construction of couplings are applicable.

5. Propellers

5.1 General

5.1.1 Scope

The following requirements apply to screw propellers and controllable pitch propellers. Where a design is proposed to which the following Rules cannot be applied, special strength calculations are to be submitted to **TL** and the necessary tests are to be agreed with **TL**.

The propellers of propulsion units of strengthened design are additionally subject to the provisions of Section 17, A.3

5.1.2 Documents for review/approval

Design drawings of propellers are to be submitted to **TL** for review/approval. In specific cases and following prior agreement with **TL** they can also be submitted in paper form in triplicate. Drawings are to contain all the details necessary to verify compliance with the following Rules.

5.1.3 Symbols and terms

A = Effective area of shrink fit [mm^2]

B = Developed blade width of cylindrical sections at radii 0,25R, 0,35R and 0,60R [mm]

c_A = Coefficient for shrunk joints [-]

= 1,0 for gear transmissions, electric motors

= 1,2 for direct diesel drives

C_G = Size factor [-]

$$= \sqrt{\frac{f_1 + 0{,}001 \cdot D}{12{,}2}}$$

with $1{,}1 \geq C_G \geq 0{,}85$

C_W = Characteristic value for propeller material as shown in Table 12.8 (corresponds to the minimum tensile strength Rm of the propeller material where this has been shown to possess sufficient fatigue strength under alternating bending stresses in accordance with 5.2)

C = Conicity of shaft ends [-]

= Difference in taper diameter/length of taper d = Pitch circle diameter of blade or propeller fastening bolts [mm]

d_k = Root diameter of blade or propeller fastening bolts [mm]

d_S = Nominal diameter of studs or bolts [mm]

Table 12.8 Characteristic values C_W for propeller materials

Material	Description (1)	C_W
Cu 1	Cast manganese brass	440
Cu 2	Cast manganese nickel brass	440
Cu 3	Cast nickel aluminium bronze	590
Cu 4	Cast manganese aluminium bronze	630
Fe 1	Unalloyed cast steel	440
Fe 2	Low-alloy cast steel	440
Fe 3	Martensitic cast chrome steel 13/1-6	600
Fe 4	Martensitic cast chrome steel 17/4	600
Fe 5	Ferritic-austenitic cast steel 24/8	600
Fe 6	Austenitic cast steel 18/8-11	500

(1) *For the chemical composition of the alloys, see the* ***TL*** *Rules for Materials.*

D = Diameter of propeller [mm]

d_m = Mean taper diameter [mm]

e = Blade rake to aft [mm]

= 0,5 · D · tan ε (see Fig. 12.4)

f, f_1 = Factors defined as:

$$f = \left(\frac{\mu_0}{S}\right)^2 - \Theta^2 \ [-]$$

f1 = 7,2 for solid propellers [-]

= 6,2 for separately cast blades of variable pitch or built-up propellers [-]

H = Propeller blade face pitch at radii 0,25R, 0,35R and 0,60R [mm]

H_m = Mean effective propeller pitch on blade face for pitch varying with the radius [mm]

$$= \frac{\Sigma(R \cdot B \cdot H)}{\Sigma(R \cdot B)}$$

where R, B and H are to be substituted by values corresponding to the pitch at the various radii

k = Coefficient for various profile shapes in accordance with Table 12.9 [-]

ℓ_M = 2/3 of the leading edge component of the blade width at 0,9.R, but at least ¼ of the total blade width at 0,9.R for propellers with heavily skewed blades [mm]

L = Pull-up length when mounting propeller on taper [mm]

L_{mech} = Pull-up length at t = 35 °C [mm]

L_{temp} = Temperature-related portion of pull-up length at t < 35 °C [mm]

n_2 = Propeller speed [min^{-1}]

P_W = Nominal power of driving engine [kW]

P = Specific pressure in shrunk joint between propeller and shaft [N/mm^2]

Q_n = Nominal peripheral force at mean taper diameter at maximum continuous rating (MCR) condition [N]

$$= 19{,}1 \frac{P_W}{n_2 \cdot d_m} \cdot 10^6$$

Q_{FR} = Peripheral force at mean taper diameter at MCR condition including Q_n and $Q_{V\text{-}MCR}$ [N]

$Q_{V\text{-}MCR}$ = Peripheral force at mean taper diameter at MCR condition due to torsional vibration [N]

$R_{P0,2}$ = 0,2 % proof stress of propeller material [N/mm^2]

R_{eH} = Yield strength [N/mm^2]

R_m = Tensile strength of the material of fitted or conventional bolts [N/mm^2]

S = Margin of safety against propeller slipping on taper

= 2,8 [-]

t = Maximum blade thickness of developed cylindrical section at radii 0,25R, 0,35R and 0,60R [mm]

T = Propeller thrust [N]

T_M = Impact moment in accordance with 5.4.3 [Nm]

$W_{0,35R}$ = Section modulus of cylindrical blade section at radius 0,35 R [mm^3]

$W_{0,6R}$ = Section modulus of cylindrical blade section at radius 0,6 R [mm^3]

Z = Total number of bolts used to retain one blade or propeller

z = Number of blades

α = Pitch angle of profile at radii 0,25R, 0,35R and 0,60R [°]

$$\alpha_{0,25} = a\tan\frac{1,27 \cdot H}{D}$$

$$\alpha_{0,35} = a\tan\frac{0,91 \cdot H}{D}$$

$$\alpha_{0,60} = a\tan\frac{0,53 \cdot H}{D}$$

α_A = Tightening factor for retaining bolts and studs, depending on the method of tightening used [-]

Guidance values:

= 1,2 for angle control

= 1,3 for bolt elongation control

= 1,6 for torque control

ε = Angle included by face generatrix and normal (see Fig. 12.4) [°]

$$= a\tan\frac{2 \cdot e}{D}$$

Θ = Half-conicity of shaft ends [-]

= C/2

μ_0 = Coefficient of static friction [-]

= 0,13 for hydraulic oil shrunk joints

= 0,15 for fitted joints, bronze to steel

= 0,18 for dry shrunk joints, steel to steel

Friction improving agents are not taken into account.

5.2 Materials

5.2.1 Approved materials

Wherever possible, propellers are to be made of established cast copper or cast steel alloys with a tensile strength of at least 440 N/mm^2 and of proven sufficient fatigue strength under alternating bending stresses.

The use of grey cast iron, un- and low-alloyed cast steel for propellers may be permitted in exceptional cases.

Composite materials may also be used, provided that a sufficient strength has been demonstrated and the propeller is manufactured according to an approved procedure.

Where use is to be made of propeller materials whose performance has not yet been sufficiently established, special proof of their suitability shall be furnished to **TL**.

5.2.2 Testing of materials

Propeller materials and materials of blade mounting screws/bolts as well as those of important components involved in the adjustment of variable pitch propellers shall possess the properties specified in the **TL** Rules for Materials. This may be demonstrated by an acceptance test certificate issued by the manufacturer.

5.3 Calculation of blade thickness

5.3.1 At radii 0,25 R, and 0,60 R (see Fig. 12.4), the blade thickness of solid propellers shall, as a minimum requirement, comply with the following formula:

$$t = K_0 \cdot k \cdot K_1 \cdot C_G$$

K_0 = Coefficient defined as

$$= 1 + \frac{e \cdot \cos\alpha}{H} + \frac{n_2}{15000}$$

K_1 = Coefficient defined as

$$= \sqrt{\frac{P_W \cdot 10^5 \cdot \left(2 \cdot \frac{D}{H_m} \cdot \cos\alpha + \sin\alpha\right)}{n_2 \cdot B \cdot z \cdot C_W \cdot (\cos\varepsilon)^2}}$$

5.3.2 The blade thicknesses of controllable pitch propellers are to be determined at radii 0,35R and 0,60R by applying the formula given in 5.3.1.

For the controllable pitch propellers of tugs and pushing vessels with similar operating conditions, the diameter/pitch ratio D/H_m for the maximum static bollard pull is to be used in formula given in 5.3.1.

For other vessels, the diameter/pitch ratio D/H_m applicable to open-water navigation can be used in formula given in 5.3.1.

5.3.3 The blade thicknesses calculated by applying formula given in 5.3.1 are minima for the finish-machined propellers without fillets.

If the propeller is subjected to an essential wear, e.g. abrasion in muddy waters, the thickness determined under 5.3.1 has to be increased. If the actual thickness in service is below 50 % at the tip and 90 % at other radii of the values obtained from formula given in 5.3.1 countermeasures have to be taken.

5.3.4 The fillet radii at the transition from the face and back of the blades should correspond, in the case of three and four-bladed propellers, to about 3,5 % of the propeller diameter. For propellers with a larger number of blades, the maximum fillet radii allowed by the propeller design should be aimed at, and the radii shall not in any case be made smaller than $0{,}4 \cdot t_{0,25R}$.

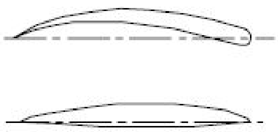
5.3.5 For special designs such as propellers with skew angle $\psi \geq 25°$, end plate propellers, tip fin propellers, special profiles, etc., special mechanical strength calculations are to be submitted to **TL**.

5.4 Controllable pitch propellers

5.4.1 Documents for review/approval

In the case of controllable pitch propellers, besides the design drawings of the blades and propeller boss, general and sectional drawings of the entire controllable pitch propeller installation are to be submitted to **TL** for review/approval. Diagrams of control systems and piping are to be accompanied by a functional description. For new designs and controllable pitch propellers which are to be installed for the first time on a vessel, a description of the controllable pitch propeller system is to be submitted at the same time.

Table 12.9 Values of k for various profile shapes

Profile shape	Values of k		
	0,25 R	0,35 R	0,6 R
Segmental profiles with circular arced suction side	73	62	44
			
Segmental profiles with parabolic suction side	77	66	47
			
Blade profiles as for Wageningen B Series propellers	80	66	44
			

5.4.2 Hydraulic control equipment

Where the pitch control mechanism is operated hydraulically, one set of pumps might be sufficient for the pitch setting. However, one hand pump shall be provided, by which blade adjustment is possible.

5.4.3 Pitch control mechanism

For the pitch control mechanism, proof is required that, when subjected to an impact moment T_M as defined by the formula below, the individual components still have a safety factor of 1,5. The calculated stress should not exceed the yield strength value.

$$T_M = \frac{1{,}5 \cdot R_{p0,2} \cdot W_{0,6R}}{\sqrt{\left(\frac{0{,}15 \cdot D}{\ell_M}\right)^2 + 0{,}75}}$$

$W_{0,6R}$ = Parameter defined in 5.1.3

= $0{,}12 \cdot (b \cdot t^2)_{0,6R}$

5.4.4 Blade retaining bolts and studs

The blade retaining bolts shall be designed in such a way as to withstand the forces induced in the event of plastic deformation at the root section at 0,35R caused by a force acting on the blade at 0,9R. The bolt material shall have a safety margin of 1,5 against its yield strength which has to be demonstrated.

The demonstration can be dispensed from, if the thread core diameter is not less than:

$$d_k = 2{,}6 \cdot \sqrt{\frac{M_{0,35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

$$M_{0,35R} = W_{0,35R} \cdot R_{p0,2}$$

The blade retaining bolts or studs are to be tightened in a controlled manner in such a way that the loading on the bolts or studs is about 60 - 70 % of their yield strength.

The shank of the blade retaining bolts may be designed with a minimum diameter equal to 0.9 times the root diameter of the thread. Blade retaining bolts shall be secured against unintentional loosening.

5.4.5 Flanges for connection of blades to hubs

The diameter D_F, in mm, of the flange for connecting the blade to the propeller hub is not to be less than that obtained from the following formula:

$$D_F = d + 1{,}8 \cdot d_S$$

The thickness of the flange is not to be less than 1/10 of the diameter D_F.

This formula is also applicable for built-up propellers.

5.4.6 Indicators

Controllable pitch propeller systems are to be provided with an engine room indicator showing the actual pitch setting of the blades. If the controllable pitch propeller is operated from the steering stand of the vessel, the steering stand is also to be equipped with an indicator showing the actual blade pitch setting. For vessels with automated machinery installations, see also A.3.8.

5.4.7 Failure of control system

Suitable devices are to be fitted to ensure that an alteration of the blade pitch setting cannot overload the propulsion plant or cause it to stall.

Steps shall be taken to ensure that, in the event of failure of the control system, the setting of the blades:

- Does not change or
- Reaches a final position slowly enough to allow the emergency control system to be put into operation or to take other suitable countermeasures.

5.4.8 Emergency control

Controllable pitch propeller systems shall be equipped with means of emergency control enabling the controllable pitch propeller to remain in operation, should the remote control system fail. It is recommended that a device has to be fitted which locks the propeller blades in the "ahead" setting.

5.5 Balancing and testing

5.5.1 Balancing

The finished propeller and the blades of controllable pitch and built-up propellers are required to undergo static balancing.

5.5.2 Testing

The finished propeller is to be presented at the manufacturer's premises to **TL** Surveyor for final inspection and verification of the dimensions.

TL reserves the right to require non-destructive tests to be conducted to detect surface cracks and casting defects.

In addition, controllable pitch propeller systems are required to undergo pressure, tightness and operational tests.

5.6 Propeller mounting

5.6.1 Tapered mountings

Where the tapered joint between the shaft and the propeller is fitted with a key, the propeller is to be mounted on the tapered shaft in such a way that approximately the mean torque can be transmitted from the shaft to the propeller by the frictional bond. The propeller nut is to be secured in a suitable manner.

Where the tapered fit is performed by the hydraulic oil technique without the use of a key, the necessary pull-up distance on the tapered shaft is given by the expression:

$$L = L_{mech} + L_{temp}$$

Where appropriate, allowance is also to be made for surface smoothening when calculating L.

L_{mech} is determined according to the formulas of elasticity theory applied to shrunk joints for a specific pressure p [N/mm^2] at the mean taper diameter determined by applying the following formula and for a temperature of 35 °C:

$$p = \frac{\sqrt{\theta^2 \cdot T^2 + f \cdot (c_A^2 \cdot Q^2 + T^2)} \pm \theta \cdot T}{A \cdot f}$$

"+" = Sign applying to shrunk joints of tractor propeller

"–" = Sign applying to shrunk joints of pusher propeller

L_{temp} applies only to propellers made of bronze and austenic steel.

t_1 = Temperature [°C] at which the propeller is mounted

The safety factor has to be taken as S = 2,8 for geared plants and Q = Q_n.

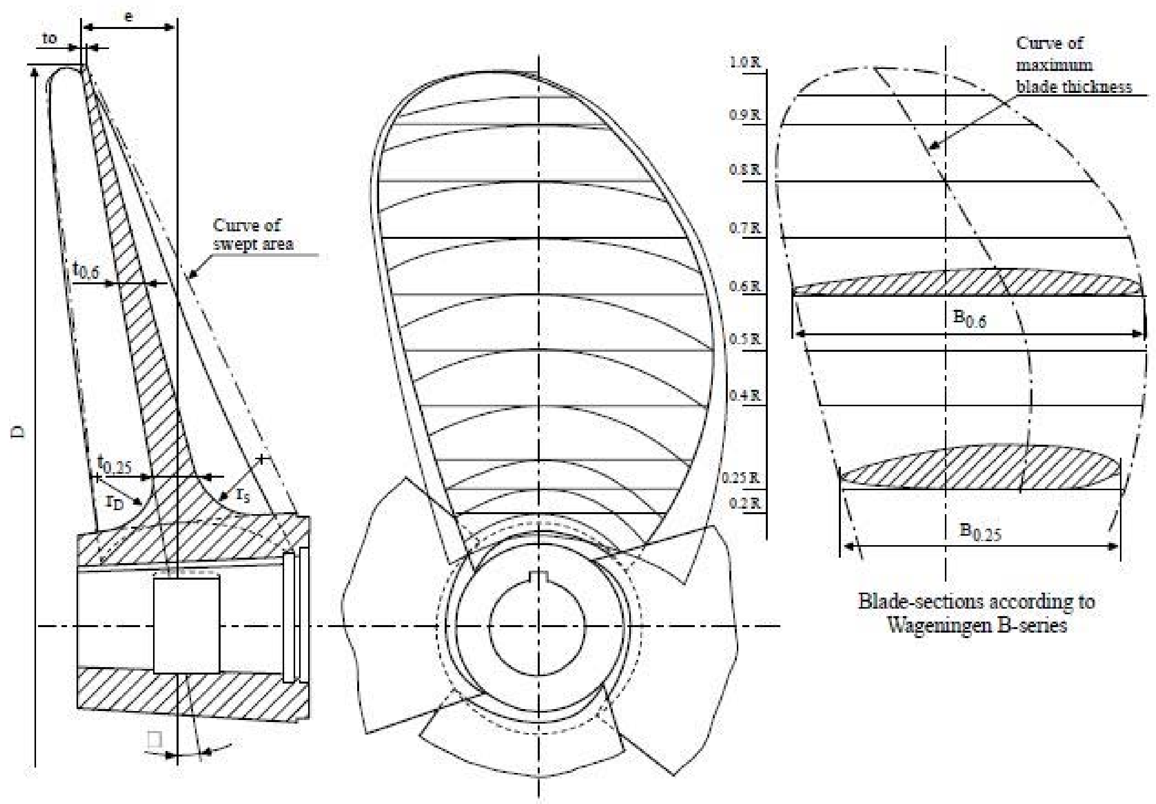


Fig. 12.4 Blade sections

For direct drives the safety factor has to be taken as S = 1,0 and the circumferential force Q has to be replaced by Q_{FR} according to the following formula:

$$Q_{FR} = 2{,}0 \cdot Q_n + 1{,}8 \cdot Q_{V\text{-}MCR}$$

Q_{FR} replaces Q in the formula of specific pressure p given here above.

$Q_{V\text{-}MCR}$ = Maximum value from torsional vibration evaluations, but is not to be taken less than 0,44 times the Q_n

The torsional vibration evaluation is to consider the worst relevant operating conditions, e.g. such as misfiring (one cylinder with no injection) and cylinder unbalance (the latter is subject to the **TL** Rules).

The tapers of propellers which are mounted on the propeller shaft with the aid of hydraulic oil technique should not be more than 1:15 or less than 1:20.

The Von Mises equivalent stress based on the maximum specific pressure p and the tangential stress in the bore of the propeller hub may not exceed 75 % of the 0,2 % proof stress or yield strength of the propeller material.

The propeller nut shall be secured to the propeller shaft by mechanical means.

5.6.2 Flange connections

Flanged propellers and the bosses of controllable pitch propellers are to be attached using fitted pins and bolts (necked down bolts for preference).

The diameter of the fitted pins is to be calculated by applying formula given in 3.5.2.

The propeller retaining bolts are to be of similar design to those described in 5.4.4.

The thread core diameter shall not be less than:

$$d_k = 4{,}4 \cdot \sqrt{\frac{M_{0,35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

In exceptional cases flange connections may transmit a fraction of the torque by friction. The fraction should not exceed 50 % and fraction multiplied by safety factor shall not be below 100 % of the maximum engine torque. The suitability of the connection has to be demonstrated. Friction coefficients have to be used according to 5.1.3.

6. Torsional vibrations

6.1 General

6.1.1 Application

The following requirements 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.

6.1.2 Definition

For the purposes of these Rules, torsional vibration stresses are additional loads due to torsional vibrations. They result from the alternating torque which is normally superimposed on the mean torque.

6.2 Calculation of torsional vibrations

6.2.1 A torsional vibration analysis covering the torsional vibration stresses to be expected in the main engine shafting system including its branches is to be submitted to **TL** for examination.

The following data shall be included in the analysis:

- Equivalent dynamic system comprising individual masses and inertialess torsional elasticities

- Prime mover: engine type, rated power, rated speed, engine cycle, engine type (in-line/V-type), number of cylinders, firing order, cylinder diameter, crank pin radius, stroke to connecting rod ratio, oscillating weight of one crank gear

- Vibration dampers, damping data

- Coupling, dynamic characteristics and damping data

- Gearing data

- Shaft diameter of crankshafts, intermediate shafts, gear shafts, thrust shafts and propeller shafts

- Propellers: propeller diameter, number of blades, pitch and area ratio.

- Natural frequencies with their relevant vibration forms and the vector sums for the harmonics of the engine excitation

- Estimated torsional vibration stresses in all important elements of the system with particular reference to clearly defined resonance speeds of rotation and continuous operating ranges

6.2.2 The calculations are to be performed both for normal operation and misfiring operation caused by irregularities in ignition. In this respect, the calculations are to assume operation for one cylinder without ignition (misfiring).

6.2.3 Where the arrangement of the installation allows various different operation modes, the torsional vibration characteristics are to be investigated for all possible modes, e.g. in installations fitted with controllable pitch propellers for zero and full pitch, with power take off from the gearing or on the output side of the engine for loaded and idling conditions of the generator unit, and for installations with disconnectable branches for clutches in the engaged and disengaged states.

6.2.4 The calculation of torsional vibrations shall also take account of the stresses resulting from the superimposition of several orders of vibration (synthesized torques/stresses).

6.2.5 If modifications are introduced into the system which have a substantial effect on the torsional vibration characteristics, the calculation of the torsional vibrations is to be repeated and submitted for checking.

6.3 Permissible torsional vibration stresses

6.3.1 General

The calculation of the permissible torsional vibration stresses as well as the determination of the permissible vibratory torques for gearing, couplings and crankshaft shall be performed in accordance with the **TL** Rules for Machinery Section 6.

6.4 Torsional vibration measurements

6.4.1 After consideration of the results of the calculations according to 6.2, **TL** may request the performance of torsional vibration measurements during river trials.

6.4.2 Torsional vibration measurements may also be required by **TL** in the case of conversions affecting significantly and resulting to major alterations of the main propulsion plant.

6.5 Barred speed range

6.5.1 Normal operation

Operating ranges which, because of the magnitude of the torsional vibration stresses, may only be passed through are to be indicated as barred ranges for continuous operation by red marks on the tachometer or in some other suitable manner at the operating stations from which the plant can be controlled. Barred speed ranges are to be passed through as quickly as possible. In specifying barred speed ranges it is important to ensure that the navigating and manoeuvring functions are not unreasonably restricted.

The speed range $\lambda \geq 0{,}8$ is to be kept free of barred speed ranges.

Even within prohibited ranges of operation, exceeding the maximum permissible loads for shafting, twice the rated torque for gear toothing systems and maximum impulse torque for flexible couplings is not permitted.

6.5.2 Deviations from normal operation

This is understood to include firing irregularities or, in an extreme case, the complete interruption of the fuel supply to a cylinder.

The actions necessary to prevent overloading of the propulsion plant in case of deviation from normal operation are to be clearly displayed on tables at all the operating stations from which the plant can be controlled.

The major components of the propulsion plant should be capable of withstanding for a reasonable time the consequences of an abnormal operation. Running under abnormal conditions should not lead to overloading as defined in 6.5.1.

Even in the event of an abnormal operation due to ignition failure of one cylinder, a continuous operation over extended time periods within certain speed ranges shall still remain possible, thus maintaining the manoeuvrability for safe operation of the vessel.

6.6 Auxiliary machinery

6.6.1 Important auxiliary machinery such as diesel generators and lateral thrust units are to be so designed that the operating speed range is free from undue stresses caused by torsional vibrations. For installations of more than 110 kW, the torsional vibration calculation is to be submitted to **TL**.

6.6.2 Essential auxiliary machinery shall be designed such that, operation under misfiring condition is possible, so far no adequate redundancy is provided.

6.6.3 In the case of diesel generators with rigidly coupled generators, the torsional vibration torque in continuous operation shall not exceed 2.5 times the generator's normal torque.

7. Windlasses

7.1 General

7.1.1 Scope

The Rules contained in this Article apply to bow anchor windlasses, stern anchor windlasses and wire rope windlasses. For anchors, chains and ropes, see Rules for Equipment in Section 10, D.

7.1.2 Documents for review/approval

For each type of anchor windlass, general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the main shaft, cable lifter and brake are to be submitted to **TL** for review/approval.

One copy of a description of the anchor windlass including the proposed overload protection and other safety devices is likewise to be submitted.

Where an anchor windlass is to be reviewed for several strengths and types of chain cable, the calculation relating to the maximum braking torque is to be submitted and proof furnished of the power and hauling- in speed in accordance with 7.4.1 corresponding to all the relevant types of anchor and chain cable.

7.2 Materials

7.2.1 Approved materials

The provisions contained in the **TL** Rules for Materials are to be applied as appropriate to the choice of materials.

7.2.2 Testing of materials

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) shall possess mechanical characteristics in conformity with the **TL** Rules for Materials. 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 the **TL** Rules for Materials

In the case of hydraulic systems, the material used for pipes as well as for pressure vessels is also to be tested.

7.3 Design and equipment

7.3.1 Type of drive

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.

Hand-operated winches shall be fitted with devices to prevent kick-back of the crank. Winches that are both power- and manually driven shall be designed in such a way that the motive-power control cannot actuate the manual control.

7.3.2 Overload protection

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 (see 7.4.1). The setting of the overload protection is to be specified (e.g. in the operating instructions)

7.3.3 Clutches

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 shall be capable of being disengaged by hand.

7.3.4 Braking equipment

Windlasses shall be fitted with cable lifter brakes which are capable of holding a load equal to 80 % of the nominal breaking load of the chain. In addition, where the gear mechanism is not of self-locking type, a device (e.g. gearing brake, lowering brake, oil hydraulic brake) is to be fitted to prevent paying out of the chain should the power unit fail while the cable lifter is engaged.

7.3.5 Pipes

For the design and dimensions of pipes, valves, fittings and hydraulic piping systems, etc. see C.

7.3.6 Cable lifters

Cable lifters shall have at least five snugs.

For cable lifters used for studless chains, the requirements of EN 14874 can be applied.

7.3.7 Windlass as warping winch

Combined anchor and mooring winches may not be subjected to excessive loads even when the maximum pull is exerted on the warping rope.

7.3.8 Electrical equipment

The electrical equipment is to comply with Section 13.

7.3.9 Hydraulic equipment

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.

7.3.10 Wire rope windlass

The rope drum diameter shall be at least 14 times the required rope diameter.

The drive of the windlass shall be capable of being uncoupled to the rope drum.

The rope end fastening of the windlass shall brake if the wire rope has to be released.

Rope drums shall be provided with flanges whose outer diameter extend above the top layer of the rope by at least 2.5 times rope diameter unless the rope is prevented from overriding the flange by a spooling device or other means.

7.3.11 Chain stoppers

Where a chain stopper is fitted, it is to be able to withstand a pull of 80 % of the chain breaking load.

Where no chain stopper is fitted, the windlass shall be able to withstand a pull of 80 % of the chain breaking load. The caused stress in the loaded parts of the windlass may not exceed 90 % of the yield strength of the respective parts and the windlass brake is not allowed to slip.

7.3.12 Connection with deck

The windlass, the foundation and the stoppers have to be connected efficiently and safely to the deck.

7.4 Power and design

7.4.1 Driving power

a) Depending on the grade of the chain cable, windlasses shall be capable of exerting the following nominal pulls at a speed of at least 0,15 m/s:

$Z_1 = 28 \cdot d^2$ for grade K 1

$Z_2 = 32 \cdot d^2$ for grade K 2

Z_i = pull [N]

d = Diameter of anchor chain [mm]

b) The nominal output of the power units shall be such that the conditions specified above can be met for 30 minutes without interruption. In addition, the power units shall be capable of developing a maximum torque equal to 1.5 times the rated torque for at least two minutes at a correspondingly reduced lifting speed.

c) At the maximum torque specified in b), a shorttime overload of up to 20 % is allowed in the case of internal combustion engines.

d) An additional reduction gear stage may be fitted in order to achieve the maximum torque.

e) With manually operated windlasses, steps are to be taken to ensure that the anchor can be hoisted at a mean speed of 0,033 m/s with the pull specified in a). This is to be achieved without exceeding a manual force of 150 N applied to a crank radius of about 350 mm with the hand crank turned at about 30 rev./min.

7.4.2 Design of transmission elements

The basis for the design of the load-transmitting components of windlasses is given by the anchors and chain cables specified in the rules for equipment (see Section 10, D.)

The cable lifter brake is to be so designed that the anchor and chain can be safely stopped while paying out the chain cable.

The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft and braking equipment, bedframe and deck fastening) is to be based on a theoretical pull equal to 80 % of the nominal breaking load specified in the **TL** Rules for Materials for the chain in question.

The design of the main shaft is to take account of the braking forces, and the cable lifter brake shall not slip when subjected to this load.

The design of all other windlass components is to be based upon a force acting on the cable lifter pitch circle and equal to 1.5 times the nominal pull specified in a) of 7.4.1.

At the theoretical pull, the force exerted on the brake handwheel shall not exceed 500 N.

The total stresses applied to components shall be below the minimum yield point of the materials used.

The foundations and pedestals of windlasses and chain stoppers shall be adequate designed to withstand the forces and loads as specified in 7.3.11 and in paragraphs here above.

7.5 Testing in the manufacturer's works

7.5.1 Testing of driving engines

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 windlass.

For electric motors, see Rules for rotating machines in Section 13, C.

Hydraulic pumps are to be subjected to pressure and operational tests.

7.5.2 Pressure and tightness tests

Pressure components are to undergo a pressure test at pressure:

$$p_{ST} = 1,5 \cdot p$$

p_{ST} = Test pressure [bar]

p = Maximum allowable working pressure or pressure at which the relief valves open [bar]
For working pressures above 200 bar, the test pressure need not exceed p + 100.

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

7.5.3 Final inspection and operational testing

After finishing manufacture, windlasses are required to undergo final inspection and operational testing at twice the nominal pull in the presence of **TL** Surveyor. The hauling-in speed is to be verified with continuous application of the nominal pull. During the tests, particular attention is to be given to the testing and, where necessary, setting of braking and safety equipment.

Where manufacturing works does not have adequate facilities, the aforementioned tests including the adjustment of the overload protection can be carried out

on board the vessel. In these cases, functional testing in the manufacturer's works is to be performed under no-load conditions.

8. Hydraulic system

8.1 General

8.1.1 Scope

The Rules contained in the following apply to hydraulic systems 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.

8.1.2 Documents for review/approval

The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used etc., are to be submitted to **TL** for review/approval.

8.1.3 Dimensional design

For the design of pressure vessels, see D.1., for the dimensions of pipes, see, C.

8.2 Materials

8.2.1 Approved materials

Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with the **TL** Rules for Materials. The use of other materials is subject to special agreement with **TL**.

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 C.

8.2.2 Testing of materials

The materials of pressure casings and pressure oil lines shall possess mechanical characteristics in conformity with the **TL** Rules for Materials. 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 the **TL** Rules for Materials.

8.3 Design and equipment

8.3.1 Control

Hydraulic systems may be supplied either from a common power station or from a number of power stations, each serving a particular system.

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.

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.

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.

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 shall be taken to ensure a slow descent following a pipe rupture.

8.3.2 Pipes

The pipes of hydraulic 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. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

Pipes are to be so installed that they are free from stress and vibration.

The piping system is to be fitted with filters for cleaning the hydraulic fluid.

Equipment is to be provided to enable the hydraulic system to be vented.

The hydraulic fluids shall be suitable for the intended ambient and service temperatures.

Where the hydraulic system includes accumulators, the accumulator chamber shall 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.

8.3.3 Oil level indicators

Tanks within the hydraulic system are to be equipped with oil level indicators.

An alarm located in the wheelhouse is to be fitted for the lowest permissible oil level.

8.3.4 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 assembliesshall meet the requirements of C. or an equivalent standard. The hose assemblies shall 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.

8.4 Testing in the manufacturer's works

8.4.1 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 Section 13, C.

Hydraulic pumps are to be subjected to pressure and operational tests.

8.4.2 Pressure and tightness tests

Pressure components are to undergo a pressure test at pressure

$$p_{ST} = 1,5 \cdot p$$

p_{ST} = Test pressure [bar]

p = Maximum allowable working pressure or pressure at which the relief valves open [bar]
For working pressures above 200 bar, the test pressure need not exceed p + 100.

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

C. Pipes, Valves, Fittings and Pumps

1. General

1.1 Scope

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 parts of the Rules.

Cargo pipelines on vessels for the carriage of chemicals in bulk are additionally subject to the provisions of Section 16.

Cargo and process pipelines on vessels for the carriage of liquefied gases in bulk are additionally subject to the provisions of Section 16.

1.2 Documents for review / approval

Diagrammatic plans of the following piping systems shall be submitted to **TL** and shall contain all the details necessary for assessment:

- Steam systems
- Boiler feed and condensate systems
- Fuel systems (bunkering, transfer and supply systems)
- Lubricating oil systems
- Cooling water systems
- Compressed air systems
- Bilge systems
- Thermal oil systems
- Air, sounding and overflow systems
- Drinking water and sewage systems
- Systems for remotely controlled valves
- Hose assemblies and compensators

Hoses and expansion joints made of non-metallic materials are to be clearly indicated.

1.3 Classes of pipes

Pipes are subdivided into two classes as indicated in Table 12.11.

2. Materials, quality assurance, pressure tests

2.1 General

Materials shall be suitable for the proposed application and shall comply with the **TL** Rules for Materials. In the case of especially corrosive media, **TL** may impose special requirements on the materials used. For welds, see the **TL** Rules for Welding. For the materials used for pipes and valves for steam boilers, see D.1.2.

2.2 Materials

2.2.1 Pipes, valves and fittings of steel

Pipes belonging to class II shall be either seamless drawn or produced by a welding procedure approved by **TL**.

2.2.2 Pipes, valves and fittings of copper and copper alloys

Pipes of copper and copper alloys shall be of seamless drawn material or produced by a method approved by **TL**. Class II copper pipes shall be seamless.

In general, copper and copper alloys pipe lines shall not be used for media having temperatures above the limits given in Table 12.10.

2.2.3 Pipes, valves and fittings of cast iron with spheroidal or nodular graphite (GGG)

Pipes, valves and fittings of nodular ferritic cast iron according to the **TL** Rules for Materials may be accepted for bilge, ballast and cargo pipes within double bottom tanks and cargo tanks and for other purposes approved by **TL** at temperatures up to 350 °C.

2.2.4 Pipes, valves and fittings of cast iron with lamellar graphite (grey cast iron) (GG)

Pipes, valves and fittings of grey cast iron may be accepted by **TL** for class III. Pipes of grey cast iron may be used for cargo and ballast pipelines within cargo tanks of tankers. Grey cast iron is not allowed for clean ballast lines to forward ballast tanks through cargo oil tanks.

Pipes, valves and fittings of grey cast iron may also be accepted for cargo lines on tankers intended to carry flammable liquids with a flash point ≤ 60 °C. Tough materials shall be used for cargo hose connections and distributor headers.

This applies also to the hose connections of fuel and lubricating oil filling lines. Grey cast iron may not be used for cargo lines in cargo systems of vessels carrying chemicals (see Section 16.).

Grey cast iron is not allowed for pipes, valves and fittings for media having temperatures above 220 °C and for pipelines subject to water hammer, excessive strains and vibrations.

Grey cast iron is not allowed for river valves and pipes fitted on the vessel sides and for valves fitted on the collision bulkhead.

Valves on fuel tanks subject to static head may be made of grey cast iron only if they are adequately protected against damage.

The use of grey cast iron for other services will be subject to special consideration by **TL**.

2.2.5 Plastic pipes

Plastic pipes may be used after special approval by **TL**. 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 **TL**. 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 shall, as a minimum requirement, be marked with the manufacturer's marking and the outside diameter of the pipe.

2.2.6 Aluminium and aluminium alloys

Aluminium and aluminium alloys shall comply with the **TL** Rules for Materials and may in individual cases, with the agreement of **TL**, be used for temperatures up to 200 °C. They are not acceptable for use in fire-extinguishing lines.

2.2.7 Application of materials

For the pipe classes named in 1.3 materials shall be applied according to Table 12.12.

2.3 Quality assurance

2.3.1 The proof of the quality of materials for pipe class II is to be in the form of an inspection certificate 3.1 according to EN 10.204 or equivalent. For this purpose, the manufacturer of the material shall have been accepted by **TL**.

2.3.2 For components in pipe class III a Works certificate issued by the manufacturer of the material is sufficient.

2.3.3 Welded joints in pipelines of class II are to be tested in accordance with the **TL** Rules for Welding.

2.4 Hydraulic tests on pipes

2.4.1 Definitions

a) Maximum allowable working pressure, PB [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 [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 [bar] formula symbol: p_p

This is the pressure to which components or piping systems are subjected for testing purposes.

d) Design pressure, PR [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.

2.4.2 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:

$$p_p = 1{,}5 \cdot p_c$$

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 **TL** 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 4.3.

Pressure testing of pipes with a nominal diameter less than 15 mm may be omitted at **TL** discretion depending on the application.

2.4.3 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 shall 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.

2.5 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 **TL** 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 a) and b) shall also undergo a tightness test at 1.0 times the nominal pressure.

For the valves of steam boilers, see D.2.

Table 12.10 Medium limit temperature

Material	Medium limit temperature
Copper and aluminium brass	200 °C
Copper nickel alloys	300 °C
High-temperature bronze	230 °C

3. Pipe wall thickness

3.1 Minimum wall thickness

3.1.1 The pipe thicknesses given in Table 12.13 and Table 12.14 are the assigned minimum thicknesses

d_a = Outside diameter of pipe [mm]

s = Minimum wall thickness [mm]

3.1.2 Air pipes, sounding pipes, overflow pipes and pipes carrying media which is different to that in the tanks may not be routed through tanks for drinking water, feedwater or lubricating oil. If this cannot be avoided, the arrangement of the pipes in the tanks is to be agreed with **TL**.

4. Principles for the construction of pipes, valves, fittings and pumps

4.1 General principles

4.1.1 Piping systems are to be constructed and manufactured on the basis of standards generally used in vessel building.

Table 12.11 Classification of pipes into "pipe classes"

Medium conveyed by the piping system	Design pressure PR [bar] Design temperature t [°C]	
Toxic media Inflammable media with service temperature above the flash point Inflammable media with a flash point below 60 °C Liquefied gases (LPG, LNG, LG) Corrosive media	all	not applicable
Steam, thermal oil	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t ≤ 170
Air, gas Lubricating oil, hydraulic oil Boiler feedwater, condensate Seawater and fresh water for Cooling	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
Liquid fuels	PR ≤ 16 and t ≤ 150	PR ≤ 7 and t ≤ 60
Cargo pipelines for tankers	not applicable	all
Open-ended pipelines (without shut-off), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	not applicable	all
Pipe class	II	III

4.1.2 Welded connections instead of detachable connections should be used for pipelines carrying toxic media and inflammable liquefied gases.

4.1.3 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

4.2 Pipe connections

4.2.1 Dimensions and calculation

The dimensions of flanges and bolting are to comply with recognized standards.

4.2.2 Pipes 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 Table 12.15.

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.

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 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 **TL** 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

4.3 Layout, marking and installation

4.3.1 Piping systems shall be adequately identified according to their purpose. Valves are to be permanently and clearly marked.

4.3.2 Pipes leading through bulkheads and tank walls shall be water and oil tight. Bolts through bulkheads are not permitted. Holes for set screws may not be drilled in the tank walls.

4.3.3 Piping systems close to electrical switchboards shall be so installed or protected that possible leakage cannot damage the electrical installation.

4.3.4 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 shall be equipped with special drain arrangements.

Table 12.12 Approved materials

<table>
<tr><th colspan="2" rowspan="2">Material or application</th><th colspan="2">Pipe classes</th></tr>
<tr><th>II</th><th>III</th></tr>
<tr><td rowspan="3">Steel</td><td>Pipes</td><td>Pipes for general applications, below −10 °C pipes made of steels with high low-temperatures toughness, stainless steel pipes for chemicals</td><td>Steel not subject to any special quality specification, weldability in accordance with the TL Rules for Welding</td></tr>
<tr><td>Forgings, plates, flanges</td><td colspan="2">Steels suitable for the corresponding loading and processing conditions, for temperatures below −10 °C steels with high low-temperature toughness</td></tr>
<tr><td>Bolts, nuts</td><td>Bolts for general machine construction, below −10 °C steels with high lowtemperature toughness</td><td>Bolts for general machine construction</td></tr>
<tr><td rowspan="3">Castings, valves, fittings, pipes)</td><td>Cast steel</td><td>Cast steel for general applications, below −10 °C cast steel with high lowtemperature toughness, for aggressive media stainless castings</td><td>Cast steel for general applications</td></tr>
<tr><td>Spheroidal/Nodular cast iron (GGG)</td><td colspan="2">Only Castings ferritic grades, elongation A5 at least 12 %</td></tr>
<tr><td>Cast iron with lamellar graphite (grey cast iron) (GG)</td><td>Not applicable</td><td>At least GG-20 for Pipe Class III up to 220 °C not permitted in:
- ballast lines of ballast tanks outside cargo are through cargo tanks
- valves on vessel's side, collision bulk-head and fuel tanks</td></tr>
<tr><td>Nonferrous Metals (valves, fittings, pipes)</td><td>Copper, copper alloys</td><td>In cargo lines on tank ships carrying chemicals only with special approval low temperature copper nickel alloys by special agreement</td><td>For seawater and alkaline water only corrosion-resistant copper and copper alloys</td></tr>
<tr><td></td><td>Aluminium, aluminium alloy</td><td>In cargo and processing lines on gas tank vessels</td><td>Only with the agreement of the Society up to 200 °C, not permitted in fire-extinguishing systems</td></tr>
<tr><td>Nonmetallic</td><td>Plastics</td><td>Not applicable</td><td>On special approval see 2.2.5</td></tr>
</table>

4.4 Shut-off devices

4.4.1 Shut-off devices shall comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover

4.4.2 Hand-operated shut-off devices are to be closed by turning in the clockwise direction.

Table 12.13 Steel pipes

d_a	s	d_a	s
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

4.4.3 Indicators are to be provided showing the open/closed position of valves unless their position is shown by other means.

4.4.4 Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service shall not be used.

4.5 Outboard connections

4.5.1 Valves may only be mounted on the vessel's side by means of reinforcing flanges or thick-walled connecting pipes.

Table 12.14 Copper and copper alloy pies

Copper pipes		Copper alloy pipes	
d_a	s	d_a	s
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 12.15 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 all special provisions for root side	II, III	
Welded sockets	III	
Screwed sockets	for subordinate systems see 4.2.2	< 50

4.5.2 Vessel's side valves shall be easily accessible. Water inlet and outlet valves shall be capable of being operated from above the floor plates. Cocks on the vessel's side shall be so arranged that the handle can only be removed when the cock is closed

4.5.3 Where discharge pipes without shutoff devices may be connected to the vessel's hull below the freeboard deck, the wall thickness of the pipes to the nearest shut-off device shall be equal to that of the shell plating at the ends of the vessel, but need not to exceed 8 mm.

4.5.4 Outboard connections are to be fitted with shut-off valves.

Cooling water discharge lines may be provided with loops led at a minimum height of 0,3 m above the maximum draft.

4.6 Remote controlled valves

4.6.1 Scope

These Rules apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

4.6.2 Construction

Remote controlled bilge valves and valves important to the safety of the vessel are to be equipped with an emergency operating arrangement.

For the emergency operation of remote controlled valves in cargo piping systems, see Section 16.

4.6.3 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 shall always be accessible.

Bilge lines valves and control lines are to be located as ar as possible from the bottom and sides of the vessel.

The requirements stated here above 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 shall 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.

4.6.4 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 shall 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 **TL** 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.

4.6.5 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 nonreturn 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.

4.6.6 After installation on board, the entire system is to be subjected to an operational test.

4.7 Pumps

4.7.1 Displacement pumps shall be equipped with sufficiently dimensioned relief valves without shutoff to prevent any excessive overpressure in the pump housing.

4.7.2 Rotary pumps shall be capable of being operated without damage even when the delivery line is closed.

4.7.3 Pumps mounted in parallel are to be protected against overloading by means of non-return valves fitted at the outlet side.

4.8 Protection of piping systems against overpressures

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 shall 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.

5. Steam systems

5.1 Laying out of steam systems

5.1.1 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.

5.1.2 Steam lines are to be so installed that water pockets will be avoided.

5.1.3 Means are to be provided for the reliable drainage of the piping system.

5.1.4 Pipe penetrations through bulkheads and decks are to be insulated to prevent heat conduction.

5.1.5 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 requirements specified in the **TL** Rules for Welding.

5.2 Steam strainers

Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.

5.3 Steam connections

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

6. Boiler feedwater and circulating arrangement, condensate recirculation

6.1 Feedwater pumps

6.1.1 At least two feedwater pumps are to be provided for each boiler installation.

6.1.2 Feedwater pumps are to be so arranged or equipped that no backflow of water can occur when the pumps are at a standstill.

6.1.3 Feedwater pumps are to be used only for feeding boilers.

6.2 Capacity of feedwater pumps

6.2.1 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.

6.2.2 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 6.2.1.

6.2.3 For continuous flow boilers the capacity of the feedwater pumps is to be at least 1.0 times the maximum steam output.

6.3 Delivery pressure of feedwater pumps

Feedwater pumps are to be so laid out that the delivery pressure can satisfy the following requirements:

- The required capacity according to 6.2 is to be achieved against the maximum allowable working pressure of the steam producer

- The safety valves shall 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 shall be taken into account.

6.4 Power supply to feedwater pumps

For electric drives, a separate lead from the common bus-bar to each pump motor is sufficient.

6.5 Feedwater systems

6.5.1 General

Feedwater systems may not pass through tanks which do not contain feedwater.

6.5.2 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 shut-off valve and a check valve at the boiler inlet. Where the shut-off 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 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.

6.6 Boiler water circulating systems

6.6.1 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.

6.6.2 The provision of only one circulating pump for each boiler is sufficient if:

- Acommon 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.

6.7 Condensate recirculation

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.

7. Fuel oil systems

7.1 Storage of liquid fuels

7.1.1 General safety precautions for liquid fuel

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 13).

7.1.2 Distribution and location of fuel tanks

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).

7.2 Fuel tank fittings and mountings

7.2.1 For fuel filling and suction systems see 7.6; for air, overflow and sounding pipes, see 13.

7.2.2 Service tanks are to be so arranged that water and residues can settle out despite the movement of the vessel.

7.2.3 Free discharge and drainage lines shall be fitted with self-closing shut-off valves.

7.2.4 Tank gauges

The following tank gauges are permitted:

- Sounding pipes
- Oil level indicating devices
- Oil gauges with flat glasses and self-closing shut-off 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 **TL**.

Fuel service tank supplying the main propulsion unit, important auxiliaries and the driving engines for bow thrusters are to be fitted with low level alarm which has been type-approved by **TL**.

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 or passenger spaces, nor shall they terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise.

7.3 Attachment of mountings and fittings to fuel tanks

7.3.1 Only appliances, mountings and fittings forming part of the fuel tank equipment may generally be fitted to tank surfaces.

7.3.2 Valves and pipe connections are to be attached to strengthening flanges welded to the tank surfaces. Holes for attachment bolts shall not be drilled in the tank surfaces. Instead of strengthening flanges, short, thick pipe flange connections may be welded into the tank surfaces.

7.4 Hydraulic pressure test

See 2.4.

7.5 Filling and delivery system

The filling of fuels is to be effected from the open deck through permanently installed lines.

7.6 Tank filling and suction systems

7.6.1 Filling and suction lines terminating below the oil level in tanks shall be fitted with remote controlled shut-off valves. The shut-off valves shall be directly at the tanks.

7.6.2 The remote-controlled shut-off valves shall be capable of being operated from a permanently accessible open deck.

7.6.3 Air and sounding pipes shall not be used to fill fuel tanks.

7.6.4 The inlet openings of suction pipes shall be located above the drain pipes.

7.6.5 Service tanks of up to 50 litres capacity mounted directly on diesel engines need not be fitted with remote controlled shut-off valves.

7.7 Pipe layout

7.7.1 Fuel lines may not pass through tanks containing feedwater, drinking water or lubricating oil.

7.7.2 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. Shut-off 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.

7.7.3 Shut-off valves in fuel spill lines to service tanks are not permitted

7.8 Filters

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.

8. Lubricating oil systems

8.1 Storage of lubricating oil

8.1.1 Tank arrangement

For the arrangement of the tanks, requirements of Section 8, E.8 are to be applied.

8.2 Tank fittings and mountings

8.2.1 Oil level glasses are to be connected to the tanks by means of self-closing shut-off valves.

8.2.2 The requirements set out under 2.4 apply likewise to the mounting of appliances and fittings on these tanks.

8.3 Capacity and construction of tanks

8.3.1 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 shall be large enough to hold at least the lubricating oil contained in the entire circulation system.

8.3.2 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.

8.3.3 Lubricating oil drain tanks are to be equipped with sufficient vent pipes.

8.4 Hydraulic pressure test

See 2.4.

8.5 Lubricating oil piping

8.5.1 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.

8.5.2 Priming pumps

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

8.6 Lubricating oil pumps

The suction connections of lubricating oil pumps are to be located as far as possible from drain pipes.

8.7 Filters

Change-over duplex filters or automatic backflushing filters are to be mounted in lubricating oil lines on the delivery side of the pumps.

9. Cooling water systems

9.1 Cooling water intakes, river chest

9.1.1 Each river chest is to be provided with an air pipe which can be shut-off and which shall extend above the bulkhead deck. The inside diameter of the air pipe shall be compatible with the size of the river chests and shall not be less than 30 mm.

9.1.2 Where compressed air is used to blow through river chests, the pressure shall not exceed 2 bar.

9.2 Cooling water intake valves

Two valves are to be provided for main propulsion plants. The cooling water pumps of important auxiliaries should be connected to the river chests over separate valves.

9.3 Filters

The suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

9.4 Expansion tanks of fresh water cooling

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.

9.5 Fresh water coolers

For fresh water coolers forming part of the vessel's shell plating and for special outboard coolers, provision shall be made for satisfactory deaeration of the cooling water. Drawings of the cooler and the cooler arrangement are to be submitted for review/approval.

10. Compressed air systems

10.1 General

10.1.1 Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.

10.1.2 Efficient oil and water traps are to be provided in the filling lines of compressed air receivers. The air discharge from relief valves in the compressed air receivers installed in the engine rooms shall lead to the open air.

10.1.3 Starting air lines may not be used as filling lines for air receivers.

10.1.4 The starting air line to each engine is to be fitted with a non-return valve and a drain.

10.1.5 Typhons are to be connected to at least two compressed-air receivers.

10.1.6 A safety relief valve is to be fitted downstream of each pressure-reducing valve.

10.1.7 Pressure water tanks and other tanks connected to the compressed air system are to be considered as pressure vessels and shall comply with the requirements in D.1.

10.2 Compressed air connections for blowing

For compressed air connections for blowing through river chests refer to 9.1.2.

10.3 Compressed air supply to pneumatically operated valves

For the compressed air supply to pneumatically operated valves refer to 4.6.

11. Bilge systems

11.1 General

The equipment of vessels with oil-separating facilities is to conform to national and international Regulations.

11.2 Bilge lines

11.2.1 Layout of bilge lines

Bilge lines and bilge suctions are to be so arranged that the bilges can be completely pumped even under disadvantageous trim conditions.

Bilge suctions are normally to be located on both sides of the vessel. For compartments located fore and aft in the vessel, one bilge suction may be considered sufficient provided that it is capable of completely draining the relevant compartment.

Spaces located forward of the collision bulkhead and aft of the stern tube bulkhead and not connected to the general bilge system are to be drained by other suitable means of adequate capacity.

The collision bulkhead may be pierced by a pipe for filling and draining of the fore peak, provided that a screw-down valve capable of being remotely operated from above the open deck is fitted at the collision bulkhead within the fore peak. Where the fore peak is directly adjacent to a permanently accessible room which is separated from the cargo space, this shut-off valve may be fitted directly at the collision bulkhead inside this room without provision for remote control.

11.2.2 Pipes led through tanks

Bilge pipes may not be led through tanks for lubricating oil, thermal oil, drinking water or feedwater.

11.2.3 Bilge suctions and strums

Bilge suctions are to be so arranged as not to impede the cleaning of bilges and bilge wells. They are to be fitted with easily detachable, corrosion-resistant strums.

11.2.4 Bilge valves

Valves in connecting pipes between the bilge and the river water and ballast water system, as well as between the bilge connections of different compartments, are to be so arranged that even in the event of faulty operation or intermediate positions of the valves, penetration of river water through the bilge system will be safely prevented.

Bilge discharge pipes are to be fitted with shut-off valves at the vessel's side.

Bilge valves are to be arranged so as to be always accessible irrespective of the ballast and loading condition of the vessel.

11.2.5 Pipe connections

To prevent water penetration, each of the branch bilge pipes from the individual compartments is to be connected to the main bilge pipe by a screw-down non-return valve. In the case of small vessels with only one cargo hold, the branch bilge pipes serving the various spaces can also be connected to the bilge pumps over changeover or three-way angle cocks.

Where a bilge pump is also to be used for pumping water over the vessel's side and from ballast water tanks, the main bilge pipe shall be connected to the suction line of the pump by a non-return device to prevent raw or ballast water from penetrating the bilge system.

Such non-return devices include three-way cocks with L plugs, three-way angle cocks and changeover gate valves. Instead of these changeover devices, a screw-down non-return valve may also be fitted between the pump and the main bilge pipe, so that two non-return valves will then be connected in series.

A direct suction from the engine room shall 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.

Where the direct suction is connected to a centrifugal pump which can also be used for cooling water, ballast water or fire-extinguishing, a screw-down nonreturn valve is to be fitted in the discharge pipe of the pump.

11.3 Calculation of pipe diameters

11.3.1 Tankers

The inside diameter of the main bilge pipe in the main engine rooms of tankers is calculated by applying the formula:

$$d_H = 3{,}0 \cdot \sqrt{(B \cdot H) \cdot \ell_1} + 25$$

ℓ_1 = Total length [m] of spaces between cofferdam or cargo bulkhead and stern tube bulkhead.

Other terms as stated under 11.3.2.

Branch bilge pipes are to be dimensioned in accordance with 11.3.2.

11.3.2 Other vessels

a) Main bilge pipes

$$d_H = 1{,}5 \cdot \sqrt{(B \cdot H) \cdot L} + 25$$

b) Branch bilge pipes

$$d_Z = 2{,}0 \cdot \sqrt{(B \cdot H) \cdot \ell} + 25$$

d_H = Inside diameter of main bilge pipe [mm]

d_Z = Inside diameter of branch bilge pipe [mm]

L = Rule length [m] defined in Section 4, A.

B = Breadth [m] defined in Section 4,A.

H = Depth [m] defined in in Section 4,A.

ℓ = Length of the watertight compartment [m]

11.4 Bilge pumps

11.4.1 Capacity of independent pumps

Each bilge pump shall be capable of delivering:

$$Q = 5{,}75 \cdot 10^{-3} \cdot d_H^2$$

Q = Minimum capacity [m³/h]

d_H = Calculated inside diameter of main bilge pipe [mm]

11.4.2 Where centrifugal pumps are used for bilge pumping, they shall be self-priming or connected to an air extracting device.

11.4.3 Capacity of attached bilge pumps

Bilge pumps having a smaller capacity than that specified in 11.4.1 are acceptable provided that the independent pumps are designed for a correspondingly larger capacity.

11.4.4 Use of other pumps for bilge pumping

Ballast pumps, general service pumps and similar units may also be used as independent bilge pumps provided they are of the required capacity according to 11.4.1.

Oil pumps may not be connected to the bilge system.

11.4.5 Number of bilge pumps

Vessels with a propulsion power of up to 225 kW shall 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 shall be provided.

On passenger vessels further bilge pumps may be required according to size and propulsion power.

11.5 Bilge pumping for various spaces

11.5.1 Machinery spaces

The bilges of every main machinery space shall be capable of being pumped as follows:

a) Through the bilge suctions connected to the main bilge system and

b) Through one direct suction connected to the largest independent bilge pump.

11.5.2 Fore and after peaks

Connection of the fore and after peaks to the general bilge system is not permitted. 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 shut-off valve. Similar emptying of the fore peak into an adjoining space is not permitted.

11.5.3 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 shut-off valve at a clearly visible and easily accessible position. The drain pipes shall have an inside diameter of at least 40 mm.

11.5.4 Cofferdams and void spaces

Bilge pumping arrangements are to be provided for cofferdams and void spaces.

11.5.5 Chain lockers

Chain lockers may be connected to the main bilge system or drained by a hand pump. Draining to the forepeak tank is not permitted.

12. Thermal oil systems

12.1 General

Thermal oil systems shall be installed in accordance with D.2.

12.2 Pumps

12.2.1 Circulating pumps

One circulating pump is to be provided; as the second circulating pump, a complete spare pump stored on board can be accepted.

With the owner’s confirmation, the spare pump on board may be omitted .

12.2.2 Transfer pumps

A transfer pump is to be installed for filling the expansion tank.

12.2.3 The pumps are to be so mounted that any oil leakage can be safely disposed of.

12.2.4 For emergency stopping, see H.2.3.

12.3 Valves

12.3.1 Only valves made of ductile materials may be used.

12.3.2 Valves shall be designed for a nominal pressure of PN 16.

12.3.3 Valves are to be mounted in accessible positions.

12.3.4 Non-return valves are to be fitted in the pressure lines of the pumps.

12.3.5 Valves in return pipes are to be secured in the open position.

12.4 Piping

12.4.1 The material of the sealing joints is to be suitable for permanent operation at the design temperature and resistant to the thermal oil.

12.4.2 Provision is to be made for thermal expansion by an appropriate pipe layout and the use of suitable compensators.

12.4.3 The pipe lines are to be preferably connected by means of welding. The number of detachable pipe connections is to be minimized.

12.4.4 The laying of pipes through accommodation, public or service spaces is not permitted.

12.4.5 Pipelines passing through cargo holds are to be installed in such a way that no damage can be caused.

12.4.6 Pipe penetrations through bulkheads and decks are to be insulated against conduction of heat.

12.4.7 The venting is to be so arranged that air/oil mixtures can be carried away without danger.

12.5 Tightness and operational testing

12.5.1 Location and equipment of thermal tanks

After installation, the entire arrangement is to be subjected to tightness and operational testing under the supervision of **TL**.

12.6 Location and equipment of thermal oil tanks

For the location and equipment of thermal oil tanks, see D.3.

12.7 Design pressure and test pressure

For design pressure and test pressure, see D.3.

13. Air, sounding and overflow pipes

13.1 Air / overflow pipes

13.1.1 Tank equipment in general

All tanks, void spaces, etc. are to be fitted at their highest point with air pipes which shall normally terminate above the open deck.

The height of air and overflow pipes above deck shall be at least 0,45 m, for fuel oil tanks of tankers 0,5 m.

Air and overflow pipes are to be laid vertically. Air and overflow pipes passing through cargo holds are to be protected against damage.

Where tanks are filled by pumping through permanently installed pipelines, the inside cross-section of the air pipes shall equal at least 125 % that of the corresponding filling pipe.

Air pipes of lubricating oil storage tanks may terminate in the engine room. Air pipes of the lubricating oil storage tanks which form part of the vessel's shell are to terminate in the engine room casing above the freeboard deck.

It is necessary to ensure that no leaking oil can spread on to heated surfaces where it may ignite.

The air pipes of lubricating oil tanks, gear and engine crankshaft casings shall not be led to a common line.

Cofferdams and void spaces with bilge connections shall be provided with air pipes terminating above the open deck.

13.2 Sounding pipes

13.2.1 General arrangement

Sounding pipes are to be provided for tanks, void spaces, cofferdams and bilges (bilge wells) in spaces which are not accessible at all times. 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 shall 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.

13.2.2 Sounding pipes for fuel and lubricating oil

Where sounding pipes cannot be extended above the open deck, they shall be provided with self-closing shut-off devices as well as with self-closing test valves.

The openings of sounding pipes shall 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.

13.3 Overflow pipes

13.3.1 Liquid fuel tanks

Where an overflow pipe is provided for liquid fuel tanks, the discharge is generally to be led to an overflow tank of appropriate capacity.

Overflows from service tanks are generally to be led back either to the fuel bunkers, or to an overflow tank of appropriate capacity.

Where filling of a tank is performed by a power pump, it is recommended to fit on the overflow pipe an alarm or a sight glass to indicate when the tank is full.

13.3.2 Design of overflow systems.

Where overflows from service tanks intended to contain the same liquid or different ones are connected to a common main, provision is to be made to prevent any risk of intercommunication between the various tanks in the course of movements of liquid when emptying or filling.

13.3.3 Construction

Overflow pipes are normally to be made of the same material as the pipes serving the corresponding compartments.

In each compartment which can be pumped up, the total cross-section of overflow pipes is not to be less than required in 13.1.1.

14. Hose assemblies and compensators

14.1 Scope

14.1.1 The following Rules are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

14.1.2 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 as well as in secondary piping systems.

14.1.3 Compensators made of non-metallic materials are not approved for the use in cargo lines of tankers.

14.2 Definitions

14.2.1 Hose assemblies consist of metallic or nonmetallic hoses completed with end fittings ready for installation.

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.

Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

14.2.2 High-pressure hose assemblies made of non-metallic materials

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

14.2.3 Low-pressure hose assemblies and compensators

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

14.2.4 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of nonmetallic materials

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.

14.2.5 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.

14.2.6 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 nonmetallic 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. For hose assemblies and compensators in process and cargo piping for gas and chemical tankers the burst pressure is required to be at least 5 times the maximum allowable working pressure.

14.3 Requirements

14.3.1 Hoses and compensators used in the systems mentioned in 14.1.2 are to be of approved type.

14.3.2 Manufacturers of hose assemblies and compensators shall be recognized by **TL**.

14.3.3 Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

14.3.4 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.

14.3.5 Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and river water systems are to be flame-resistant.

14.4 Installations

14.4.1 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.

14.4.2 The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

14.4.3 Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

14.4.4 In fresh water systems with a working pressure of ≤ 5 bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

14.4.5 Where hose assemblies and compensators are installed in the vicinity of hot components they shall be provided with approved heat-resistant sleeves.

14.5 Tests

Hose assemblies and compensators are to be subjected in the manufacturer's works to a pressure test in accordance with 2.4 under the supervision of **TL**.

14.6 Vessel cargo hoses

14.6.1 Vessel cargo hoses for cargo-handling on chemical tankers and gas tankers shall be typeapproved.

Mounting of end fittings is to be carried out only by approved manufacturers.

14.6.2 Vessel cargo hoses are to be subjected to final inspection at the manufacturer under supervision of a **TL** 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

14.7 Marking

Hose assemblies and compensators shall 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 **TL** inspection.

D. Pressure Vessels and Heat Exchangers, Boilers and Thermal Oil Heaters

1. Pressure vessels and heat exchangers

1.1 General

1.1.1 Scope

The following Rules apply to pressure vessels for the operation of the main propulsion plant and its auxiliary machinery. They also apply to pressure vessels and equipment necessary for the operation of the inland waterway vessel and to independent cargo tanks if these are subjected to internal or external pressure in service.

Cargo tanks and containers with design temperatures of < 0 °C are subject to Section 16.

These Rules do not apply to pressure vessels with permitted working pressures of up to 1,0 bar and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 litres, nor to pressure vessels with working pressures of > 1 bar where the product of pressure [bar] x capacity [litres] is ≤ 200.

Manufacture and inspection of these pressure vessels are subject to the rules of good engineering practice.

Pressure vessels manufactured to recognized standards can be accepted if they have been subjected in the manufacturer's works to tests conforming to the standard.

1.1.2 Division into classes

Pressure vessels are to be assigned to classes in accordance with the operating conditions indicated in Table 12.16.

Pressure vessels filled partly with liquids and partly with air or gases or which are blown out with air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, are to be classified as pressure vessels containing air or gas.

1.1.3 Documents for review/approval

Drawings of pressure vessels, heat exchangers and pressurized equipment containing all the data necessary for their safety assessment are to be submitted to **TL**. The following details, in particular, are to be specified:

- Intended use, substances to be contained in the vessel
- Maximum allowable working pressure and temperatures; if necessary, secondary loads and the volume of the individual pressure spaces
- Design details of the pressurized parts
- Substance to be contained in the pressure vessel, working pressures and temperatures
- Materials to be used, welding details, heat treatment

1.2 Materials

1.2.1 General requirements

The materials of pressure-containing parts shall be suitable for the intended use and shall comply with the **TL** Rules for Materials.

Parts such as gussets, girders, lugs, brackets etc. welded directly to pressure vessel walls are to be made of a material compatible with that of the wall and of guaranteed weldability.

Welded structures are also subject to the **TL** Rules for Welding.

1.2.2 Testing of materials

Tests in accordance with the **TL** Rules for Materials are prescribed for materials belonging to pressure vessel classes I and II used for:

a) All surfaces under pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter ≤ DN 32 mm, together with forged or rolled steel valve heads for compressed air receivers

b) Forged flanges for service temperatures > 300 °C and for service temperatures ≤ 300 °C if the product of the maximum allowable working pressure, PB [bar] by the nominal diameter, DN [mm] is < 2500 or the nominal diameter DN is > 250

c) Bolts and nuts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm^2, or more than 600 N/mm2 in the case of nuts, and alloy or heat-treated steel bolts above M 16.

1.2.3 For class II parts subject to mandatory testing, proof of material quality may take the form of works inspection certificates 3.1 according to EN 10204 provided that the test results certified therein comply with the **TL** Rules for Materials.

Works inspection certificates may also be recognized for series-manufactured class I parts made of unalloyed steels, e.g. hand- and manhole covers, and for branch pipes where the product of PB × DN ≤ 2500 and the nominal bore DN ≤ 250 mm for service temperatures of < 300 °C

Table 12.16 Pressure vessel classes

Operating medium	Design pressure p_c [bar] Design temperature t [°C]		
Liquefied gases (propane, butane, etc.), toxic and corrosive media	all	NA	NA
Steam, compressed air, gases, thermal oil	$p_c > 16$ or $t > 300$	$p_c \leq 16$ and $t \leq 300$	$p_c \leq 7$ and $t \leq 170$
Liquid fuels, lubricating oils, flammable hydraulic fluids	$p_c > 16$ or $t > 150$	$p_c \leq 16$ and $t \leq 150$	$p_c \leq 7$ and $t \leq 60$
Water, nonflammable hydraulic fluids	$p_c > 40$ or $t > 300$	$p_c \leq 40$ and $t \leq 300$	$p_c \leq 16$ and $t \leq 200$
Pressure vessel class	I	II	III
NA = not applicable			

1.2.4 For all parts not subject to testing of materials by **TL**, alternative proof of the characteristics of the material is to be provided, e.g. a works certificate or manufacturer's guarantee as to the properties of the materials used.

1.3 Manufacturing principles

1.3.1 Manufacturing processes applied to materials

Manufacturing processes shall be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold working are to undergo heat treatment in accordance with the **TL** Rules for Materials.

1.3.2 Welding

The execution of welding work, the approval of welding shops and the qualification testing of welders are to be in accordance with the **TL** Rules for Welding.

1.3.3 Reinforcement of openings

Due account is to be taken of the weakening of walls caused by openings and, where necessary, reinforcement is to be provided.

1.3.4 End plates

The flanges of dished ends may not be unduly hindered in their movement by any kind of fixtures, e.g. fastening plates or stiffeners. Supporting legs may only be attached to dished ends which have been adequately dimensioned for this purpose.

Where covers or ends are secured by hinged bolts, the latter are to be safeguarded against slipping off.

1.3.5 Branch pipes

The wall thickness of branch pipes shall be so dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes should be appropriate to the wall thickness of the part into which they are welded. The walls shall be effectively welded together.

Pipe connections in accordance with C. are to be provided for the attachment of piping.

1.3.6 Tube plates

Tube holes shall be carefully drilled and deburred. Bearing in mind the tube-expansion procedure and the combination of materials involved, the ligament width shall be such as to ensure the proper execution of the expansion process and the sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.

1.3.7 Compensation for expansion

The design of pressure vessels and equipment is to take account of possible thermal expansion, e.g. between the shell and nest of heating tubes.

1.3.8 Corrosion protection

Pressure vessels and equipment exposed to accelerated corrosion owing to the medium which they contain shall be protected in a suitable manner.

1.3.9 Cleaning and inspection

Pressure vessels and equipment are to be provided with inspection and access openings which should be as large as possible and conveniently located. For the minimum dimensions of these, see 2.3.

Pressure vessels over 2,0 m long shall have inspection openings at each end at least. Where the pressure vessel can be entered, one access opening is sufficient.

Pressure vessels with an inside diameter of more than 800 mm shall be capable of being entered.

In order to provide access with auxiliary or protective gear, a manhole diameter of at least 600 mm is generally required. The diameter may be reduced to 500 mm where the pipe socket height to be traversed does not exceed 250 mm.

Inspection openings may be dispensed with where experience has proved the unlikelihood of corrosion or deposits, e.g. in steam jackets.

Where pressure vessels and equipment contain dangerous substances (e.g. liquefied or toxic gases), the covers of inspection and access openings shall not be secured by crossbars but by bolted flanges.

Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

1.3.10 Mountings

Wherever necessary, strengthening elements are to be fitted at mountings and supports to prevent excessive stress increases in the pressure vessel shell due to vibration.

1.3.11 Identification and marking

Each pressure vessel is to be provided with a plate or permanent inscription indicating the manufacturer, the serial number, the year of manufacture, the capacity, the maximum allowable working pressure of the pressurized parts and the identification of the inspection body. On smaller items of equipment, an indication of the working pressures is sufficient.

1.4 Design

Design calculations are to be performed according to existing **TL** Rules or to international codes such as AD-Merkblätter, ASME or harmonized European Standards accepted by **TL**, taking into consideration the special requirements for pressure vessels installed on inland waterway vessels.

Applicable statutory requirements of the Flag State Authority are to be observed additionally.

1.5 Equipment and installation

1.5.1 Shut-off devices

Shut-off devices shall be fitted in pressure lines as close as possible to the pressure vessel. Where several pressure vessels are grouped together, it is not necessary that each pressure vessel should be capable of being shut-off individually and means need only be provided for shutting off the group. In general, not more than three pressure vessels should be grouped together. Starting air receivers and other pressure vessels which are opened in service shall be capable of being shut off individually. Devices incorporated in piping, e.g. water and oil separators, do not require shut-off devices.

1.5.2 Pressure gauges

Each pressure vessel which can be shut-off and every group of pressure vessels with a shutoff device shall be equipped with a pressure gauge, also capable of being shut-off, suitable for the medium contained in the pressure vessels. The measuring range and calibration shall extend to the test pressure with a red mark to indicate the maximum working pressure.

Equipment need only be fitted with pressure gauges when these are necessary for its operation.

1.5.3 Safety equipment

1.5.3.1 Each pressure vessel which can be shut-off or every group of pressure vessels with a shut-off device shall be equipped with a spring-loaded safety valve which cannot be shut-off and which closes again reliably after blow-off.

Appliances for controlling pressure and temperature are no substitute for relief valves.

1.5.3.2 Safety valves shall be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10 %. Means shall be provided to prevent the unauthorized alteration of the safety valve setting. Valves cones shall be capable of being lifted at all times.

1.5.3.3 Means of drainage which cannot be shut-off are to be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities shall be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out shall be drained off via an open funnel.

1.5.3.4 Steam-filled spaces are to be fitted with a safety valve if the steam pressure inside them is liable to exceed the maximum allowable working pressure. If vacuum will occur, e.g. by condensating, an appropriate safety device is necessary.

1.5.3.5 Heated spaces which can be shut off on both the inlet and the outlet side are to be fitted with a safety valve which will prevent an inadmissible pressure increase should the contents of the space undergo dangerous thermal expansion or the heating elements fail.

1.5.3.6 Pressure water tanks are to be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with if the air pressure supplied to the tank cannot exceed its maximum allowable working pressure.

1.5.3.7 Calorifiers are to be fitted with a safety valve at the cold water inlet.

1.5.3.8 Rupture disks are permitted only with the consent of **TL** in application where their use is specially justified. They must be designed that the maximum allowable working pressure PB cannot be exceeded by more than 10 %.

Rupture disks are to be provided with a guard to catch the fragments of the rupture element and shall be protected against damage from outside. The fragments of the rupture element shall not be capable of reducing the necessary section of the discharge aperture.

1.5.3.9 Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the pressure-volume product is PB [bar] x capacity [litres] $\leq$ 200.

1.5.3.10 Electrically heated equipment has to be equipped with a temperature limiter besides of a temperature controller.

1.5.3.11 Oil-fired warm water generators are to be equipped with limiters for temperature and pressure above a specified threshold. Additionally, a low water level limiter, a limiter for minimum pressure or a low flow limiter is to be provided. The actuation of the limiters shall shut-down and interlock the oil burner.

Warm water generators heated by exhaust gases are to be equipped with the corresponding alarms.

1.5.3.12 The equipment on pressure vessels has to be suitable for the use on inland navigation vessels. The limiters for e.g. pressure, temperature and flow are safety devices and have to be type-approved and have to be provided with appropriate type approval certificates. For type approval of safety valves, the test requirements outlined in ISO/ EN 4196 shall be observed.

1.5.4 Liquid level indicators and feed equipment for heated pressure vessels

1.5.4.1 Heated pressure vessels in which a fall of the liquid level can result in unacceptably high temperatures in the vessel walls are to be fitted with a device for indicating the level of the liquid.

1.5.4.2 Pressure vessels with a fixed minimum liquid level are to be fitted with feed equipment of adequate size.

1.5.4.3 Warm water generating plants are to be designed as closed systems with external pressure generation and membrane expansion vessel. Water shall be circulated by forced circulation.

1.5.5 Sight glasses

Sight glasses in surfaces subject to pressure are allowed only if they are necessary for the operation of the plant and other means of observation cannot be provided. They shall not be larger than necessary and shall preferably be round. Sight glasses are to be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses shall be fitted with closable covers.

1.5.6 Draining and venting

Pressure vessels and equipment shall be capable of being depressurized and completely emptied or drained. Particular attention is to be given to the adequate drainage facilities of compressed air pressure vessels.

Suitable connections and a vent at the uppermost point shall be provided for the execution of hydraulic pressure tests.

1.5.7 Installation

Pressure vessels and equipment are to be installed in such a way as to provide for maximum all-round visual inspection and to facilitate the execution of periodic tests. Where necessary, ladders or steps are to be fitted inside pressure vessels.

Wherever possible, horizontal compressed air receivers should be installed at an angle and parallel to the fore- and aft line of the inland waterway vessel. The angle should be at least 10° (with the valve head at the top.) Where pressure vessels are installed athwartships, the angle should be greater.

Where necessary, compressed air receivers are to be so marked on the outside that they can be installed on board inland waterway vessels in the position necessary for complete venting and drainage.

1.5.8 Cargo tanks for liquefied gases

For the equipment and installation of cargo tanks for liquefied gases, see Section 16.

1.6 Tests

1.6.1 Constructional test and pressure tests

On completion, pressure vessels and equipment are to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the loads specified in Table 12.17 may not be exceeded.

For Group I pressure vessels and equipment, the test pressure is generally 1.5 times the permitted working pressure subject to a minimum of p + 1 bar.

For pressure vessels and equipment of Groups II and III, the test pressure is 1.3 times the permitted working pressure subject to a minimum of p + 1 bar. For working pressures below atmospheric pressure, the test pressure is 2 bar excess pressure

Air coolers (e.g. charge air coolers) are to be tested on the water side at 1.5 times the permitted working pressure subject to a minimum of 4 bar.

In special cases the use of media other than water for the pressure tests may be agreed.

Table 12.17 Loads during hydrostatic tests

For materials with a definite yield point	For materials without a definite yield point
$R_{eH,\,20}$ / 1,1	$R_{m,\,20}$ / 2,0
$R_{eH,\,20}$ = Guaranteed yield strength or minimum value of the 0,2 % proof stress at room temperature $R_{m,\,20}$ = Guaranteed minimum tensile strength [N/mm^2] at room temperature	

1.6.2 Tightness tests

Where pressure vessels and equipment contain hazardous substances (e.g. liquefied gases), **TL** reserves the right to call for a special test of gastightness.

1.6.3 Certification of tests

The constructional test and the pressure test are to be performed in the manufacturer's works in the presence of a Surveyor. For pressure vessels and equipment of Group II and III the manufacturer's test certificates are acceptable if the permitted working pressure PB ≤ 1 bar or if the product of the pressure [bar] x capacity [litres] PB × I ≤ 200

1.6.4 Testing after installation on board

After installation on board the fittings of pressure vessels and equipment and the arrangement and settings of the safety devices are to be checked and, wherever necessary, subjected to a functional test.

2. Steam boilers

2.1 General

2.1.1 Scope

For the purpose of these Rules the term "steam boiler" includes all closed pressure vessels and piping systems used for:

a) Generating steam with a pressure above atmospheric pressure (steam generators) - the generated steam is to be used in a system outside of the steam generators or

b) Raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators) - the generated hot water is to be used in a system outside of the hot water generators.

The term "steam boiler" also includes any equipment directly connected to the aforementioned pressure vessels or piping systems in which the steam is, for example, superheated or cooled, as well as external drums, and the circulating lines and the casings of circulating pumps serving forced-circulation boilers.

For warm water generators having a maximum allowable discharge temperature of not more than 120 °C and steam or for hot water generators which are heated solely by steam or hot liquids 1. applies.

2.1.2 Other Rules

As regards their construction and installation, steam boiler plants are also required to comply with the applicable statutory requirements and regulations of the inland waterway vessel's country of registration.

2.1.3 Definitions

Steam boiler walls are the walls of the steam and water spaces located between the boiler isolating devices. The bodies of these isolating devices form part of the boiler walls.

The maximum allowable working pressure PB (design pressure) is the approved steam pressure in bar (gauge pressure) in the saturated steam space prior to entry into the superheater. In once-through forced flow boilers, the maximum allowable working pressure is the pressure at the superheater outlet or, in the case of continuous flow boilers without a superheater, the steam pressure at the steam generator outlet.

The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.:

a) the area [m^2] measured on the side exposed to fire or exhaust gas, or

b) in the case of electrical heating, the equivalent heating surface [m^2]:

$$H = \frac{860 \cdot P}{18000} \, [m^2]$$

P = electrical power [kW]

The allowable steam output is the maximum hourly steam quantity which can be produced continuously by the steam generator operating under the design steam conditions.

The “dropping time” is the time taken by the water level under conditions of interrupted feed and allowable steam production, to drop from the lowest water level (LWL) to the level of the highest flue (HF).

$$T = \frac{V}{D \cdot v'} \text{ [min]}$$

T = dropping time [min]

V = volume [m^3] of water between the lowest water level and the highest flue

D = allowable steam output [kg/min]

v′ = specific volume of water at saturation temperature [m^3/kg]

The lowest water level is to be set so that the dropping time is not less than 5 minutes.

2.1.4 Manual operation

For steam boilers which are operated automatically means for operation and supervision are to be provided which allow manual operation with the following minimum requirements by using an additional control level:

At boilers with a defined highest flue at their heating surface (e.g. oil-fired steam boilers and exhaust gas boilers with temperature of the exhaust gas > 400 °C) at least the water level limiters, and at hot water generators the temperature limiters, have to remain active.

The monitoring of the oil content of the condensate or of the ingress of foreign matters into the feding water may not lead to a shut-down of the feding pumps during manual operation.

The safety equipment not required for manual operation may only be deactivated by means of a keyoperated switch. The actuation of the key-operated switch is to be indicated.

For detailed requirements in respect of manual operation of the oil firing system, see 4.

Manual operation demands constant and direct supervision of the steam boiler plant.

2.1.5 Documents for review/approval

The following documents are to be submitted for approval.

- drawings of all steam boiler parts subject to pressure, such as shells, drums, headers, tube arrangements, manholes and inspection covers etc.,
- drawings of the expansion vessel and other pressure vessels for hot water generating plants
- equipment and functional diagrams with description of the steam boiler plant
- circuit diagrams of the electrical control system and, as applicable, monitoring and safety devices with limiting values.

These drawings shall contain all the data necessary for strength calculations and design assessment, such as maximum allowable working pressure, heating surfaces, lowest water level, allowable steam production, steam conditions, superheated steam temperatures, as well as materials to be used and full details of welds.

Further the documents shall contain information concerning the equipment of the steam boiler as well as a description of the boiler plant with the essential boiler data, information about the installation location in relation to the longitudinal axis of the ship and data about feeding and oil firing equipment.

2.2 Materials

2.2.1 General requirements

With respect to their workability during manufacture and their characteristics in subsequent operation, materials used for the manufacture of steam boilers shall satisfy the technical requirements, particularly those relating to high-temperature strength and, where appropriate, weldability.

2.2.2 Approved materials

The requirements specified in 2.2.1 are recognized as having been complied with if the materials shown in Table 12.19 are used.

Materials not specified in the **TL** Rules for Materials may be used provided that proof is supplied of their suitability and mechanical properties.

2.2.3 Material testing

The materials of boiler parts subject to pressure shall be tested under supervision of **TL** in accordance with the **TL** Rules for Materials (see Table 12.19). For these materials, an A-Type Certificate is to be issued.

Material testing under supervision of **TL** may be waived in the case of:

a) small boiler parts made of unalloyed steels, such as stay bolts, stays of ≤ 100 mm diameter, reinforcing plates, handhole, headhole and manhole closures, forged flanges up to DN 150 and nozzles up to DN150 and

b) smoke tubes (tubes subject to external pressure).

For the parts mentioned in a) and b), the properties of the materials are to be attested by Manufacturer Inspection Certificates.

If the design temperature is 450 °C or higher or the design pressure is 32 bar or higher, pipes shall be non-destructively tested in accordance with the **TL** Rules for Materials.

Special agreements may be made regarding the testing of unalloyed steels to recognized standards. The materials of valves and fittings shall be tested under supervision of **TL** in accordance with the data specified in Table 12.18. For these materials, an A-Type Certificate needs to be issued.

Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc. shall be designed for the intended purpose and shall be made of suitable materials.

Table 12.18 Testing of materials for valves and fittings

Type of material (1)	Service temperature	Testing required for
Steel, cast steel	> 300	DN > 32
Steel, cast steel Nodular cast iron	≤ 300	p_{zul} x DN > 2500 **(2)** or DN > 250
Copper alloys	≤ 225	p_{zul} x DN > 1500 **(2)**

P_{zul} = Working pressure [bar]
DN = Nominal diameter [mm]
(1) *No tests are required for grey cast iron*
(2) *Testing may be dispensed with if the nominal DN is ≤ 32*

2.3 Principles applicable to manufacture

2.3.1 Manufacturing processes applied to boiler materials

Materials are to be checked for defects during the manufacturing process. Care is to be taken to ensure that different materials cannot be confused. During the course of manufacture care is likewise required to ensure that marks and inspection stamps on the materials remain intact or are transferred in accordance with regulations.

Steam boiler parts whose microstructure has been adversely affected by hot or cold forming are to be subjected to heat treatment and testing in accordance with the **TL** Rules for Materials.

2.3.2 Welding

Steam boilers are to be manufactured by welding.

The execution of welds, the approval of welding shops and the qualification testing of welders are to be in accordance with the **TL** Rules for Welding.

2.3.3 Tube expansion

Tube holes shall be carefully drilled and deburred.

Sharp edges are to be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses.

Tube ends to be expanded are to be cleaned and checked for size and possible defects. Where necessary, tube ends are to be annealed before being expanded.

Smoke tubes with welded connections between tube and tube plate at the entry of the second path shall be roller-expanded before and after welding.

2.3.4 Stays, stay tubes and stay bolts

Stays, stay tubes and stay bolts are to be so arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section, in threads and at welds are to be minimized by suitable component geometry.

Stay bars and stay bolts are to be welded preferably by full penetration. Any vibrational stresses are to be considered for longitudinal stays.

Stay bars and stay bolts are to be drilled at both ends in such a way that the holes extend at least 25 mm into the water or steam space. Where the ends have been upset, the continuous shank shall be drilled to a distance of at least 25 mm.

The angle made by gusset stays and the longitudinal axis of the boiler shall not exceed 30°. Stress concentrations at the welds of gusset stays are to be minimized by suitable component geometry. Welds are to be executed as full penetration welds. In fire tube boilers, gusset stays are to be located at least 200 mm from the fire tube.

Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of the said bolts shall not generally exceed 200 mm.

2.3.5 Stiffeners, straps and lifting eyes

Where flat end surfaces are stiffened by profile sections or ribs, the latter shall transmit their load directly (i.e. without welded-on straps) to the boiler shell.

Doubling plates may not be fitted at pressure parts subject to flame radiation.

Where necessary to protect the walls of the boiler, strengthening plates are to be fitted below supports and lifting brackets.

2.3.6 Welding of flat unrimmed ends to boiler shells

Flat unrimmed ends (disc ends) on shell boilers are only permitted as socket-welded ends with a shell projection of ≥ 15 mm. The end/shell wall thickness ratio s_B/s_M shall not be greater than 1,8. The end is to be welded to the shell with a full penetration weld.

2.3.7 Nozzles and flanges

Nozzles and flanges are to be of rugged design and properly welded, preferably by full penetration to the shell. The wall thickness of nozzles shall be sufficiently large to safely withstand additional external loads. The wall thickness of welded-in nozzles shall be appropriate to the wall thickness of the part into which they are welded.

Welding-neck flanges shall be made of forged material with favourable grain orientation.

2.3.8 Cleaning and inspection, openings, cutouts and covers

Steam boilers are to be provided with openings through which the space inside can be cleaned and inspected. Especially critical and high-stressed welds, parts subjected to flame radiation and areas of varying water level shall be sufficiently accessible to inspection. Boiler shells with an inside diameter of more than 1200 mm, and those measuring over 800 mm in diameter and 2000 mm in length, are to be provided with means of access.

Parts inside drums shall not obstruct internal inspection or shall be capable of being removed.

Inspection and access openings are required to have the following minimum dimensions (see Table 12.20):

The edges of manholes and other openings, e.g. for domes, are to be effectively reinforced if the plate has been unacceptably weakened by the cut-outs. The edges of openings closed with covers are to be reinforced by welded on edge-stiffeners.

Cover plates, manhole frames and crossbars shall be made of ductile material (not grey or malleable cast iron). Grey cast iron (at least GG-20) may be used for handhole cover crossbars of headers and sectional headers, provided that the crossbars are not located in the heating gas flow.

Unless metal packings are used, cover plates shall be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening is to be uniform round the periphery and may not exceed 2 mm for boilers with a working pressure of less than 32 bar, or 1 mm where the pressure is 32 bar or over. The height of the rim or spigot shall be at least 5 mm greater than the thickness of the packing.

Only continuous rings may be used as packing. The materials used shall be suitable for the given operating conditions.

Table 12.19 Approved materials

Material and product form	Limits of application	Material grade in accordance with the TL Material Rules
Steel plates and strips	NA	Steel plates for steam boilers and pressure vessels
Steel tubes	NA	Steel pipes for high temperatures service
Steel forgings and formed parts	NA	Steel forgings for steam boilers and pressure vessels
Steel castings	NA	Steel castings for steam boilers and pressure vessels
Nodular cast iron	≤ 300 °C ≤ 40 bar ≤ DN 175 for valves and fittings	Nodular graphite iron castings
Lamellar (grey) cast iron: boiler parts only for unheated surfaces and not for thermal oil heaters valves and fittings	 ≤ 200 °C ≤ 10 bar Φ ≤ 200 ≤ 200 °C ≤ 10 bar ≤ DN 175	 Grey iron castings
Bolts and nuts	NA	Bolts and nuts for elevated temperature
Valves and fittings of copper alloy castings	≤ 225 °C ≤ 25 bar	Copper alloy castings
Φ = diameter [mm] NA = not applicable		

Table 12.20 Opening dimensions

Manholes	300 x 400 mm or 400 mm diameter where the annular height is > 150 mm, the opening is to measure 320 x 420 mm
Holes for the head	220 x 320 mm or 320 mm diameter
Handholes	87 x 103 mm
Sight holes	are required to have a diameter of at least 50 mm; they should, however, be provided only when the design of the equipment makes a handhole impracticable.

2.4 Design

Design calculations are to be performed according to existing **TL** Rules or to international codes accepted by **TL** such as AD-Merkblätter, ASME, CODAP, British standards or harmonized European standards, taking into consideration the special requirements for steam boilers installed on inland waterway vessels.

Applicable statutory requirements of the Flag State Authority are to be observed additionally.

2.5 Equipment and installation

2.5.1 Feed and circulating equipment

Each boiler shall generally be provided with two feedwater pumps, each of which shall be capable of supplying a quantity of water equivalent to 1.25 times the boiler output.

One feedwater pump is sufficient for boilers which are not needed to keep the machinery in operation, provided that the following conditions are met:

a) The steam pressure and the water level shall be automatically controlled.

b) After the firing has been shut-down, the heat stored in the boiler may not cause any inadmissible lowering of the water level.

c) In the event of a failure of the power supply to the feedwater pump drive, the firing system shall shut-down automatically.

d) The boiler shall be fitted with a water-level limiting device independent of the water-level control.

In the case of continuous-flow boilers a pump delivery rate equal to 1.0 times the boiler output is sufficient.

The feedwater system shall be capable both of supplying the required quantity of feedwater against the maximum allowable working pressure and of delivering the quantity of feedwater corresponding to the steaming capacity against 1.1 times the maximum allowable working pressure.

For electrically driven feedwater pumps, each motor is to be supplied via a separate line from the bus-bar.

Each feedwater pump shall be independently capable of being isolated from the suction and delivery lines.

Each boiler feed line shall be equipped with a shut-off device and a non-return valve. If the shut-off device and the non-return valve are not mounted in immediate conjunction, the intervening length of pipe shall be fitted with a pressure relief device.

Continuous-flow boilers require no shut-off device or non-return valve provided that the feed system serves only one boiler.

The feed devices are to be fitted to the steam generator in such a way that it cannot be drained lower than 50 mm above the highest flue when the non-return valve is not tight.

The feedwater is to be fed into the steam generator in such a way as to prevent damaging effects to the boiler walls and to heated surfaces.

Each forced-circulation boiler shall generally be equipped with two independently driven circulating pumps. Failure of the circulating unit in service shall trip an alarm.

One circulating pump is sufficient for continuous-flow boilers.

Should the power supply to the circulating pump drive fail, the firing shall shut-down automatically.

2.5.2 Shut-off devices

Each steam boiler shall be capable of being shut off from all connected pipes. The shut-off devices are to be installed as close as possible to the boiler shell and are to be operated without risk.

2.5.3 Scum removal, sludge removal, drain, venting and sampling devices

Steam boilers and external steam drums are to be fitted with devices to allow them to be drained and vented and the sludge to be removed. Where necessary, steam generators are to be fitted with a scum removal device.

Drain devices and their connections are to be protected from the effects of the heating gases and shall be capable of being operated without risk. Self-closing sludge removal valves shall be lockable when closed or, alternatively, an additional shut-off device is to be fitted in the pipe.

With the exception of once-through forced-flow steam generators, devices for taking samples from the water contained in the steam generator are to be fitted to the generator.

Scum removal, sludge removal, drain, venting and sampling devices are to be capable of safe operation. The media being discharged are to be drained away safely.

2.5.4 Safety valves

Each steam boiler which has its own steam space is to be equipped with at least two type-approved, springloaded safety valves. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded.

In combination, the safety valves are to be capable of discharging the maximum quantity of steam which can be produced by the steam generator during continuous operation without the maximum allowable working pressure being exceeded by more than 10 %.

The closing pressure of the safety valves shall be not more than 10 % below the response pressure.

The minimum flow diameter of the safety valves shall be at least 15 mm.

The safety valves are to be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the highest point of the boiler or in the immediate vicinity.

The steam may not be supplied to the safety valves through pipes in which water may collect.

A drain which cannot be shut off is to be fitted at the lowest point at the discharge side of the safety valve.

2.5.5 Water level indicators

Each steam with a free surface is to be equipped with at least two indicators giving a direct reading of the water level.

Cylindrical glass water level gauges are not permitted.

The water level indicators are to be fitted so that a reading of the water level is possible when the ship is heeling and during the motion of the inland waterway vessel when it is at sea. The limit for the lower visible range shall be at least 30 mm above the highest flue, but at least 30 mm below the lowest water level. The lowest water level shall not be above the centre of the visible range.

Water level indicators shall be separately and individually connected to the boiler. The connecting lines shall be free from sharp bends so as to avoid water and steam pockets, and shall be safeguarded against the effects of the heated gases and against cooling.

The connection pipes shall have an inner diameter of at least 20 mm. Where water level indicators are linked by means of common connection pipes or where the connection pipes on the water side are longer than 750 mm, the inside diameter of these pipes shall be at least 40 mm.

Water level indicators are to be connected to the water and steam space of the steam boiler by means of quick-acting shut-off devices that are easily accessible and simple to control .

The devices used for blowing through the water level indicators are to be designed so that they are safe to operate and so that blow-through can be monitored. The discharged media are to be drained away safely.

In place of water level indicators, once-through forced flow boilers are to be fitted with two mutually independent devices which trip an alarm as soon as water flow shortage is detected. An automatic device to shut down the oil burner may be provided in place of the second warning device.

2.5.5.1 Lowest water level

The lowest water level (LWL) has to be located at least 150 mm above the highest flue, even when the ship heels 4° to either side.

The highest flue (HF) shall remain wetted even when the ship is at the static heeling angles laid down in Table 12.1.

The height of the water level is crucial to the response of the water level limiters.

The lowest specified water level is to be indicated permanently on the boiler shell by means of a water level pointer. The location of the pointer is to be included in the documentation for the operator. Reference plates are to be attached additionally beside or behind the water level gauges pointing at the lowest water level.

The highest flue (HF)

- Is the highest point on the side of the heating surface which is in contact with the water and which is exposed to flame radiation, and
- Is to be defined by the boiler manufacturer in such a way that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400 °C at the level of the highest flue, before, under the condition of interrupted feedwater supply, the water level has dropped from the lowest water level to a level 50 mm above HF

The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes. The requirements relating to the highest flue do not apply to:

- Water tube boiler risers up to 102 mm outer diameter
- Flues in which the temperature of the heating gases does not exceed 400 °C at maximum continuous power
- Once-through forced flow boilers
- Superheaters

The heat accumulated in furnaces and other heated boiler parts may not lead to any inadmissible lowering of the water level due to subsequent evaporation when the oil burner is switched off.

This requirement with regard to an inadmissible lowering of the water level is met for example, if it has been demonstrated by calculation or trial that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400 °C at the level of the highest flue, before, under the condition of interrupted feedwater supply, the water level has dropped from the lowest water level LWL to a level 50 mm above the highest flue HF.

The water level indicators have to be arranged in such a way that the distance 50 mm above HF can be identified.

2.5.6 Pressure indicators

Each steam boiler is to be fitted with at least one pressure gauge directly connected to the steam space. The maximum allowable working pressure is to be marked on the dial by means of a permanently and easily visible red mark. The indicating range of the pressure gauge shall include the test pressure.

At least one additional pressure indicator having a sensor independent from the pressure gauge has to be located at the machinery control station or at some other appropriate site.

The pipe to the pressure gauge shall have a water trap and shall be provided with a blow-through connection.
A connection for a test gauge is to be installed close to the pressure gauge.

In the case of pressure gauges which are at a lower position, the test connection shall be provided close to the pressure gauge and close to the connection piece of the pressure gauge pipes.

Pressure gauges are to be protected against radiant heat and shall be well illuminated.

2.5.7 Name plate

A name plate is to be permanently affixed to each steam boiler, displaying the following information:

- manufacturer's name and address
- serial number and year of construction
- maximum allowable working pressure [bar]
- allowable steam production [kg/h] or [t/h]

The name plate is to be attached to the largest part of the boiler or to the boiler frame so that it is visible.

2.5.8 Special requirements for low capacity boilers

In the case of boilers with a water volume of not more than 150 litres and a permitted working pressure of up to 10 bar and where the volume of water in litres multiplied by the max. allowable working pressure in bar does not exceed 500 bar · L, the second feed pump and the second water level indicator, or for continuous-flow boilers the second warning device, may be dispensed with.

2.5.9 Special requirements for automatically controlled steam boilers not under permanent supervision

With the exception of steam boilers which are heated by exhaust gas, steam boilers are to be operated with rapid-control, automatic oil burners.

After the oil burner has been shut down, the heat stored in the firebox and the heating gas paths may not cause any inadmissible evaporation of the water contained in the steam generator.

The control system shall be capable of adapting the boiler to changes in the operating load without actuating the safety devices.

The steam pressure shall be automatically regulated by controlling the supply of heat. The steam pressure of boilers heated by exhaust gas may also be regulated by condensing the excess steam.

In the case of steam generators which have a specified minimum water level, the water level is to be regulated automatically by controlling the supply of feedwater.

In the case of forced-circulation steam generators whose heating surface consists of a steam coil and of once-through forced flow steam generators, the supply of feedwater may be regulated as a function of fuel supply.

Fired steam generators are to be equipped with a pressure limiter which cuts out and interlocks the oil burner before the maximum allowable working pressure is reached.

In steam generators on whose heating surfaces a highest flue is specified, two mutually independent water level limiters have to respond to cut out and interlock the oil burner when the water falls below the specified minimum water level.

In the case of forced-circulation steam generators with a specified lowest water level, two mutually independent safety devices are to be fitted in addition to the requisite water level limiters, which will cut out and interlock the oil burner in the event of any unacceptable reduction in water circulation.

In the case of forced-circulation steam generators where the heating surface consists of a single coil and once-through steam generators, two mutually independent safety devices are to be fitted in place of the water level limiters in order to provide a sure means of preventing any excessive heating of the heating surfaces by cutting out and interlocking the oil burner.

Where there is a possibility of oil or grease getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feedwater supply or the circulation resp. if the concentration at which boiler operation is put at risk is exceeded. The control device for oil or grease ingress may be waived for a dual circulation system.

Where there is a possibility of acid, lye or seawater getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feedwater supply or the circulation, as applicable, if the concentration at which boiler operation is put at risk is exceeded. The control device for acid, lye or seawater ingress may be waived for a dual circulation system.

The controls for steam pressure and water level and any additional safety devices (trips) shall take the form of mutually independent units.

The safety devices have to trip visual and audible alarms at the steam boiler control panel.

The electrical devices associated with the limiters are to be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut out and interlock the systems unless an equivalent degree of safety is achieved by other means.

The electrical interlocking of the oil burner following tripping by the safety devices is only to be cancelled out at the oil burner control panel itself.

The receptacles for water level limiters located outside the steam boiler are to be connected to the steam boiler by means of lines which have a minimum inner diameter of 20 mm. Shut-off devices in these lines shall have a nominal diameter of at least 20 mm and have to indicate their open or closed position. Where water level limiters are connected by means of common connection lines, the connection pipes on the water side are to have an inner diameter of at least 40 mm.

Operation of the oil burner shall only be possible when the shut-off devices are open or else, after closure, the shut-off devices are reopening automatically and in a reliable manner.

Water level limiter receptacles which are located outside the steam boiler are to be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines is carried out.

Emergency shut-down of the oil burner shall be possible from the burner control platform.

If an equivalent level of safety cannot be achieved by the self-monitoring of the equipment, the functional testing of the safety devices shall be practicable even during operation. In this case, the operational testing of the water level limiters shall be possible without dropping the surface of the water below the lowest water level (LWL).

2.5.10 Design and testing of valves and fittings

Valves and fittings for boilers are to be made of ductile materials as specified in Table 12.19 and all their components shall be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in Table 12.19, but shall not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow-off valves.

Testing of materials for valves and fittings is to be carried out as specified in Table 12.18. Care is to be taken to ensure that the bodies of shut-off gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets shall be safe guarded to prevent unintentional loosening of the bonnet.

All valves and fittings are to be subjected to a hydrostatic pressure test at 1.5 times the nominal pressure before they are fitted. Valves and fittings for which no nominal pressure has been specified are to be tested at twice the maximum allowable working pressure. In this case, the safety factor in respect of the 20 °C yield strength value shall not fall below 1.1. The sealing efficiency of the closed valve is to be tested at the nominal pressure or at 1.1 times the maximum allowable working pressure, as applicable.

Safety valves are to be subjected to a test of the set pressure. After the test the tightness of the seat is to be checked at a pressure 0.8 times the set pressure. The setting is to be secured against unauthorized alteration.

2.5.11 Installation of boilers

Steam boilers are to be installed in the inland waterway vessel with care and have to be secured to ensure that they cannot be displaced by any of the circumstances arising when the inland waterway vessel is at sea. Means are to be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings are to be well accessible from all sides or shall be easily made accessible.

Safety valves and shut-off mechanisms shall be capable of being operated without danger. Wherever necessary, permanent steps, ladders or platforms shall be fitted. Water level indicator cocks and valves, except safety valves, which cannot be directly reached by hand from the floor plates or a platform shall be fitted with draw rods or chains enabling them to be operated from the boiler control platform. Cocks shall be so arranged that they are open when the draw rod is in its lowest position.

2.6 Testing of boilers

2.6.1 Manufacturing test

After completion, steam boilers are to undergo a constructional check.

The constructional check includes verification that the steam boiler complies with the approved drawings and is of satisfactory construction. For this purpose, all parts of the boiler shall be accessible to allow adequate inspection. If necessary, the constructional check is to be performed at separate stages of manufacture.

The following documents are to be presented: material test certificates covering the materials used, reports on the non-destructive testing of welds and, where applicable, the results of tests of workmanship and proof of the heat treatment applied.

2.6.2 Hydrostatic pressure tests

A hydrostatic pressure test is to be carried out on the steam boiler before refractory insulation and casing are fitted. Where only some of the component parts are sufficiently accessible to allow proper visual inspection, the hydrostatic pressure test may be performed in stages. Steam boiler surfaces have to withstand the test pressure without leaking or suffering permanent deformation.

The test pressure is generally required to be at least 1.5 times the maximum allowable working pressure, subject to a minimum of p_{zul} + 1 bar.

In the case of once-through forced flow boilers, the test pressure shall be at least 1.1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steam output. In the event of danger that parts of the boiler might be subjected to stresses exceeding 0.9 of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

2.7 Hot water generators

2.7.1 Design

In respect of the materials used and the strength calculations, hot water generators heated by solid, liquid or gaseous fuels, by waste gases or by electrical means are to be treated in a manner analogous to that applied to steam generators. The materials and strength calculations for hot water generators which are heated solely by steam or hot liquids only are subject to the requirements in 1.

2.7.2 Equipment

The safety equipment of hot water generators is subject to the requirements contained in recognized standards

accepted by **TL** with due regard for the special conditions attaching to shipboard operation.

2.7.3 Testing

Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at

least 1.5 times the maximum allowable working pressure, subject to a minimum of 4 bar.

3. Thermal oil heaters

3.1 General

3.1.1 Scope

The following Rules apply to the components in thermal oil systems in which organic liquids (thermal oils) are heated by oil burners or electricity to temperatures below their initial boiling point at atmospheric pressure.

Thermal oil heaters to which thermal energy is supplied by engine exhaust gases can also be approved. The safety equipment is subject, as applicable, to the **TL** Rules.

3.1.2 Definitions

The "maximum allowable working pressure" is the maximum pressure which may occur in the individual parts of the equipment under service conditions.

The "thermal oil temperature" is the temperature of the thermal oil at the centre of the flow cross-section.

The "discharge temperature" is the temperature of the thermal oil immediately at the heater outlet. The "return temperature" is the temperature of the thermal oil immediately at the heater inlet.

The "film temperature" is the wall temperature on the thermal oil side. In the case of heated surfaces, this may differ considerably from the temperature of the thermal oil.

3.1.3 Documents for review/approval

The following documents are to be submitted for approval.

- A description of the system stating the discharge and return temperatures, the maximum allowable film temperature, the total volume of the system and the physical and chemical characteristics of the thermal oil

- Drawings of the heaters, the expansion vessel and other pressure vessels

- Circuit diagrams of the electrical control system and monitoring and safety devices with limiting values respectively

- A functional diagram with information about the safety and monitoring devices and valves provided.

If specially requested, mathematical proof of the maximum film temperature in accordance with a recognized standard, accepted by **TL**, is to be submitted.

3.1.4 Construction and manufacture

Design calculation, materials, manufacture and testing are governed by:

- 2 for heaters

- 1 for expansion and pressure vessels

- 4 for oil firing systems (the cut-out conditions for trips are as stated in 3.2.2 and 3.3.2)

- C. for pipes, pumps, valves and fittings

However, grey cast iron is not permitted for components of the hot thermal oil circuit.

Welded structures are subject to the **TL** Rules for Welding.

3.1.5 Thermal oils

The thermal oil has to remain serviceable for at least 1 year at the specified thermal oil temperature. Its suitability for further use is to be verified at appropriate intervals, but at least once a year.

Thermal oils may only be used within the limits set by the manufacturer. A safety margin of about 50 °C is to be maintained between the discharge temperature and the maximum allowable film temperature specified by the manufacturer.

Precautions are to be taken to protect the thermal oil from oxidation.

Copper and copper alloys, which due to their catalytic effect lead to an increased ageing of the thermal oil are to be avoided or oils with specific additives are to be used.

3.1.6 Manual operation

For thermal oil heaters which are operated automatically, means for operation and supervision are to be provided which allow a manual operation with the following minimum requirements by using an additional control level:

At least the temperature limiter on the oil side and the flow limiter shall remain operative at the oil-fired heater.

The safety equipment not required for manual operation may only be deactivated by means of a keyoperated switch. The actuation of the key-operated switch is to be indicated.

For details of requirements in respect of the manual operation of the oil firing equipment, see 4.

Manual operation requires constant and direct supervision of the system.

3.2 Heaters

3.2.1 Design

The heater is to be equipped with an automatic, rapidly controllable heating system.

Heaters are to be designed thermodynamically and by construction in a way that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

The surfaces which come into contact with the thermal oil are to be designed for the maximum allowable working pressure, subject to a minimum gauge pressure of 10 bar.

Oil-fired heaters are to be provided with inspection openings for the examination of the combustion chamber.

Sensors for the temperature measuring and monitoring devices are to be introduced into the system through welded-in immersion pipes.

Heaters are to be fitted with devices enabling them to be completely drained.

3.2.2 Equipment and safety devices

Temperature-indicating devices are to be fitted at the discharge and return line as well as in the flue gas outlet of the heater.

The outlet of the circulating pump is to be equipped with a pressure gauge. The maximum allowable working pressure PB is to be indicated on the scale by a red mark which is permanently fixed and well visible. The indicating range has to include the test pressure.

For automatic control of the discharge temperature, oilfired heaters are to be equipped with an automatic and rapidly adjustable heat supply in accordance with 4.

If the allowable discharge temperature is exceeded for oil-fired heaters, the oil burner is to be switched off and interlocked by a temperature limiter.

Parallel-connected heating surfaces are to be monitored individually at the discharge side of each coil. At the oil-fired heater, the oil burner is to be switched off and interlocked by a temperature limiter in case the allowable discharge temperature is exceeded in at least one coil. An additional supervision of the allowable discharge temperature of the heater is not necessary.

A flow monitor switched as a limiter is to be provided at the oil-fired heater. If the flow rate falls below a minimum value, the oil burner has to be switched off and interlocked.

3.2.3 Start-up of the oil burner is to be prevented by interlocks if the circulating pump is at standstill.

If the specified flue gas temperature is exceeded, theheating shall be switched off by a temperature limiter.

Electrical equipment items are subject to Section 13 and in particular to Section 13, M.

3.3 Pressure vessels

3.3.1 All pressure vessels, including those open to the atmosphere, are to be designed for a pressure of at least 2 bar, unless provision has to be made for a higher working pressure

Air ducts are to be installed above the free deck and are to be fitted with automatic shut-off devices.

Drains shall be self-closing.

3.3.2 Expansion vessel

An expansion vessel is to be placed at a high level in the system. The space provided for expansion shall be such that the increase in the volume of the thermal oil at the maximum thermal oil temperature can be safely accommodated. The following are to be regarded as minimum requirements: 1.5 times the increase in volume for charges up to 1000 litres, and 1.3 times the increase for charges over 1000 litres. The volume is the total quantity of thermal oil contained in the system up to the lowest liquid level in the expansion vessel.

The expansion vessel shall be equipped with a liquid level gauge with a mark indicating the lowest allowable liquid level.

Level gauges made of glass, plexiglass or plastic are not allowed.

A limit switch is to be fitted which shuts down and interlocks the oil burner and switches off the circulating pumps if the liquid level falls below the allowable minimum.

Additionally, an alarm for low liquid level is to be installed, e.g. by means of an adjustable level switch on the level indicator, in order to give an early warning of a falling liquid level in the expansion vessel (e.g. in case of a leakage).

An alarm is also to be provided for the maximum liquid level.

The expansion vessel is to be provided with an overflow line leading to the drainage tank.

For rapid drainage in case of danger, a quick-opening valve is to be fitted directly to the expansion vessel with remote control from outside the space in which the equipment is installed.

The quick drainage line may be routed jointly with the overflow line to the drainage tank.

The opening of the quick drainage valve shall activate an alarm. At the same time, a non-safety related shutdown of the oil burner at the oil-fired heater should be carried out.

Where the expansion vessel is installed outside the engine room, the quick drainage valve may be replaced by an emergency shut-off device which, in the event of danger, prevents the egress of large quantities of thermal oil.

A safety expansion line shall connect the system to the expansion vessel. This shall be installed with a continuous positive gradient and shall be dimensioned in a way that a pressure increase of more than 10 above the maximum allowable working pressure in the system is avoided.

The dimensions of the expansion, overflow, drainage and venting pipes shall comply with Table 12.21.

All parts of the system in which thermal oil can expand due to the absorption of heat from outside are to be safeguarded against excessive pressure. Any thermal oil emitted is to be safely drained off.

3.3.3 Pre-pressurized systems

Pre-pressurized systems are to be equipped with an expansion vessel, which content is blanketed with an inert gas. The inert gas supply to the expansion vessel has to be guaranteed and monitored for minimum pressure.

The pressure in the expansion vessel shall be indicated and safeguarded against overpressure.

A pressure limiter which gives an alarm and shuts down and interlocks the oil burner at a set-pressure below the set-pressure of the safety valve is to be provided at the expansion vessel.

Tablo12.21 Nominal diameter of expansion, overflow, drainage and venting pipes depending on the output of the heaters

Total output of heaters [kW]	Expansion and overflow pipes - nominal diameter DN	Drainage and venting pipes - nominal diameter DN
≤ 600	25	32
≤ 900	32	40
≤ 1200	40	50
≤ 2400	50	65
≤ 6000	65	80

3.3.4 Drainage tanks

At the lowest point of the system, a drainage tank is to be located, the capacity of which is sufficient to hold the volume of the largest isolatable system section.

In exceptional cases, approval may be given for the drainage tank and the storage tank to be combined. Combined storage/drainage tanks are to be dimensioned in a way that in addition to the stock of thermal oil, there is volume for the content of the largest isolatable system section.

For air ducts and drains, see 3.3.1.

For sounding pipes, see C.13.

3.4 Fire precautions

See H.4.3.

3.5 Testing

After completion of installation on board, the system including the associated monitoring equipment is to be subjected to pressure, tightness and functional tests in the presence of the **TL** Surveyor.

4. Oil burners and oil firing equipment

4.1 General

4.1.1 Scope

The following Rules apply to oil burners and oil firing equipment that are to be used for the burning of liquid fuels and installed in auxiliary steam boilers, thermal oil heaters and hot water generators, these being referred to as heat generators in the following.

The oil firing equipment of automatically controlled auxiliary steam boilers and thermal oil heaters is subject to the Rules in 4.2.

The following general requirements of this Section are mandatory for all installations and appliances.

4.1.2 Documents for review/approval

The following documents are to be submitted for approval.

- General drawings of the oil burner

- Piping and equipment diagram of the burner including parts list
- Description of function
- Electrical diagrams
- List of equipment regarding electrical control and safety

4.1.3 Approved fuels

See A.2.6

4.1.4 Equipment of the heat generators 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 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 to allow unburnt fuel to be safely drained.

Observation openings are to be provided at suitable points on the heat generator or burner through which the ignition flame, the main flame and the lining can be observed.

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 to be drained away.

4.1.5 Simultaneous operation of oil burners and internal combustion machinery

The operation of oil burners in spaces containing other plants with a high air consumption, e.g. internal combustion engines or air compressors, is not to be impaired by variations in the air pressure.

4.2 Oil firing equipment for boilers and thermal oil heaters

4.2.1 Preheating of fuel oil

The equipment has to enable the heat generators to be started up with the facilities available on board.

Where only steam-operated preheaters are present, fuel which does not require preheating has to be available to start up the boilers.

Any controllable heat source may be used to preheat the fuel oil. Preheating with open flame is not permitted.

The fuel oil supply temperature is to be selected so as to avoid excessive foaming, the formation of vapour or gas and also the formation of deposits on the heating surface.

Temperature or viscosity control shall be done automatically. 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, an alarm system has to signal this fact to the heat generator control panel.

When a change is made from heavy to light oil, the light oil shall not be passed through the heater or be excessively heated (alarm system).

The dimensional and constructional design of pressurized fuel oil preheaters is subject to the rules set out in 1.

Electrically heated continuous-flow heaters are to be equipped with temperature safety trips in accordance with 1.5.3.

4.2.2 Pumps, pipelines, valves and fittings

Fuel oil service pumps may be connected only to the fuel system.

Pipelines shall be permanently installed and joined by oiltight welds, oiltight threaded connections of approved design or with flanged joints. Flexible hoses may be used only immediately in front of the burner or to enable the burner to swivel. They shall be installed with adequate bending radii and shall be protected against undue heating. For non-metallic flexible pipes and expansion compensators, see C.14.

Suitable devices, e.g. relief valves, shall 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 mounted at the fuel oil manifold, it shall be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on the design and method of operation, a quick-closing device may also be required directly in front of each burner.

4.2.3 Safety equipment

The correct sequence of safety functions when the burner is started up or shut down is to be ensured by means of a burner control box.

Two automatic quick-closing devices have to be provided at the fuel oil supply line to the burner.

For the fuel oil supply line to the ignition burner, one automatic quick-closing device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.

The automatic quick-closing devices shall not release the oil supply to the burner during start-up and shall interrupt the oil supply during operation (automatic restart possible) 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 or primary air pressure too low (rotary cup atomizers)

- Failure of combustion air supply

- Failure of control power supply

- Failure of induced-draught fan or insufficient opening of exhaust gas register

- burner not in operating position

The fuel oil supply has to be interrupted by closing the automatic quick-closing devices and interlocked by means of the burner control box if

- The flame does not develop within the safety period following start-up

- The flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or

- Limit switches are actuated

Every burner is to be equipped with a safety device for flame monitoring suitable for the particular fuel oil (spectral range of the burner flame is to be observed) in use. This appliance has to 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 it is justified, longer safety periods may be permitted for burners with an oil throughput of up to 30 kg/h. Measures are to be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniters (e.g. ignition burners).

“Safety period” is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.

Oil firing equipment with electrically operated components shall also be capable of being shut down by an emergency switch located outside the space in which the equipment is installed.

In an emergency, it shall be possible to close the automatic quick-closing devices from the heat generator control platform and - where applicable - from the engine control room.

4.2.4 Design and construction of burners

The type and design of the burner and its atomizing and air turbulence equipment shall ensure virtually complete combustion.

Oil burners shall be so designed and constructed that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter shall 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 highvoltage ignition system shall be automatically disconnected when this occurs. A catch is to be provided to hold the burner in the swung out position.

Burners that can be retracted or pivoted are to be provided with a catch to hold the burner in the swung-out position.

Steam atomizers shall 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 shall be taken to ensure that air for purging the combustion space is always available unless the oil supply is positively interrupted.

Every burner shall be equipped with an igniter. The ignition is to be initiated immediately after purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and fan) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

Where dampers or similar devices are mounted in the air supply line, care shall be taken to ensure that air is available in all circumstances for purging the combustion space.

Pivoted oil burners shall be so constructed that they can be swivelled out only after the fuel oil has been cut off. The high-voltage ignition equipment shall likewise be disconnected when this happens.

The plant shall also be capable of being shut down by means of an emergency switch located outside the space in which the plant is installed.

4.2.5 Purging of combustion chamber and flues, exhaust gas ducting

The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

A threefold renewal of the total air volume of the combustion chamber and the flue gas duct 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 heating power of the firing system.

Bends 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 shall 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 shall be indicated at the boiler control platform.

Where an induced-draught fan is fitted, an interlocking system shall 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.

4.2.6 Electrical equipment

Electrical equipment and its degree of protection has to comply with Section 13.

Safety appliances and flame monitors shall be selfmonitoring and shall 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.

The equipment in the oil firing system has to be suitable for the use in oil firing systems and on ships. The proof of the suitability of the limiters and the alarm transmitters for e.g. burner control box, flame monitoring device and automatic quick-closing device is to be demonstrated by a type approval examination according to the requirements of **TL** Rules.

High-voltage igniters shall be adequately protected against unauthorized interference.

4.2.7 Manual operation

For oil burners at heat generators that are operated automatically, means for operation and supervision are to be provided which allow a manual operation with the following minimum requirements by using an additional control level.

4.2.8 Flame monitoring shall remain active.

4.2.9 The safety equipment not required for manual operation may only be set out of function by means of a key-operated switch. The actuation of the keyoperated switch is to be indicated.

4.2.10 Manual operation requires constant and direct supervision of the system.

4.2.11 Testing

Test at the manufacturer's workshop

For burners of heat generators, the following examinations have to be performed at the manufacturer's shop and documented by a **TL** approval certificate:

- Visual inspection and completeness check

- Pressure test of the oil preheater, if available and required according to this Section

- Pressure test of the burner

- Insulation resistance test

- High voltage test

- Functional test of the safety-related equipment

Tests on board

After installation, a pressure and tightness test of the fuel system, including fittings, has to be performed.

The system, including the switchboard installed at the heat generator on board the vessel, has to be functionally tested as follows; in particular, the required purging time has to be identified and manual operation has to be demonstrated.

- Completeness check for the required components of the equipment

- Functional test of all safety-relevant equipment

- functional test of the burner control box

- Identification of maximum and minimum burner power

- Identification of flame stability on start-up, at maximum and at minimum burner power, under consideration of combustion chamber pressure (unspecified pressure changes are not permitted).

- Proof regarding required purging of flues and safety times

- In case the oil burner is operated with different fuel oils, the proper change-over to another fuel oil quality and especially the safe operation of the flame monitoring, the quick-closing devices and the preheater, if existing, are to be checked

- Proof regarding combustion properties, e.g. volumetric content of CO_2 (and possibly O_2 and CO) and soot number at minimum, mean and maximum power, in case of statutory requirements

The correct combustion at all settings as well as the function of safety equipment has to be verified. A **TL** approval Certificate of the oil burner regarding examination at the manufacturer's shop is to be presented to **TL** during functional testing.

Burners for warm water generators are to be delivered with a test protocol issued by the manufacturer.

E. Steering Gears

1. Symbols

d_T = Theoretical rudder stock diameter [mm] based on ahead run in accordance with Section 10, A.3.1

d = Minimum actual rudder stock diameter [mm]

$$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$$

R_{eH} = Yield stress [N/mm²] of the steel used, and not exceeding the lower of $0{,}7.R_m$ and 450 N/mm²

R_m = Minimum ultimate tensile strength [N/mm²] of the steel used,

n_1 = Coefficient

= 0,75 for $R_{eH} > 235$ N/mm²

= 1,00 for $R_{eH} \leq 235$ N/mm²

2. General

2.1 Scope

The following Rules apply to the steering gear, the steering station and all transmission elements from the steering station to the steering gear.

For the rudder and manoeuvring arrangement, see Section 10, A.

For the purposes of these Rules, steering gears comprise all the equipment used to operate the rudder from the rudder actuator to the steering station including the transmission elements.

This section is to be applied in analogous manner to rudder propellers in their function as steering gears.

2.2 Documents for review/approval

Assembly and general drawings of all steering gears (arrangement in normal and arrangement in emergency condition), diagrams of the hydraulic and electrical equipment together with detail drawings of all important load-transmitting components are to be submitted to **TL** for review/approval.

The drawings and other documents shall contain all the information relating to materials, working pressures, pump delivery rates, drive motor ratings, etc. necessary to enable the documentation to be checked.

3. Materials

3.1 Approved materials

3.1.1 As a rule, important load transmitting components of the steering gear (e.g. tiller, hydraulic cylinder, plunger, rotary vane, bolts, keys and so on) should be made of steel or cast steel complying with the **TL** Rules for Materials.

With the consent of **TL**, cast iron may be used for certain components.

Pressure vessels should, in general, be made of steel, cast steel or nodular cast iron (with predominantly ferritic matrix).

For welded structures, the **TL** Rules for Welding are to be observed.

3.1.2 The pipes of hydraulic steering gears are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to external influences, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

3.1.3 High pressure hose lines may be used for short connections subject in compliance with B.7.

The materials used for pressurized components including the seals shall be suitable for the hydraulic oil in use.

3.2 Testing of materials

The materials of important load-transmitting components of the steering gear including the pressurized oil pipes and the pressurized casings of hydraulic steering gears shall possess mechanical characteristics conforming to the **TL** Rules for Materials. Evidence of this may take the form of manufacturer's acceptance test certificate.

For welded pressurized casings, the **TL** Rules for Welding are to be applied.

4. Design and equipment

4.1 Number of steering gears

Every vessel shall be equipped with at least one main and one auxiliary steering gear. Each steering gear shall be able to operate the rudder on its own and independently of the other system. **TL** may agree to components being used jointly by the main and auxiliary steering gear. For the electrical part of steering gear systems, see Section 13, H.

4.2 Main steering gear

4.2.1 Main steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 35° port to 35° starboard and vice versa and the vessel travelling at full speed, see Section 10, A. The time required to put the rudder over shall not exceed 20 seconds.

The main steering gear shall normally be poweroperated.

4.2.2 Manual operation is acceptable for rudder stock diameters up to 150 mm calculated for torsional loads in accordance with Section 10, A.3.1.1. In the case of multi-surface rudders controlled by a common steering gear, the specified diameter is to be determined by applying the formula:

$$d_T = \sqrt[3]{\Sigma d_{Ti}^{\,3}}$$

d_{Ti} = rule diameter inside of tiller [mm]

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.

The manual wheel shall not be driven by a powered drive unit.

Regardless of rudder position, a kick-back of the wheel shall be prevented when the manual drive is engaged automatically.

4.3 Auxiliary steering gear

Auxiliary steering gears shall be designed to ensure continued adequate manoeuvrability with the rudder fully immersed and the vessel travelling at reduced speed.

Manual operation of auxiliary steering gear systems is permitted where the size of the system allows this.

4.4 Power unit

4.4.1 Where power operated hydraulic main steering gears are equipped with two or more identical power units, no auxiliary steering gear need be installed provided that the following conditions are fulfilled.

4.4.2 In the event of failure of a single component of the main steering gear, excluding the rudder tiller or similar components as well as the cylinders, rotary vanes and casing, means shall be provided for quickly regaining control of one steering system.

4.4.3 In the event of a loss of hydraulic oil, it shall be possible to isolate the damaged system in such a way that the second control system remains fully serviceable and may take over in not more than 5 sec.

4.4.4 If the second drive unit or manual drive is not placed in service automatically, it shall be possible to do so immediately by means of a single operation by the helmsman that is both simple and quick.

4.4.5 Hydraulic pumps should be protected by means of non-return valves mounted at the discharge part.

4.4.6 The second drive unit or manual drive shall ensure the manoeuvrability required by Section 10, A.3.1 as well.

4.5 Rudder angle limitation

The rudder angle of power-operated steering gears is to be limited to the specified maximum amount by devices fitted to the steering gear (e.g. limit switches).

4.6 End position limitation

4.6.1 For limitation of end positions, stoppers are

to be provided. Where necessary, a mechanical safety device at the end position is to be supplied.

4.6.2 In the case of hydraulic steering gears without an end position limitation of the tiller and similar components, an end position limiting device shall be fitted within the rudder actuator.

4.7 Locking equipment

Steering gear systems are to be equipped with a locking system effective in all rudder positions.

For hydraulic plants shut-off valves directly at the cylinder are accepted instead.

4.8 Overload protection

4.8.1 Power-operated steering gear systems are to be fitted with overload protection (slip coupling, relief valve) to ensure that the driving torque is limited to the maximum permissible value. Means shall be provided for checking the setting while in service.

4.8.2 The pressurized casings of hydraulic steering gears which also fulfil the function of the locking equipment mentioned in 4.7 are to be fitted with relief valves unless they are so designed that the pressure generated when the elastic limit torque is applied to the rudder stock cannot cause rupture or permanent deformation of the pressurized casings.

4.8.3 In the case of hydraulic steering gears, the torque transmitted by the rudder as a result of grounding, e.g., shall in addition, be limited by safety valves.

4.9 Controls

Control of the main and auxiliary steering gears shall be exercised from a steering gear station. Controls shall be mutually independent and so designed that the rudder cannot move unintentionally.

Alarm for oil high temperature has to be provided for.

4.10 Rudder angle indication

4.10.1 The rudder position shall be clearly indicated in the wheelhouse and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle shall 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.

4.10.2 The rudder position at any moment shall also be indicated at the steering gear itself.

4.11 Piping

4.11.1 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.

Hydraulic hoses are:

a) only permissible if vibration absorption or freedom of movement of components makes their use inevitable;

b) to be designed for at least the maximum service pressure;

c) to be renewed at the latest every eight years.

Hydraulic cylinders, hydraulic pumps and hydraulic motors as well as electric motors shall be examined at the latest every eight years by a specialized firm and repaired if required.

4.11.2 The pipes of main and auxiliary steering gear systems are normally to be laid independently of each other. With **TL** 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 1.5 times the maximum permissible working pressure.

4.11.3 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.

4.11.4 For the design and dimensions of pressure vessels, pipes, valves, fittings, etc., see D. and C.

4.12 Oil level indicators, filters, etc.

4.12.1 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

4.12.2 The lowest permissible oil level is to be alarmed.

4.12.3 Filters for cleaning the operating fluid are to be located in the piping system.

4.12.4 Hydraulic tanks shall be equipped with a warning system that monitors for any dropping of the oil level below the lowest content level needed for safe operation.

4.13 Arrangement

Steering gears are to be so installed that they are accessible at all times and can be maintained without difficulty.

5. Power and design

5.1 Power of steering gears

5.1.1 The power of the steering gear is governed bythe requirements set out in 4.2 and 4.3. The minimum requirement with regard to the maximum effective torque (M_{TR}) [Nm] for which the steering gear including piping is to be designed is to be calculated according to the following formula:

$$M_{TR} = \frac{d_T^3}{74 \cdot k_1}$$

For the determination of the pertinent working pressure (maximum pressure), the frictional losses in the steering gear including piping are to be considered.

The relief valves are to be set at this pressure value.

5.1.2 Electrical drive motors are also subject to Section 13, H.1.

5.2 Design of transmission components

5.2.1 The design calculations for those parts of the steering gear which are not protected against overload are to be based on the elastic limit torque of the rudder stock. The elastic limit torque [Nm] is:

$$M_F = \frac{26{,}6 \cdot d^3}{1000 \cdot k_1}$$

where, the value used for the minimum actual rudder stock diameter, d, need not be larger than 1,145 · d_T.

In the case of multi-surface rudders, the diameter of only one rudder stock, i.e. the largest, is to be taken into account.

The loads on the components of the steering gear determined in this way shall be below the yield strength of the materials used. The design of parts of the steering gear with overload protection is to be based on the loads corresponding to the response threshold of the overload protection.

5.2.2 Tiller and rotary vane hubs

Tiller and rotary vane hubs made of material with tensile strength of up to 500 N/mm^2 shall satisfy the following conditions in the area where the force is applied (see Fig. 12.5).

Height of hub [mm]: $H_0 \geq d$

Outside diameter [mm]: $d_a \geq 1,8 \cdot d$

In special cases the outer diameter may be reduced to:

$d_a \geq 1,7 \cdot d$

but the height of the hub shall then be at least:

$H_0 \geq 1,145 \cdot d$

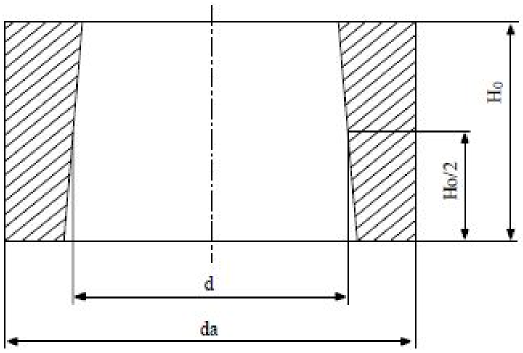


Fig. 12.5 Hub dimensions

5.2.3 Tillers, tiller arms, quadrants and key ways

a) The scantling of the tiller is to be determined as follows:

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 [cm^3] calculated from the following formula:

$$Z_b = \frac{0,147 \cdot d^3}{1000 \cdot} \cdot \frac{L'}{L} \cdot \frac{R_e}{R_e'}$$

L = distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig. 12.6)

L′ = distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig. 12.6)

R_e = value of the minimum specified yield strength of the material at ambient temperature [N/mm^2]

R_e' = design yield strength [N/mm^2] determined by the following formulae:

= R_e, where $R \geq 1,4 . R_e$

= $0,417 . (R_e+R)$ where $R < 1,4 . R_e$

R = value of the minimum specified tensile strength of the material at ambient temperature [N/mm^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 **TL**, and the depth of the boss may be reduced by 10 per cent.

c) Keys should be designed according to 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

- the thickness of the key is not to be less than 0,10.d

- 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 per cent of the key thickness

- the permissible surface pressure of the key and keyway should not exceed 90 % of the materials yield strength.

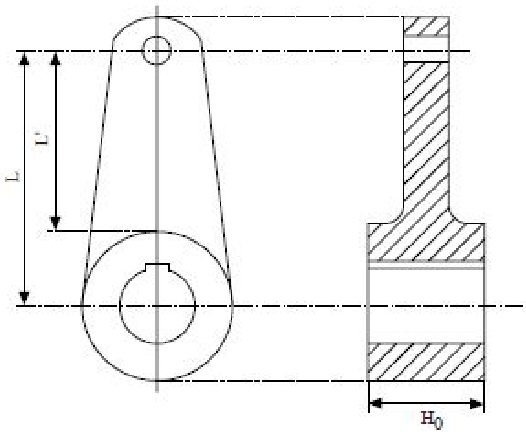


Fig. 12.6 Tiller arm

5.2.4 Where materials with a tensile strength greater than 500 N/mm² are used, the section of the hub may be reduced by 10 %.

5.2.5 Where the force is transmitted by clamped or tapered connections, the elastic limit torque may be transmitted by a combination of frictional resistance and a positive locking mechanism using adequately tightened bolts and a key.

For the elastic limit torque according to formula given in 5.2.1, the thread root diameter, in mm, of the bolts can be determined by applying the following formula:

$$d_B = 9{,}76 \cdot d \cdot \sqrt{\frac{1}{z \cdot R_{eH} \cdot k_1}}$$

z = Total number of bolts

5.2.6 Split hubs of clamped joints shall be joined together with at least four bolts.

The key is not to be located at the joint in the clamp.

6. Tests in the manufacturer’s works

6.1 Testing of power units

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 Section 13, C.

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 **TL** Surveyor.

6.2 Pressure and tightness tests

Pressure components are to undergo a pressure test, using the following testing pressure:

$$p_{ST} = 1{,}5 \cdot p$$

p_{ST} = Testing pressure [bar]

p = Maximum allowable working pressure or pressure at which the relief valve is open however, for working pressures above 200 bar, the testing pressure need not exceed p + 100 bar

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

6.3 Final inspection and operational test

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of **TL** Surveyor. The overload protection is to be adjusted at this time.

F. Lateral Thrust Units

1. General

1.1 Scope

The following requirements apply to the lateral thrust unit, the control station and all the transmission elements from the control station to the lateral thrust unit.

1.2 Documents for review/approval

Assembly and sectional drawings together with detail drawings of the gear mechanism and propellers containing all the necessary data and calculations are to be submitted to **TL** for review/approval.

2. Materials

Materials are subject, as appropriate, to the provisions of B.2.2 and B.3.2.

3. Thruster tunnel

3.1 Scantlings and arrangements

The scantlings and arrangements of the thruster tunnel are to be in compliance with Section 9, A.7

4. Machinery and systems

4.1 Dimensions and design

4.1.1 The dimensional design of the driving mechanisms of lateral thrust units is to be in compliance with B.3. and B.4.

The dimensional design of the propellers is to comply with B.5.

The free end of the driving shaft from the non drive end bearing to the propeller is to be dimensionally designed as a propeller shaft in accordance with B.3.

4.1.2 The pipes for drive systems of lateral thrust units are to be of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to danger, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.
Hose lines comprise hoses and their fittings in a fully assembled and tested condition.

High pressure hose lines are to be used if necessary for flexible connections. These hose lines shall meet the requirements of C. or an equivalent standard. The hose lines shall 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 lines are to be flame resistant or to be protected correspondingly.

4.1.3 Lateral thrust units shall be capable of being operated independently of other connected systems.

4.2 Steering thruster control

Controls for steering thrusters are to be provided from the wheelhouse, machinery control station and locally.

Means are to be provided to stop any running thruster at each of the control stations.

A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

5. Electrical installations

5.1 General

Electrical installations of lateral thrust units are to comply with Section 13, H.2.

5.2 Cables

The cables are to be intended to supply a short-time load for up to one hour service.

5.3 Auxiliary machinery

5.3.1 Thruster auxiliary plants

The thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

6. Test in the manufacturer's works

6.1 Testing of power units

The power units are required to undergo a test on a test stand. The relevant manufacturers test certificates are to be presented at the time of the final inspection of unit.

For electrical motors, see Section 2.

Hydraulic pumps are to be subjected to pressure and operational tests.

6.2 Pressure and tightness tests

Pressure components are to undergo a pressure test, using the following testing pressure:

$$p_{ST} = 1,5 \cdot p$$

p_{ST} = Testing pressure [bar]

p = Maximum allowable working pressure or pressure at which the relief valve is open however, for working pressures above 200 bar, the testing pressure need not exceed p + 100 bar

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

6.3 Final inspection and operational test

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of **TL** Surveyor. The overload protection is to be adjusted at this time.

G. Domestic Gas Installations

1. General

1.1 Application

1.1.1 The following requirements 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 applicable requirements of Section 16.

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 to be submitted

Diagrammatic drawings including following information, are to be submitted to**TL**:

- 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 the state of the art.

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 shall 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 installation.

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 The pressure reducer, or in the case of two-stage reduction the first pressure reducer, 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 fireresistant 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 reducers

2.4.1 Gas-consuming appliances may be connected to receptacles only through a distribution system fitted with one or more reducing valves to bring the gas pressure down to the utilization pressure. The pressure may be reduced in one or two stages. All reducing valves shall be set permanently at a pressure determined in accordance with 2.5.

2.4.2 The final pressure reducers 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 reducing valve. It shall be ensured that in the event of a breach in the airtight 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 reducing 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 reducer 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 C.
However, pipes connecting with the receptacles shall be high-pressure flexible tubes or spiral tubes suitable for propane. Gas-consuming appliances may 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 unencumbered and fitted in such a way that they 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 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 reducer. It shall be ensured using a closing device that in pressure tests the pressure reducer 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 as to avoid any risk of accidental wrenching of the connecting pipes.

2.8.3 Heating and water-heating appliances and refrigerators shall be connected to a duct 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 control runs leading 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 nonflammable materials. Their operation shall not be affected by the ventilators.

4. Tests and trials

4.1 Definition

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 2.8.4, of the first reducing device and the valves fitted before the final pressure reducer:

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 utilization pressure between the closing device, referred to in 2.7.4, of the single pressure reducer or the final pressure reducer 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 single pressure reducer or the final pressure reducer 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 (b), 4.2.3 and 4.2.4, the pipes are deemed gastight if, after sufficient time to allow for normal balancing, no fall in the test pressure is observed during the following 10 minutes.

4.2.6 Receptacle connectors, piping and other fittings subjected to the pressure in the receptacles, and joints between the reducing valve 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 and tested at the nominal pressure to ensure that combustion is satisfactory with the regulating knobs in the different positions.

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 pressure, with windows and doors closed and the ventilation devices in operation, any combustion gases are escaping through the damper.

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.

H. Fire-Protection and Fire-Extinguishing

1. General

1.1 Scope

1.1.1 These Rules apply to fire-protection and fireextinguishing.

1.1.2 For fire detection, see Section 13, Table 13.16.

1.1.3 For additional requirements on fire protection on passenger vessels, see Section 15, D.3

1.1.4 For additional requirements on fire protection on tankers, see Section 16.

1.1.5 For additional requirements on fire protection on dry cargo vessels carrying dangerous goods, see Section 16.

1.2 Approval

Hoses, nozzles, fire-extinguishers, fire-detection and alarm systems, fire-protection equipment and extinguishing media shall have been approved. Exceptions to the Rules compatible with the statutory Regulations of the vessel's country of registration may be agreed with **TL**.

1.3 Documents for review/approval

Plans of the following equipment are to be submitted to**TL** at least in triplicate, where applicable:

- General water fire-extinguishing systems
- CO_2 extinguishing systems
- Other gas fire-extinguishing systems
- Foam extinguishing systems
- Fire-detection and alarm systems
- Fire control plan

  The plan shall clearly show for each deck the control stations, the various fire sections enclosed by class A and B divisions together with particulars of the fire-detection and alarm systems, the sprinkler installation, if any, the fireextinguishing appliances, means of access to the different compartments and the ventilation system including the location of fire dampers and fan control positions.

1.4 Definitions

1.4.1 The term "Type Approval" is defined in Section 1, A.1.2.15.

1.4.2 Non-combustible material

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 (see Note).

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 1, adopted by IMO by Resolution MSC.61 (67).

1.4.3 A-class divisions

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 type approved noncombustible 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 min

- Class A-30 30 min

- Class A-0 0 min

d) They are constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test (see Note)

Note :

Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61 (67).

1.4.4 B-class divisions

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 noncombustible 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 flamespread 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 min

- class B-0 0 min

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 (see Note)

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61 (67)."

1.4.5 Low flame spread surface material

Low flame spread means that the surface thus described will adequately restrict the spread of flame (see Note).

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 5, adopted by IMO by Resolution MSC.61 (67).

1.4.6 Not readily ignitable material

Not readily ignitable materials means a material which will not give rise to smoke or toxic and explosive hazards at elevated temperatures (see Note).

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 6, adopted by IMO by Resolution MSC.61 (67).

2. Fire protection

2.1 Installation of boilers

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 shall, 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.

2.2 Insulation of exhaust gas lines

See B.2.6.4.

2.3 Emergency stops, remotely operated

Fuel pumps, fan motors and boiler fans are to be equipped with emergency stops. The outlet valves of fuel service tanks shall be fitted with remotely operated shut-off devices. Emergency stops and remotely operated shut-off devices shall be capable of being operated from permanently accessible open deck and protected from unauthorized use.

2.4 Airtight seals

Means shall 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 shall also be able to be closed from outside.

2.5 Escapes

2.5.1 Every engine room 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 shall be possible to open it from the inside.

2.5.2 The escape trunk shall have clear dimensions of at least 0,6 x 0,6 m.

2.5.3 In case of engine rooms of less than 35 m^2 one means of escape may be accepted.

2.5.4 At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

3. Fixed fire-extinguishing system design

3.1 Automatic pressure water spraying system (sprinkler system)

3.1.1 General

Alternative systems complying with recognized standards may subject to approval be accepted.

3.1.2 Pressure water tanks

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 D. is to be applied.

The volume of the pressure water tank shall be equivalent to at least twice the specified pump delivery per minute.

The tank shall contain a standing charge of fresh water equivalent to at least the specified volume delivered by the pump in one minute.

The tank is to be fitted with a connection to enable the entire system to be refilled with fresh water.

The pressure water tank is to be installed in a frostproof space.

Means are to be provided for replenishing the air cushion in the pressure water tank.

3.1.3 Pressure water-spraying pumps

The pressure pumps may only be used for supplying water to the pressure water-spraying systems.

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.

The capacity of the pump shall be sufficient to cover the area of the greatest protected space at the pressure required for the spray nozzles.

The pump is to be provided with a direct suction connection at the vessel's side. The shut-off 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.

3.1.4 Location

Pressure water tanks and pressure water pumps are to be located outside, and at a sufficient distance from, the rooms to be protected.

3.1.5 Water supply

The system shall be completely charged with fresh water when not in operation.

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.

The equipment shall be kept permanently under pressure and shall 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.

3.1.6 Power supply

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.

3.1.7 Piping, valves and fittings

Lines between suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in C., Table 12.13. Lines shall be effectively protected against corrosion.

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.

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.

Each line leading to a section of the system is to be equipped with an alarm valve (see also 3.1.9).

Shut-off devices located between the pump delivery and the alarm valves are to be secured in the open position.

3.1.8 Spray nozzles

The spray nozzles are to be grouped into sections. A sprinkler section may extend only over one main fire section or one watertight compartment and may not include more than two vertically adjacent decks.

The spray nozzles are to be so arranged in the upper deck area that a water volume of not less than 5 $l/(m^2 \cdot min)$ is sprayed over the area to be protected.

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.

The nozzles are to be made of corrosion-resistant material. Nozzles of galvanized steel are not allowed.

3.1.9 Indicating and alarm systems

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 shall be permanently manned. In addition, each alarm valve is to be fitted with a pressure gauge and a test valve with an I.D. corresponding to a spray nozzle.

At the positions mentioned here above, an automatic indicating device is to be mounted which identifies the actuated sprinkler section.

The electrical installation shall be self-monitoring and shall be capable of being tested separately for each section.

3.2 Fixed gas fire-extinguishing systems

3.2.1 General

Fire-extinguishing systems, inert gas systems, CO_2 systems, etc. are to be installed after agreement with **TL** in accordance with the **TL** Rules.

Fire-extinguishing systems not dealt with in these Rules are to be in compliance with other **TL** Rules.

3.2.2 Application

The following requirements apply to fixed fireextinguishing systems for the engine room, boiler room, pump room and all spaces containing essential equipment (switchboards, compressors, etc.) for the refrigeration equipment, if any.

3.2.3 Extinguishing agents

The following extinguishing agents are permitted:

a) CO_2 (carbon dioxide)

b) HFC 227 ea (heptafluoropropane) (FM 200)

c) IG-541 (52 % nitrogen, 40 % argon, 8 % carbon dioxide) (INERGEN)

d) FK-5-1-12 (dodecafluoro-2-methylpentan-3-one) (NOVEC 1230)

Other extinguishing agents are permitted only on the basis of recommendations by the Administrative Committee.

The fixed fire-extinguishing systems according to b) and c) here above shall be type-approved by the class society (based on the requirements laid down in IMO MSC/Circ. 848).

If other extinguishing agents will be permitted, these fixed fire-extinguishing systems are to be type-approved by the class society as well.

3.2.4 Ventilation, air extraction

a) The combustion air required by the combustion engines which ensure propulsion should not come from spaces protected by permanently fixed fire-extinguishing systems. This requirement is not mandatory if the vessel has two independent main engine rooms with a gastight separation or if, in addition to the main engine room, there is a separate engine room installed with a bow thruster that can independently ensure propulsion in the event of a fire in the main engine room.

b) All forced ventilation systems in the space to be protected shall be shut-down automatically as soon as the fire-extinguishing system is activated.

c) All openings in the space to be protected which permit air to enter or gas to escape shall be fitted with devices enabling them to be closed quickly from outside the space to be protected. It shall be clear whether they are open or closed.

d) Air escaping from the pressure-relief valves of the pressurized air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.

e) Overpressure or negative pressure caused by the diffusion of the extinguishing agent shall not cause an unacceptable over- or under pressure in the space concerned. It shall be possible to ensure the safe equalization of pressure.

f) Protected spaces shall be provided with a means of extracting the extinguishing agent. If extraction devices are installed, it shall not be possible to start them up during extinguishing.

3.2.5 Fire-detection system

The space to be protected shall be monitored by an appropriate type-approved fire-detection system. The alarm signal shall be audible in the wheelhouse, the accommodation and the space to be protected.

3.2.6 Piping system

a) 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 and type approved. Piping shall be protected against corrosion both internally and externally.

b) The discharge nozzles shall be so arranged as to ensure the regular diffusion of the extinguishing agent, also below the floor plates.

3.2.7 Triggering device

a) Automatically activated fire-extinguishing systems are not permitted.

b) It shall be possible to activate the fireextinguishing system from outside the space to be protected.

c) 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-EXTINGUISHING SYSTEM

d) If the fire-extinguishing system is intended to protect several spaces, it shall comprise a separate and clearly marked triggering device for each space.

e) 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, they are to be at least in English, n addition.

They shall include information concerning:

- the activation of the fire-extinguishing system
- the need to ensure that all persons have left the space to be protected
- the correct behaviour of the crew in the event of activation
- the correct behaviour of the crew in the event of the failure of the fire-extinguishing system to function properly

f) 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. All ventilation inlet and outlet openings shall be closed prior to the activation of the fire-extinguishing system.

3.2.8 Alarm device

a) Permanently fixed fire-extinguishing systems shall be fitted with an audible and visual alarm device.

b) The alarm device shall be activated 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.

c) 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.

d) 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.

e) 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.

f) 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-EXTINGUISHING
SYSTEM!

LEAVE THIS SPACE IMMEDIATELY
WHEN THE … (DESCRIPTION) ALARM IS
ACTIVATED!

3.2.9 Pressurized tanks, fittings and piping

a) Pressurized tanks, fittings and piping shall conform to the requirements of the competent authority.

b) Pressurized tanks shall be installed in accordance with the manufacturer's instructions.

c) Pressurized tanks, fittings and piping shall not be installed in the accommodation.

d) The temperature of cabinets and storage spaces for pressurized tanks shall not exceed 50 °C.

e) 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.

3.2.10 Quantity of extinguishing agent

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.

3.2.11 Fire-extinguishing system operating with CO_2

In addition to the requirements contained in 3.2.1 to 3.2.10, fire-extinguishing systems using CO_2 as an extinguishing agent shall conform to the following provisions:

a) 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: danger", not less than 5 cm high and "CO_2" in the same colours and the same size.

b) 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.

c) The level of filling of CO_2 tanks shall not exceed 0,75 kg/l. The volume of depressurized CO_2 shall be taken to be 0,56 m^3/kg.

d) The concentration of CO_2 in the space to be protected shall be not less than 40 % of the gross volume of the space. 85 % of this quantity shall be released within 120 seconds. It shall be possible to monitor whether diffusion is proceeding correctly.

e) The opening of the tank valves and the opening of the directional valve shall correspond to two different operations.

f) The appropriate period of time mentioned in 3.2.8 b shall be not less than 20 seconds. A reliable installation shall ensure the timing of the diffusion of CO_2.

3.2.12 Fire-extinguishing system operating with HFC-227 ea (heptafluoropropane) - FM 200

In addition to the requirements of 3.2.1 to 3.2.10, fireextinguishing systems using HFC-227 ea as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system.

b) 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.

c) Every tank shall be fitted with a device permitting control of the gas pressure.

d) The level of filling of tanks shall not exceed 1,15 kg/l. The specific volume of depressurized HFC-227 ea shall be taken to be 0,1374 m^3/kg.

e) The concentration 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.

f) 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.

g) After discharge, the concentration in the space to be protected shall not exceed 10,5 % (volume).

h) The fire-extinguishing system shall not comprise aluminium parts.

3.2.13 Fire-extinguishing system operating with IG-541

In addition to the requirements of 3.2.1 to 3.2.10, fireextinguishing systems using IG-541 as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, every space shall be equipped with its own fire-extinguishing system.

b) 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.

c) Each tank shall be fitted with a device for checking the contents.

d) The filling pressure of the tanks shall not exceed 200 bar at a temperature of +15 °C.

e) 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.

3.2.14 Fire-extinguishing system operating with FK-5-1-12

In addition to the requirements of 3.2.1. to 3.2.10, fire-extinguishing systems using FK-5-1-12 as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system.

b) 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.

c) Every tank shall be fitted with a device permitting control of the gas pressure.

d) 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 m3/kg.

e) The concentration 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.

f) 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.

g) After discharge, the concentration in the space to be protected shall not exceed 10,0 % (volume).

4. General water fire-extinguishing system

4.1 Fire pumps

4.1.1 Self-propelled vessels are to be equipped with a power-driven pump suitable for use as a fire pump.

4.1.2 The capacity of the fire pump, acting through fire mains and hoses, shall 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 shall be 10 m3/h.

4.1.3 The pump shall have a drive independent of the main propulsion unit. On vessels with a gross volume ($L \cdot B \cdot D$) 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.

4.1.4 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.

4.1.5 Fire pumps are to be located aft of the forward collision bulkhead.

4.1.6 Outboard connections for fire pumps are to be located as deep as possible. Pump suction shall be safeguarded even in lightship condition.

4.2 Fire mains and hoses

4.2.1 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. At least three hydrants are to be provided.

For vessels less than 40 m in length, at least two hydrants are to be provided.

Deck-washing lines may be incorporated in the fireextinguishing system.

4.2.2 Hoses shall be able to be connected to the fire mains via fire hydrants and quick couplings.

4.2.3 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.

4.3 Water fire-extinguishing systems for vessels without self-propulsion

Where a water fire-extinguishing system is provided on a vessel without self-propulsion, the rules set out in 4.1 and 4.2 are to be applied as appropriate.

5. Portable fire-extinguishers

5.1 Extinguishing media and weights of charge

5.1.1 Fire-extinguishers shall have been type-approved or approved by Authorities.

5.1.2 In the case of water and foam extinguishers, the charge shall not be less than 9 l and not more than 13,5 l.

The weight of the charge in dry powder extinguishers should be at least 6 kg. The maximum weight of a portable fire extinguisher ready for use shall not exceed 20 kg.

5.1.3 The extinguishing agent shall 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.

On vessels with electrical installations having an operating voltage greater than 50 V, the extinguishing agent shall also be suitable for fighting fire in electrical equipment.

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, B and C fires.

5.1.4 As extinguishing agent, fire-extinguishers may contain neither CO_2 nor agents capable of emitting toxic gases in use.

Nevertheless, CO_2 extinguishers may be used for galleys and electrical installations.

5.1.5 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.

5.1.6 Where fire-extinguishers are mounted under cover, the covering shall be properly marked.

5.2 Number of portable fire-extinguishers

5.2.1 One portable fire-extinguisher each is to be provided:

- In the wheelhouse
- At each entrance from the deck to accommodation areas
- At 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

5.2.2 In the part of machinery spaces situated below deck and containing internal combustion engines, additional fire extinguishers are to be mounted in such a way that an extinguisher is accessible in the immediate vicinity of any part of the room.

The number of additional fire-extinguishers shall be as indicated in Table 12.23.

Table 12.22 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

Table 12.23 Portable fire-extinguishers in machinery space

Total power [kW]	Number of fire-extinguishers
Over 100 up to 375	1
up to 750	2
over 750	1 further extinguisher for each additional 750 kW or part thereof

I. Tests on Board

1. General

1.1 Application

The following covers onboard tests, both at the moorings and during river trials. Such tests are additional to the workshop tests required in the other Subsections.

1.2 Purpose of onboard tests

Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in particular in respect of the criteria imposed by the Rules. The tests are to be witnessed in the presence of a **TL** Surveyor.

1.3 Documentation to be submitted

A comprehensive list of the shipboard tests intended to be carried out by the shipyard is to be submitted to **TL**. For each test, the following information is to be provided:

- Scope of the test
- Parameters to be recorded

2. General requirements for shipboard tests

2.1 Trials at the moorings

Trials at the moorings are to demonstrate the following:

a) Satisfactory operation of the machinery in relation to the service for which it is intended

b) Quick and easy response to operational commands

c) Safety 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, **TL** reserves the right to require the repetition of the trials at the moorings, either wholly or in part, 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 the following:

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 **TL** in the case of vessels having a sister ship for which the satisfactory behaviour 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. Shipboard tests for machinery

3.1 Conditions of river trials

3.1.1 Displacement of the vessel

Except in cases of practical impossibility, or in other cases to be considered individually, the river trials are to be carried out at a displacement as close as possible to the deadweight (full load) or to one half of the deadweight (half load).

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 and gas turbines, 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 **TL**.

As an alternative, for reciprocating internal combustion engines and gas turbines, 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 **TL** on a case-by-case basis.

3.2 Navigation and manoeuvring tests

3.2.1 Speed trials

a) Where required, the speed of the vessel is to be determined using procedures deemed suitable by **TL**.

b) The vessel speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.2.2 Astern trials

a) 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.

b) The stopping times, vessel headings and distances recorded on trials, together with the results of trials to determine the ability of vessels having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, shall be available on board for the use of the Master or designated personnel.

c) Where the vessel is provided with supplementary means for manoeuvring or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b).

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, etc.

b) Where the machinery installation is designed for residual or other 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 n0 for at least 2 hours

b) Operation at engine speed corresponding to normal continuous cruise power for at least 1 hours

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.

Notes

- *The test in c) is to be performed only where permitted by the engine adjustment.*

- *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 river trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of 3.3.1.

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 hours

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

Notes

- *The test in d) may be performed during the dock or river trials.*

- *The above tests a) to f) are to be performed at rated speed (with a constant governor setting).*
The powers refer to the rated electrical powers 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 hours.

b) It is to be demonstrated that the engine is capable of supplying 100 % of its rated power and, in the case of shipboard generating sets, account is to be taken of the times needed to actuate the generator's overload protection system.

3.4 Tests of gears

3.4.1 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

- test of the monitoring, alarm and safety systems

3.4.2 Check of the tooth contact

a) Prior to the start of river trials, the teeth of the gears belonging to the main propulsion plant are to be coloured with suitable dye to enable the contact pattern to be established. During the river trials, the gears are to be checked at all forward and reverse speeds to establish their operational efficiency and smooth running as well as the bearing temperatures and the pureness of the lubricating oil. At latest on conclusion of the river trials, the gearing is to be examined via the inspection openings and the contact pattern checked. If possible the contact pattern has to be checked after conclusion of every load step. Assessment of the contact pattern is to be based on the guide values for the proportional area of contact in the axial and radial directions of the teeth given in Table 12.24 and shall take account of the running time and loading of gears during the river trial.

b) In the case of multistage gear trains and planetary gears manufactured to a proven high degree of accuracy, checking of the contact pattern after river trials may, with the consent of **TL**, be reduced in scope.

Table 12.24 Percentage area of contact

Material Shaping of teeth	**Working depth (without tip relief)**	**Width of tooth (without end relief)**
heat-treated, hobbed, formed by generating method	33 % average values	70 %
surface-hardened, gound, shaved	40 % average values	80 %

3.5 Tests of main propulsion shafting and propellers

3.5.1 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by B.5. The type of the measuring equipment and the location of the measurement points are to be specified.

3.5.2 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in 3.1.2

3.5.3 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage at the stern tube seal.

3.5.4 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 sea trials.

3.6 Tests of piping systems

3.6.1 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.

3.6.2 Performance tests

TL reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.7 Tests of steering gear

3.7.1 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 E. 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 **TL**. In such case, the vessel speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.7.2 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 E.4.2 and E.4.3

b) **T**est 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 required by E.4.4

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.

Notes

- *Tests d) to i) may be carried out either during the mooring trials or during the river trials.*

- *For vessels of less than 500 tons gross tonnage, **TL** may accept departures from the above list, in particular to take into account the actual design features of their steering gear.*

- *Azimuth thrusters are to be subjected to the above tests, as far as applicable.*

3.8 Tests of windlasses

3.8.1 The working test of the windlass is to be carried out in the presence of a Surveyor.

3.8.2 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 B.7.4 can be fulfilled.

4. Inspection of machinery after river trials

4.1 General

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, **TL** may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to **TL** for information.

4.2 Diesel engines

a) In general, for all diesel engines, the following items are to be verified:

- the deflection of the crankshafts, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine

- 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.

SECTION 13

ELECTRICAL INSTALLATIONS

A. General

1. General

1.1 Scope

These Construction Rules apply to electrical installations aboard inland vessels as well as on other water craft and floating gear on inland waters. **TL** reserves the right to authorize departures from these Rules in individual cases or to stipulate special requirements for new types of installation or operating equipment.

1.2 Rules and standards

Beside these Rules electrical equipment shall meet a standard approved by **TL** such as IEC and EN.

1.3 Basic requirements

1.3.1 All electrical machinery, appliances, cables and accessories are to be selected, designed and constructed for satisfactory performance under the conditions stated in Table 13.1.

Where other conditions are likely (e.g. in the case of inland vessels for non-European waters) proper account shall be taken of these.

Table 13.1 Working conditions

Conditions	
Permanent list to port or starboard **(1)**	12°
Permanent trim **(1)**	5°
Ambient temperature	40 °C
(1) *May occur simultaneously*	

Ambient temperature inside 0 to +40°C

Ambient temperature on open decks -20 to +40°C

For vessels built in line with the EU Directive 2006/87/EC the equipment shall be designed for permanent lists of up to 15°.

1.3.2 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 shipboard service. Unless other wise specified, considerations may be based on the variations shown in Table 13.2.

Networks or sub-networks with greater voltage variations may be approved for consumers intended for operation with greater variations.

Table 13.2 Voltage and frequency variations

	Variable	**Variations**	
		Permanent	**Transient**
General	Frequency	± 5 %	± 10 % 5 s
	Voltage	+ 6 % - 10 %	± 20 % 1,5 s
Battery operation	Voltage	± 20 %	-

1.3.3 In equipment with electronic frequency converters, the voltage waveform may deviate from that specified in B.5.2.1 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.

The total harmonic distortion shall be less than or equal to 5 %.

1.3.4 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.

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.

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.

1.3.5 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.

1.4 Protective measures

1.4.1 Protection against shock and water

The type of protection or enclosure of every machine and every other item of equipment shall be compatible with the site where it is installed. The particulars in Table 13.3 are minimum requirements.

1.4.2 Protection against electric shock: direct

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.

1.4.3 Protection against electric shock: 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 1.4.4)

- 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.

1.4.4 Protective earthing

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.

Special earthing may be dispensed 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

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.

For the earthing of metal sheaths, armouring and cable braiding, see L.15.1.4.

Protection shall be provided by an additional cable, an additional lead or an additional core in the power cable.

Table 13.3 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 instrument**	**Switchgear**	**Installation material**	**Lamp fittings**
Service spaces, machinery and steering gear spaces	IP 22	IP 22	IP 22	IP 22 **(1),(4)**	IP 22	IP 22 **(1),(4)**	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 **(5)** and (EX)
Ventilating trunks (deck)		IP 44					IP 55	
Exposed deck, steering stations on open deck		IP 55 **(3)**		IP 55 **(3)**	IP 55 **(3)**	IP 55 **(3)**	IP 55 **(3)**	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 **(2)**	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 laid behind ceiling.*
(3) *IP 56 for appliances subject to flooding.*
(4) *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.*
(5) *Electrical appliance of certified safety, e.g. in accordance with IEC Publication 60079 or EN 50014-50020.*

Table 13.4 Cross-section of earthing conductors

Cross-section of main conductors [mm²]	Minimum cross-section of earthing conductor	
	Earthing conductor incorporated in the cable [mm²]	Earthing conductor separated from the cable [mm²]
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

Metal cable armouring may not be used as an earthing conductor.

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.

The cross-section of the earthing conductor shall be at least in accordance with Table 13.4.

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.

The casings of mobile power consumers and portable devices shall, during normal operation, be earthed by means of an additional earthing conductor, that is incorporated into the power cable. That provision shall not apply where a protective circuit separation transformer is used, nor to appliances fitted with protective insulation (double insulation).

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.

1.4.5 Explosion protection: 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 **TL**

1.4.6 Explosion protection: 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 below 60 °C, or inflammable gases, see 1.4.10
- Ventilation trunks

Areas subject to explosion hazard zone 1 also include tanks, vessels, heaters, pipelines, etc. for liquids or fuels with a flash point over 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 **TL**. Notes and restrictions at the certificate have to be observed.

Certified safe type equipment listed in Table 13.5 is permitted.
Cables in hazardous areas zone 0 and 1 shall be armoured or screened, or run inside a metal tube.

1.4.7 Explosion protection: 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

Table 13.5 Certified safe type equipment

Permitted 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

1.4.8 Explosion protection: 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 1.4.6 and comply at least with II B, T3.

Switches, protective devices and motor switchgear for electrical equipment in these areas shall be of allpoles switchable type and shall preferably be fitted in the safe area.

Doors to paint rooms have to be gastight with selfclosing devices without holding back means.

1.4.9 Protective measures in the case of ignitable dust

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.

1.4.10 Explosion protection: 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 below 60 °C, e.g. in ore or oil carriers, or where pipes inside these tunnels convey combustible liquids with a flash point below 60 °C, all the equipment and devices in pipe tunnels shall be certified explosion-protected in accordance with 1.4.6 (zone 1).

1.4.11 Amount of electrical facilities

Amount and ignition protection of approved electrical equipment in zones 0,1 and 2 may be restricted in the different areas where they are used. The relevant current construction Rules have to be observed for this reason.

1.4.12 Explosion protection on tankers

Regarding hazardous areas and approved electrical equipment on tankers see Section 16.

1.4.13 Explosion protection for vessels for the carriage of dangerous goods

Regarding hazardous areas and approved electrical equipment on vessels for the carriage of dangerous goods, see Section 16.

1.4.14 Batteries room

See E.

1.4.15 Electromagnetic compatibility (EMC)

Where necessary, appropriate measures shall be taken to avoid interference due to electromagnetic energy.

This applies especially to radio equipment and electronic appliances (e.g. self-steering gear for river navigation).

Details are contained in IEC 60533.

2. Documents for review/approval

2.1 New buildings

2.1.1 The drawings and documents listed below are to be submitted to **TL** for examination in sufficiently good time to enable them to be reviewed/approved and made available to the Building Yard and the Surveyor by the time the manufacture or installation of the electrical equipment begins.

Where non-standard symbols are used in circuit and wiring diagrams, a legend explaining the symbols is to be provided.

All documents for review/approval shall bear the yard number and the name of the shipbuilder.

TL reserves the right to call for additional documents and drawings should those stipulated in 2.1.2 to 2.1.9 prove insufficient for an assessment of the plant.

2.1.2 Details of the nature and extent of the electrical installations including the power balance (electrical balance).

2.1.3 A general circuit diagram of the electrical plant showing the basic configuration of the power distribution system with details of the power ratings of generators, converters, transformers, storage batteries and all major consumers.

2.1.4 Cable layout or tabulated list of cables showing cable sections and types as well as generator and consumer loads (currents).

2.1.5 Circuit diagrams for:

- Main switchgear installations
- Emergency switchgear installations (where applicable)
- Spaces with an explosion hazard with details of installed equipment
- Lighting system
- Navigation light system
- Electrical propulsion plants, where applicable

2.1.6 Circuit diagrams of control, alarm and monitoring installations, where applicable, such as:

- Alarm systems
- Fire alarm systems
- Tank level indicators, alarms, shut-off facilities
- Gas detector systems
- Emergency shut-off facilities
- Watertight door control systems
- Computer systems
- Communication systems
- Propulsion system

2.1.7 Steering gear circuit diagrams with details of the drive, control and monitoring systems. The steering gear includes lateral thrust propellers, active rudder equipment etc.

2.1.8 Installation plan

The plan is to provide details of the exact location of the switchboard, the size of service passageways, distances from bulkheads and frames etc.

2.1.9 For tankers carrying cargo with a flash point of ≤ 61 °C additional plans are to be submitted which shall show the following:

- The installation sites of all electrical equipment
- The limits of the cargo area with differentiation of those parts of the installation situated above and below deck
- Machines and equipment whose use is forbidden during loading, unloading and gas-freeing are to be marked in red
- Details in line with Section 16 are to be observed.

3. Systems, Voltages and Frequencies

3.1 Systems

3.1.1 As a general principle, systems listed in 3.1.2 to 3.1.4 are permitted.

3.1.2 For direct current and single-phase alternating current:

- 2 conductors, one of which is earthed
- Single conductors with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)
- 2 conductors insulated from the vessel's hull

3.1.3 For 3-phase alternating current:

- 4 conductors with earthed neutral and no hull return
- 3 conductors insulated from the hull
- 3 conductors with hull as neutral conductor, however, not in final subcircuits.

3.1.4 Other systems have to be approved by **TL** in each case.

3.1.5 Special rules

Systems using the hull as neutral conductor are not permitted:

- On tankers (see Section 16.)
- On floating craft or vessels whose hull can be dismantled.

3.2 Voltage and frequencies

3.2.1 Standard voltages

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.

3.2.2 Operating voltages

The operating voltages indicated in Table 13.6 may not be exceeded.

In special installations (e.g. radio equipment, specific power systems, ignition equipment) higher voltages are permitted subject to compliance with the necessary safety measures.

4. Type approvals

4.1 General

4.1.1 The installations, equipment and assemblies mentioned in 4.1.5 are subject to mandatory type approval.

4.1.2 Type tests shall be carried out in the presence of a **TL** Surveyor either in the manufacturer's works or, by agreement, in suitable institutions.

4.1.3 Type tests are carried out according to the **TL** Rules for approval of equipment.

Table 13.6 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	500 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	500 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	500 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*

4.1.4 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.

4.1.5 Installations, apparatuses and assemblies subject to type testing

Following installations, apparatuses and assemblies are subject to type testing:

- Steering gear electronic control systems

- Variable pitch propeller electronic control systems

- Main engine electronic control systems for speed and power

- Fire detection- and alarm systems on passenger vessels

- Tank level gauging equipment on tankers

- Computer systems with Requirement Class 3 and higher

4.2 Exceptions

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 **TL** prior to testing is required.

B. Design and Construction of Power Generating Plant

1. General requirements

Every power supply system on inland vessels shall comprise at least one main and one auxiliary power source.

2. Power source

2.1 Design

The power source may take the form of:

a) Two diesel sets. Special restrictions for the supply of steering gear systems see H.1.4.8.

b) One diesel set and one power supply battery (in accordance with 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 **TL**.

Note: *For installation and safety requirements of lithium batteries used for propulsion or as part of a hybrid propulsion system, refer to the* ***TL*** *rules "Additional Rules for Certification, Installation and Testing of Lithium Batteries".*

3. Power balance

3.1 Power requirements

A power balance for the electrical plant shall be furnished as proof that the generator rating is sufficient.

The power requirements are to be determined for day/night running service and emergency supply, if any.

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.

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.

The sum of the loads represented by a) and c), with due allowance for the battery charging capacity, is to be used when deciding the generator rating.

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.

4. Emergency power source on passenger vessels

4.1 General

For emergency power sources on passenger vessels, see Section 15, D.4.

5. Generator ratings control

5.1 DC generators

5.1.1 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

5.1.2 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 shortcircuit 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 networkis assured at even lower sustained short-circuit currents, possibly in conjunction with a parallelconnected 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.

5.2 Single and 3-phase AC generators

5.2.1 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 paralel 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.

5.2.2 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 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 steadystate 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.

5.2.3 Three-phase AC generators for paralel operation

Where generators of the same output are run in paralel 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.

6. Generator prime movers

6.1 Design and control

The design and control of generator prime movers are to conform to Section 12, B.

6.2 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.

6.3 Cyclic irregularity

The permissible cyclic irregularity is to be agreed upon between the prime mover and generator manufacturers.

The following has 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

7. Special rules

7.1 General

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.

C. Electrical 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 **TL**.

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 Table 13.7 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 cut-outs.

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.

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.

1.1.7 Generators driven by the main engine, the propeller shaft or by an auxiliary set intended for other purposes shall be designed with respect to the range of rotational speeds which can occur during normal operation.

2. Testing of electrical machines

2.1 Works test 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, Works test 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 steadystate 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 Table 13.7 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 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 Table 13.7.

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:

Table 13.7 Permitted temperature-rises of air cooled machines at an ambient temperature of 40 °C (difference values in K)

No	Machinery component	Method of measurement (3)	Installation class A	E	B	F(1)	H (1)
1	AC windings of machines	R	60	75	80	105	125
2	Commutator windings	R	60	75	80	105	125
3	Field windings of AC and DC machines with DC excitation, other than those specified under 4	R	60	75	80	105	125
4	a) Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors	R			90	110	130
	b) Stationary field windings of DC machines having more than one layer	R	60	75	80	105	125
	c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one laye	R Th	60	75	80	100	120
	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	R Th	60	80	90	110	130
5	Permanently short-circuited, insulated windings	Th	60	75	80	100	120
6	Permanently short-circuited, uninsulated windings	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					
7	Iron cores and other parts not in contact with windings						
8	Iron cores and other parts in contact with windings	Th	60	75	80	100	120
9	Commutators and slip rings, open or closed	Th	60	70	80	90	110
10	Plain bearings – measured in the lower bearing shell or in the oil sump after shut-down		50				
11	Roller bearings Roller bearings with special grease – measured in the lubrication nipple bore or near the outer bearing seat		50 80				
12	Surface temperature		Reference 40 **(2)**				

(1) *The values may need correction in the case of high-voltage AC windings*

(2) *Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidently touched and there is a risk of burns (> 80 °C), the Society resrves the right to request means of protection such as a handrail to prevent accidental contacts*

(3) *R = resistance method*

Th = thermometer method

Table 13.8 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 [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-cicuited (e.g. if intended for rheiostatic starting) a) for non-reversing motors or motors reversible from standsill only	 1000 + twice the open-circuit standsill 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 cicuit secondary voltage as defined in item 5a)
6	Exciters (exception below) a) Exception 1 Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting	As for the windings to which they are connected twice rated exciter voltage + 1000, with a minimum of 1500
	b) Exception 2 Separately excited field windings of exciters	as under item 3

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.

2.2.4 Short-circuit test on 3-phase AC generators

a) On all synchronous generators, the steady shortcircuit current shall be determined with the exciter unit in operation (see B.5.2.2 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 Table 13.8.
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 Table 13.8.

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 noload 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 tested at the manufacturer's works in the presence of a Surveyor.

TL 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.

D. Transformers and Reactors

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 **TL**'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.

E. Storage Batteries

1. General

1.1 Application

1.1.1 These regulations apply to permanently installed storage batteries.

1.1.2 Only storage batteries suitable for vessels use can be used.

1.1.3 For installation and safety requirements for lithium battery electrical storage systems, refer to the **TL** rules "Additional Rules for Certification, Installation and Testing of Lithium Batteries".

2. Design and construction of cells

2.1 General

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 information for proper maintenance and operation.

4. Installation and location

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 6.3.

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 **TL**.

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. Ventilation

6.1 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.

6.2 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 the 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.

6.3 Ventilated spaces, battery 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, provided that they are protected against falling objects and dripping water. The charging power for automatic IU-charging should be calculated as follows:

$P = U.I$

$I = 8.C/100$ for Pb - batteries

$I = 16 \cdot C/100$ for NiCd - batteries

P = Charging power [W]

U = Rated battery voltage [V]

I = Charging current [A]

C = Rated battery capacity [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 should be calculated depending on battery size as follows:

$V = 2{,}5 \cdot Q$

V = Free air volume [m^3]

Q = Air quantity [m^3/h]

$= 0{,}25 \cdot f \cdot I \cdot x \cdot n$

n = Number of battery- cells in series connection

f = 0,03 for lead batteries (VRL) with solid electrolyte

= 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 crosssection as follows, assuming an air speed of 0,5.m/s:

$A = 5{,}6 \cdot Q$

A = Cross section [cm^2]

The required minimum cross-sections of ventilation ducts are shown in Table 13.9.

Small air ducts and dimensions of air inlet and outlet openings should be calculated based on lower air speed (≤ 0,5.m/s).

6.4 Ventilated rooms, battery 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 selfclosing devices without holding back means.

6.5 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.

6.6 Forced ventilation

If natural ventilation is not sufficient or required crosssections of ducts according to Table 13.9 are too big, forced ventilation shall be provided. The air quantity Q shall be calculated according to 6.3. 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.

7. Warning signs

7.1 General

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.

8. Starter batteries

8.1 General requirements

8.1.1 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.

8.1.2 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.

8.1.3 Starting internal combustion engines with the vessel's supply battery is permitted only in emergencies.

Table 13.9 Cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU- charging)			
Battery charging power	**Cross-section [cm^2]**		
[W]	Lead battery solid electrolyte VRL	Lead battery fluid electrolyte	Nickel-Cadmium battery
< 500	40	60	80
500 < 1000	60	80	120
1000 < 1500	80	120	180
1500 < 2000	80	160	240
2000 < 3000	80	240	forced ventilation
> 3000	forced ventilation		

8.1.4 Wherever possible storage batteries used for starting and preheating internal combustion engines are to be located close to the machines.

9. Rating of storage battery chargers

9.1 General requirements

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.

Battery chargers with a rated power of 2 kW upwards have to be tested in manufacturer’s works in the presence of the **TL** Surveyor.

F. Power Distribution

1. Subdivision of the distribution network

1.1 General

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

2. Hull return

2.1 General

In systems using hull return, the final subcircuits for space heating and lighting are to be insulated on all poles. 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. 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. 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. 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 crosssections. The smallest permissible size is M 6.

3. Final subcircuits

3.1 General

3.1.1 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 subcircuit shall not exceed the following maxima:

3.1.2 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.

3.1.3 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.

Table 13.10 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

4. Navigation lights and signal lamps

4.1 General

4.1.1 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.

4.1.2 Navigation light, each shall be individually supplied, protected and controlled from the navigation lights switchboard.

4.1.3 The navigation lights switchboard may be enlarged to provide connections for other signal lamps. No other consumers may be connected to this switchboard.

4.1.4 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. However it shall not be possible to use both light sources in a double light (two lights mounted one above the other or in the same housing) simultaneously.

4.1.5 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.

4.1.6 Navigation lights shall be designed for the standard voltages: 24 V, 110 V or 220 V.

4.1.7 The voltage at the lamp socket shall not permanently deviate by more than 5 % above or below the standard voltages mentioned in 4.1.6.

5. Shore connection

5.1 General

5.1.1 Shore line terminal containers are to be connected to the main switchboard by a permanently laid cable. The shore connection is to be protected against short-circuit and overload 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 paralel with the shore mains or another external network. A brief period of concurrent operation shall be permitted when changing from one system to another without break in voltage.

5.1.2 When using plug-type shore connectors with a current rating of more than 16 A, an interlocking device with switch is to be fitted so that the connection on board can only be made in the dead condition.

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. 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.

5.1.3 The main switchboard is to be equipped with an indicator showing whether the shore connection cable is live.

5.1.4 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-over switch is recommended.

5.1.5 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

- Concerning measures to be taken for the shore connection

5.1.6 To reduce the load on the terminals, the shore line is to be provided with a tension relief device.

5.1.7 Only flexible, oil-resistant and flame retardant cables are to be used as feeder cables.

6. Power supply to other vessels

6.1 General

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 50V and/or currents of more than 16 A are transmitted, it is necessary to ensure that the connection 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 de-energized 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.

G. Switchgear Installations and Switchgear

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. Terminals for voltages up to 50 V, and those for voltages higher than 50 V, shall be kept separately and marked appropriately.

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 A.1.4).

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 crosssections 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, shortcircuits.

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 Installation of switchboards

1.2.1 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 floor plates 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 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.

The materials of switchboard shall have suitable mechanical strength and be durable, flame retardant and self-extinguishing, they shall not ne hygroscopic.

1.2.2 A service passageway of not less than 0,5 m behind the switchboard is called for only when required by its construction or maintenance.

1.2.3 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.

1.3 Distribution boards

1.3.1 The Rules set out in 1.1 apply in analogous manner.

1.3.2 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.

1.3.3 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.

1.3.4 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.

1.3.5 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.

1.4 Switchboard testing

1.4.1 Before being installed on board, every switchboard together with all its equipment is to be subjected to the following test (1.4.2 to 1.4.4).

1.4.2 A test at the manufacturer's works in the presence of a **TL** 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. **TL** 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 Table 13.11.

Measuring instruments and other ancillary equipment may be disconnected during the test.

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 Megohm.

Table 13.11 Test voltages for main circuits

Rated insulation voltage U_i [V]	Test voltage A.C. (r.m.s) [V]
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 690$	2500

2. Switchgear

2.1 General

As a general principle, switchgear shall be designed and constructed in accordance with standard IEC, EN or to other standards recognized by **TL**.

2.2 Selection of switchgear

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

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 **TL** 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. If high rupture capacity (HRC) fuses are installed in electrical switchboards, accessories and personal protective equipment shall be available for installing and removing such fuses.

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 shortcircuit 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 prime-mover 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

The following equipment is to be provided in addition to the switchgear and protective devices specified above 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 de-energized. 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 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) maxim*u*m, 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 shortcircuit trip is to have a short time delay of up to about 200 ms.

b) A polarity-reversing facility, if necessary.

3.3.2 Switchgear and protective devices for paralel 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 nodelay 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 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

On-load switches, power circuit breakers and, generally speaking, reverse-current cut-outs 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

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. Vibrating reed instruments with 21 reeds are recommended.

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 multicircuit instruments with changeover switch. The rated service values are to be marked in red on the scales of all instruments.

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) 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 for DC generator here above.

3.6.3 Special rules

Instead of the ammeter and the blue pilot light specified in b), a charging pilot light may be provided for installations with an output of up to 10 kW/ kVA and a voltage of ≤ 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 cut-outs):

- 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 ohms per volt of the network voltage.

With a full earth fault the measuring current may not exceed 30 mA.

3.6.7 For vessels built in line with the EU Directive 2006/87/EC, monitoring equipment giving audible and visual alarm signals is mandatory.

3.7 Transformer protection

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

Motors rated at more than 1 kW shall be individually protected against overloads and short circuits.

For steering gear motors see H.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

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 the above Rules. 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 H.1. Automatic cut-outs 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 cut-outs without selectively staggered disconnecting delay may not be arranged in series.

3.10 Storage battery protection

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 Table 13.13 and Table 13.14, column 3, or of power circuit breakers with suitably adjusted short-circuit protection.

3.11 Protection of measuring instruments,

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

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

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

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

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.

H. Steering Gears, Lateral Thrust Propeller Systems and Active Rudder Systems

1. Steering gear

1.1 General requirements

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 Section 12, E.

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.

Note
For definition of service factor S, see IEC 60024.

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 the 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 **TL**'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

An indicator light showing that the autopilot 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

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 abovementioned system.

2. Lateral thrust propellers and active

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.

I. Electric Heating Appliances

1. General

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).

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.

2. Space heaters

2.1 Arrangement of heaters

2.1.1 No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

2.1.2 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.

2.1.3 Only waterproof heaters according to IEC 60335 may be used in washrooms, bathrooms and other damp spaces as well as in machinery spaces.

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.

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 G.4.2

2.4 Electrical equipment of heaters

2.4.1 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.

2.4.2 Self-regulating material in heating elements may be dispensed with.

2.4.3 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.

2.4.4 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.

3. Oil and water heaters

3.1 General

See Section 12, D.

4. Electric ranges and cooking equipment

4.1 Cooking plates

Only enclosed-type cooking plates may be used.

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 G.4.2 are applicable.

J. Lighting Installations

1. General

1.1 Lighting installations are to be designed in compliance with the paragraphs listed below:

- A.3.2, Voltages and frequencies
- F.3.1, Final subcircuits
- F.4.1, Navigation lights
- A.1.4.2, A.1.4.3 and A.1.4.5 to A.1.4.13, Explosion proofing
- For additional requirements on lighting installations on passenger vessels, see Section 15, D.5.7

2. Design of lighting installations

2.1 The number of lamps and their distribution shall be such as to ensure satisfactory illumination.

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.

2.3 Wherever possible, separate circuits are to be provided for plug sockets.

2.4 The use of normal shore type light fittings is permitted in accommodation, day rooms and commissary spaces provided that they comply with the Rules contained in 3.

3. Design of lighting fixtures

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.

3.2 The temperature of lighting fixtures should not exceed 60 °C where they can be touched easily.

3.3 Heat-resistant leads are to be used for the internal wiring of lamp-holders.

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.

3.5 Every lighting fixture shall be permanently marked with the maximum permissible wattage of the lamps to be fitted.

4. Mounting of lighting fixtures

4.1 General

4.1.1 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.

4.1.2 In bathrooms and shower rooms lighting fixtures shall be mounted in accordance with IEC.

4.1.3 Lighting appliances on open decks shall be so installed as not to impede the recognition of navigation lights.

5. Lighting in cargo holds

5.1 General

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 A.1.4.5 to A.4.13.

K. Installation Material

1. Design and mounting

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.

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.

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.

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.

1.5 Terminals, screws and washers shall be made of brass or another corrosion-resistant material.

2. Plug connections and switches

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.

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.

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.

2.4 Plug connections shall conform to the required class of enclosure irrespective of whether or not the plug is in or out.

2.5 Wherever possible, appliances are to be so designed and mounted that the plugs are inserted from below.

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.

2.7 Only sockets with a permissible operating voltage in accordance with A., Table 13.6 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.

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.

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.

L. Cables and Insulated Wires

1. General

1.1 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 **TL**.

1.2 Except for lighting and space heating, only cables with multi-strand conductors are to be used.

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

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 Table 13.12).

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 **TL** for approval before installation.

2.2 Fire resistance

Cables and insulated wires shall be flame-retardant and self-extinguishing (according to IEC 60332).

2.3 Cable sheaths

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.

2.4 Movable connections

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 rubbersheathed 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 Table 13.13 respectively in Table 13.14 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 - Minimum cross-sections). See Table 13.12 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.

Table 13.12 Correction factors for cables in higher ambient temperatures

Maximum permissible conductor operating temperature		Ambient temperature [°C]				
[°C]	Table	40	45	50	60	70
60	13.13	1	0,87	0,71	-	-
85	13.14	1	0,94	0,89	0,74	0,57

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 startups, it is necessary to ensure that the voltage drop in the cable does not occasion any malfunction of the system.

3.2 Minimum cross-sections

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

See F.2.1

3.4 Protective earth wires

See A.1.4.4

3.5 Neutral conductors of 3-phase systems

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 Table 13.14 respectively Table 13.15.

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 Table 13.13 respectively Table 13.14. The short-circuit trip shall be set to 4-6 times the indicated amperages.

For short-circuit protection, see also G.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.

Table 13.13 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 crosssection of the copper conductor [mm²]	**Continuous service**		**Short time service S 2 = 30 min**		**Short time service S 2 = 60 min**	
	Maximum permissible current	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**	**Maximum permissible current**	**Rated fuse current**
	[A]	**[A]**	**[A]**	**[A]**	**[A]**	**[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	1	160	234	225	161	200
5 to 24-core cables 1,5 mm²						
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 13.14 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 crosssection of the copper conductor [mm²]	Continuous service		Short time service S 2 = 30 min		Short time service S 2 = 60 min	
	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current
	[A]	[A]	[A]	[A]	[A]	[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				

5. Cable laying

5.1 General

5.1.1 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 **TL** 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.

5.1.2 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 crosssections, the outgoing and return lines shall be laid as close as possible to each other over their entire length to avoid stray magnetic fields.

5.1.3 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.

5.1.4 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 tL.

5.1.5 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 lowestcapacity type are taken as the basis for all cables.

5.1.6 Should it be impossible to use multi-core cables in accordance with 5.1.3 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 tL in each case.

5.1.7 Table 13.15 indicates the minimum internal radius of curvature of cable bends according to the type and outside diameter of the cable concerned.

5.1.8 Terminations and joints in all conductors shall be made as to retain the original electrical, mechanical, flame-retardant and, where necessary, fire resistant properties. The number of joints shall be kept to a minimum.

6. Cable runs

6.1 General

6.1.1 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.

6.1.2 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.

6.1.3 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.

7. Fastening of cables and wires

7.1 General

7.1.1 Cables are to be fastened to trays or carriers. Individually run cables are to be fixed with clips.

7.1.2 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 **TL** 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.

Table 13.15 Minimum internal radius of curvature

Outer diameter of cable, D [mm]	Cables without metal sheath or braid	Cables with metal sheath or braid
up to 25	4.D	6.D
over 25	6.D	6.D

8. Tension relief

8.1 General

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 crosssection and to those installed in vertical trays or vertical ducts.

9. Protection against mechanical damage

9.1 General

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.

10. Laying of cables and wires in conduits or enclosed metal ducts

10.1 General

10.1.1 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.

10.1.2 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.

10.1.3 Extensive cable ducts and conduits are to be fitted with inspection and draw containers.

11. Laying in non-metallic conduits and ducts

11.1 General

The conduits or ducts shall be made of flame-retardant material.

12. Bulkhead and deck penetrations

12.1 General

12.1.1 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.

12.1.2 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 **TL**. 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.

13. Cables laid in refrigerated spaces

13.1 General

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.

14. Cable laying to wheelhouses using extending cable feeds (moveable cable loops)

14.1 General

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.

15. Cable junctions and branches

15.1 General

15.1.1 Branches from cables and wires may only be made inside containers.

15.1.2 Junction and distribution containers shall be located in easily accessible positions and shall be clearly marked.

15.1.3 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.

15.1.4 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.

M. Control, Monitoring, Alarm and Safety Systems

1. Scope

1.1 General requirements

The following sets out requirements for the control, monitoring, alarm and safety systems necessary to

operate essential equipment for vessel's propulsion, steering and safety.

The requirements cover installations of the main propulsion and associated machinery, which are under manned supervision.

Requirements for automatic and remote control systems and equipment which shall be approved in lieu of continuous manning have to be agreed with the authority.

1.2 Planning and design

1.2.1 The design of safety measures, open and closed loop controls and monitoring of equipment shall limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

1.2.2 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 recognise faults and test capability

- Reproducibility of values

1.2.3 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

1.2.4 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.

1.2.5 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.

1.2.6 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.

1.3 Design and construction

1.3.1 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.

1.3.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities shall be provided to permit independent manual operation.

Manual operation shall override all remote and automatic control.

1.3.3 In the event of disturbances automatically switched off plants shall not be released for restarting until having been manually unlocked.

It shall be possible to start, stop and reverse the ship's propulsion reliably and quickly.

1.4 Application of computer systems

If computer systems are used, P. has to be observed.

1.5 Maintenance

1.5.1 Access shall 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.

1.5.2 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

1.5.3 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 shall be fitted to indicate the risk.

1.5.4 Circuit boards and plug-in connections shall be protected against unintentional mixing up. Alternatively they shall be clearly marked to show where they belong.

2. Machinery control and monitoring installations

2.1 General

2.1.1 Where vessels have only one main engine, that engine shall not be shut down automatically except in order to protect against overspeed.

2.1.2 Where vessels have only one main engine that engine may be equipped with an automatic device for the reduction of the engine speed only If an automatic reduction of the engine speed is indicated both optically and acoustically in the wheelhouse and the device for the reduction of the engine speed can be switched off from the helmsman's position.

2.2 Protective Devices for Machinery Plants

2.2.1 Protective devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

2.2.2 When reaching dangerous limits, protective devices shall adapt the operation to the remaining technical capabilities.

2.2.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.2.4 Protective devices shall be so designed that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, ship or machinery.

2.2.5 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

2.2.6 The monitored open-circuit principle is to be applied to protective devices which can activate an automatic shut-down. Equivalent monitoring principles are permitted.

2.2.7 The tripping of a protective device and faults shall be alarmed. The reason for the tripping shall be identifiable.

2.2.8 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

2.2.9 The adjustment facilities for protective devices shall be so designed that the last setting is traceable.

2.2.10 Protective devices which can activate an automatic shut down of the main propulsion plant shall be equipped with overriding facilities from the wheelhouse.

2.3 Reductions of the main propulsion plant

2.3.1 Reductions can be initiated automatically or by a request for manual reduction.

2.3.2 Reductions may be a function of the machinery alarm system.

2.3.3 Overriding capabilities have to be provided for automatic reductions from the wheelhouse.

2.4 Manual Emergency stop

2.4.1 Manual emergency stops are to be protected against unintentional activation.

2.4.2 The manual emergency stop shall not be automatically cancelled.

2.4.3 It shall be recognizable which manual emergency stop has been activated.

2.4.4 The monitored open-circuit principle is to be applied to manual emergency stops. Equivalent monitoring principles are permitted.

2.5 Safety Devices for Machinery Plants

2.5.1 Safety devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

2.5.2 When reaching dangerous limits, safety devices shall initiate an automatic shut down.

2.5.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.5.4 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

2.5.5 The monitored open-circuit principle is to be applied to safety devices. Equivalent monitoring principles are permitted.

2.5.6 The tripping of a safety device and faults shall be alarmed and recorded. The reason for the tripping shall be identifiable.

2.5.7 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

2.5.8 The adjustment facilities for safety devices shall be so designed that the last setting is traceable.

2.5.9 Safety devices of the main propulsion plant may be equipped with overriding facilities. The overspeed protection is excluded.

2.6 Safety Systems for Machinery Plants

2.6.1 The safety system of a machinery plant is the subsumption of the protective and safety devices related to this machinery plant.

2.6.2 It is allowed to combine protective and safety devices for one individual system only.

2.7 Open-loop control

2.7.1 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 1.2.2.

2.7.2 Control equipment shall have built-in protection features where incorrect operation would result in serious damage or in the loss of essential functions.

2.7.3 The consequences of control commands shall be indicated at the respective control station.

2.7.4 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.

2.7.5 It shall be possible to control the essential equipment at or near to the equipment concerned.

2.7.6 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 shall 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.

2.7.7 Open-loop control for speed and power of main engines are subject to mandatory type testing.

2.8 Closed-loop control

2.8.1 Closed-loop control shall keep the process variables under normal conditions within the specified limits.

2.8.2 Closed-loop controls shall maintain the specified reaction over the full control range. Anticipated variations of the parameters shall be considered during the planning.

2.8.3 Defects in a control loop shall not impair the function of operationally essential control loops.

2.8.4 The power supply of operationally essential control loops shall be monitored and power failure shall be signalled by an alarm.

2.8.5 Closed-loop control for speed and power of main engines are subject to mandatory type testing.

2.9 Alarm systems

2.9.1 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.

2.9.2 Alarm delays shall be kept within such time limits that any risk to the monitored system is prevented if the limit value is exceeded.

2.9.3 Optical signals shall be individually indicated. The meaning of the individual indications shall be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal shall remain visible until the fault has been eliminated. It shall be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

2.9.4 It shall be possible to acknowledge audible signals.

The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes.

Alarms shall 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 shall be installed.

2.9.5 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.

2.9.6 Alarm systems shall be designed according to the closed-circuit principle or the monitored opencircuit principle. Equivalent monitoring principles are permitted.

2.9.7 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.

2.9.8 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.

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 acknowledgement, shall be available for further signals.

It shall be possible to silence 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.

2.9.9 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 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).

2.9.10 Alarm delays shall be kept within time limits to prevent any risk to the monitored system in the event of exceeding the limit value. 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.

2.9.11 A failure of the power supply or disconnection of the system shall not alter the limit value settings at which a fault is signalled.

2.9.12 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.

2.9.13 It is recommended that input devices approved by **TL** should be used.

2.9.14 It is recommended that the alarm signals should be automatically suppressed when the main engine and auxiliaries are taken out of service.

2.10 Integration of systems for essential equipment

2.10.1 The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

2.10.2 A defect in one of the subsystems (individual module, unit or subsystem) of the integrated system shall not affect the function of other subsystems.

2.10.3 Any failure in the transfer of data of autonomous subsystems which are linked together shall not impair their independent function.

2.10.4 Essential equipment shall also be capable of being operated independently of integrated systems.

2.11 Remote control of machinery installations

2.11.1 Machinery installations are to be equipped with monitoring equipment as detailed in Table 13.16.

2.11.2 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.

2.11.3 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 shall be recognizable at all control stations.

2.11.4 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.

2.11.5 With each new command, stored commands shall be erased and replaced by the new input.

2.11.6 In the case of set speed stages, a facility shall be provided to change the speed in the individual stages.

2.11.7 An overload limitation facility is to be provided for the propulsion machinery.

2.11.8 It shall be possible to stop the propeller thrust from the wheelhouse independently of the remote control system.

2.11.9 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.

2.11.10 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, **TL** 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 shall 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 black-out.

2.11.11 The failure of the remote control system and of the control power is to be signalled by an alarm.

Table 13.16 Remote 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			
	Engine power > 220 kW	HH	x	G		x
Shaft revolution indicator			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature		H	x	G		
Leakage of fuel injection pipe **(5)**		H		G		
Failure in electronic fuel injection system		H		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	G	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 **(3)**
Fault in the electronic governor		x	x	G		
REDUCTION GEAR						
Tank level			x			
Lubricating oil temperature			x			
Lubricating oil pressure			x			
AUXILIARY MACHINE (2)						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		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			
	Engine power > 220 kW	HH	x	G		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		

Table 13.16 Remote control of machinery installations -continued-

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**
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		
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 OR HEATING OIL					
High pressure	HH				x
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) *For diesel engines with more than two cylinders*

2.11.12 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

2.11.13 Remote control systems for main propulsion plants are subject to mandatory type approval.

2.11.14 The transfer of control between the wheelhouse and machinery space shall be possible only in the machinery area.

2.11.15 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.

2.11.16 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.

2.12 Fire detection and alarm

2.12.1 General

2.12.2 Any required fixed fire detection and fire alarm system shall be capable of immediate operation at all times.

2.12.3 The fixed fire detection and fire alarm system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

2.12.4 The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

2.12.5 The system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.13 Detector requirements

2.13.1 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.

2.13.2 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 per cent obscuration per metre, but not until the smoke density exceeds 2 per cent 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.

2.13.3 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.

2.13.4 At the discretion of the Society, the permissible temperature of operation of heat detectors may be increased to 30 °C above the maximum deckhead temperature in drying rooms and similar spaces of a normal high ambient temperature.

2.13.5 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.

2.13.6 The detectors are to be mounted in such a way that they can operate properly. Mounting places near ventilators, where the operation of detectors may be impaired or where mechanical damage is expected, shall be avoided.

2.13.7 Detectors mounted to the ceiling shall generally be placed at least 0,5 m away from bulkheads, except in corridors, lockers and stairways.

2.13.8 The maximum monitored area, respectively the maximum distance between detectors shall not exceed the following values:

- Heat detectors 37 m^2 or distance not more than 9 m

- Smoke detectors 74 m^2 or distance not more than 11 m

2.13.9 The distance from bulkheads shall not exceed:

- 4,5 m for heat detectors

- 5,5 m for smoke detectors

2.13.10 The society may require or permit different spacing of detectors based upon test data which demonstrate the characteristics of the detectors.

2.14 System requirements

2.14.1 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.

2.14.2 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.

2.14.3 Accommodation and service spaces of cargo carriers shall be protected by a fixed fire detection and fire alarm system.

2.14.4 Machinery installations which have been designed for automatic and remote control in lieu of continuous manning have to be protected by a fixed fire detection and fire alarm system.

2.14.5 Additional demands are laid down within the type and service notation of the vessel.

N. Power Electronics

1. General

For power electronics in electrical propulsion plants, see O.

2. Construction

2.1 General

2.1.1 The rules set out in A. to M. are to be observed, wherever applicable.

2.1.2 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.

2.1.3 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.

2.1.4 Control and alarm electronics shall be galvanically separated from power circuits.

2.1.5 External pulse cables are to be laid twisted in pairs and screened, and kept as short as possible.

3. Rating and Design

3.1 General

3.1.1 Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation, see D.1. and H.1.

3.1.2 Rectifier systems shall guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see D.1. In the event of unacceptably large frequency and/or voltage variations in the supply voltage, the system shall shut-off or remain in a safe operating condition.

3.1.3 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.

3.1.4 Electrical charges in power electronic modules shall 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.

3.1.5 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 shall be notifying to this effect.

3.1.6 The absence of external control signals, e.g. due to a circuit break, shall not cause a dangerous situation.

3.1.7 Control-circuit supplies are to be safeguarded against unintended disconnection, if this could endanger or damage the plant.

3.1.8 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.

3.1.9 Special attention shall be paid to the following points:

- Mutual interference of static converters connected to the same busbar system
- To voltage distortion and reacting to other consumers
  – the 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 following:

- Reaction on the mean and peak value of the system voltage in case of frequency fluctuations
- Inadmissible effects on the voltage regulation of generators

4. Cooling

4.1 General

4.1.1 Natural cooling is preferred.

4.1.2 The safety in operation shall be proved for liquid cooling and forced cooling.

4.1.3 An impairment of cooling shall not result in unacceptable overtemperatures, an overtemperature alarm shall be provided.

5. Control and monitoring

5.1 General

Control, adjustment and monitoring shall ensure that the permissible operating values of the facilities are not exceeded.

6. Protection equipment

6.1 General

6.1.1 Power electronic equipment shall be protected against exceeding of their current and voltage limits.

For protective devices, it shall 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

6.1.2 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.

6.1.3 Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semiconductor components.

7. Tests

7.1 General

Power electronics assemblies shall be individually tested at the maker's works. A Works Test Report shall be rendered on the tests carried out. Essential equipment from 50 kW/kVA upwards shall be tested in the presence of a **TL** Surveyor.

7.2 Extent of route tests

7.2.1 Voltage test

Prior to the start of the operational tests a high-voltage test shall be carried out. The RMS value of the alternating test voltage is:

$$U = 2 \cdot U_n + 1000 \geq 2000 \text{ [V]}$$

duration = 1 minute

U_n = Maximum nominal voltage between any two points on the power electronics device [V]

For this purpose, switchgear in power circuits shall be bridged, and the input and output terminals of the power electronics devices and the electrodes of the rectifiers hall be electrically connected with each other. The test voltage shall be applied between the input/output terminals or between the electrodes and:

- The cabinet

- The mains connection side, if the power electronics device is electrically isolated from the mains.

7.2.2 Test of insulation resistance

Following the voltage test, the insulation resistance shall be measured at the same connections as for the voltage test. The measurement shall be performed at a voltage of at least 500 V DC. The resistance shall be at least 1 kOhm/V.

7.2.3 Operational test

The function shall be demonstrated as far as possible.

O. Electrical Propulsion Plants

1. General

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.

1.2 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.

1.3 Auxiliary propulsion plants are additionally propulsion systems.

1.4 The engines driving the generators for the electrical propulsion plant are main engines. Motors driving the propeller shaft are propulsion motors.

1.5 If electrical main propulsion plants are supplied from the vessel's general mains, the Rules in this Section apply also to the generators and the associated switchgear. For auxiliary propulsion plants, the Rules of this Section are to be met correspondingly.

2. Drives

2.1 Basis for dimensioning

2.1.1 The electrical machinery and plants shall, 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 shall also conform to the requirements of Section 12.

2.2.2 The diesel governors shall 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 shall also conform to the requirements of A. to H.

2.3.2 The effects of the harmonics of currents and voltages are 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 **TL**.

2.3.5 Electrical propulsion motors shall 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 Power-electronic equipment shall also conform to the requirements of N.

3.2 Static converters shall be designed for the load to be expected under all operating and manoeuvring conditions, including overloads and short circuits.

3.3 If static converters are separately cooled, the plant shall be capable to continue operation at reduced power level if the cooling system fails.

3.4 The circuits for main power supply and exciter equipment shall be supplied directly from the switchboard and shall be separate for each motor and each winding.

3.5 Exciter circuits whose failure can endanger the operation shall only be protected against short circuit.

3.6 The static converters shall be easily accessible for inspection, repair and maintenance.

4. Control stations

4.1 Should the remote control system fail, local operation shall be possible. Changeover shall 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.

4.2 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.

4.3 All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

4.4 A defect in a system for synchronising or in a position equalisation 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 It shall be possible to connect and disconnect generators without interrupting the propeller drive.

5.2 If a power management system is available, the automatic stop of main engines during manoeuvring shall be prevented.

6. Control and regulating

6.1 If computer systems are used, the requirements of P. shall be observed.

6.2 An automatic power limitation of the propulsion motors shall ensure that the vessel mains will not be overloaded.

6.3 The reverse power during reversing or speed-reducing manoeuvres shall be limited to the acceptable maximum values.

7. Protection of the plant

7.1 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.

7.2 Protection devices shall be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring.

7.3 Defects in reducing and stopping devices shall not impair the limited operation in accordance with 1.2.

7.4 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.

7.5 The following additional protection equipment shall be provided:

- Where drives uncontrolled can be mechanically blocked, they shall 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

7.6 The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition shall remain recognisable even after switching-off.

8. Measuring, indicating, monitoring and alarms equipment

8.1 General

Failures in measuring, monitoring and indicating equipment shall 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 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 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

Abnormal values of the different parameters of the equipment listed here below 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 (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

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

The cable network for electrical propulsion plants shall comply with the requirements of L. 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 **TL**.

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 A. to N.

10.1.3 Shaft material for generators and propulsion motors

Tests of the shaft material for generators and propulsion motors. 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 **TL**.

10.2 Tests after installation

Newly-constructed or enlarged plants require testing and trials on board.

The scope of the trials is to be agreed with **TL**.

10.2.1 Dock trial

For scope and extent of dock trials, see Q.3.8.

10.2.2 River trial

For river trial programme, see Q.4.2.

P. Computer Systems

1. General

1.1 Scope

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

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 fulfil 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 Table 13.17. This assignment shall be accepted by **TL**. Table 13.18 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 organisational measures may be required if the risk increases. These measures shall be agreed with **TL**.

2.2 Risk parameters

2.2.1 The following aspects may lead to assignment to a different requirement class, see Table 13.17.

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 **TL**.

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 Table 13.19).

Computer systems shall be protected against unintentional or unauthorised 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 shall 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 Table 13.19 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.

Table 13.17 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 13.18 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 Bilge draining systems Integrated monitoring and control systems Control systems for tank, ballast 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

Note

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 shall 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.

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 shall be retraceable.

Table 13.19 Program and data protection measures in relation to the requirement class

Requirement class	Program/Data memory
1	Protection measures are recommended
2	Protection against unintentional /unauthorised modification
3	Protection against unintentional/ unauthorised modification and loss of data
4	No modifications by the user possible
5	No modifications possible

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 connected to the link. Detected failures shall initiate an alarm.

3.5.4 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

3.5.5 The characteristics of the data communication link shall be such as to transmit that all necessary information in adequate time and overloading is prevented.

3.5.6 When the same data communication link is used for two or more essential functions, this link shall be redundant.

3.5.7 Means are to be provided to ensure protect the integrity of data and provide timely recovery of corrupted or invalid data.

3.5.8 Switching between redundant links shall not disturb data communication or continuous operation of functions.

3.5.9 To ensure that data can be exchanged between various systems, standardised interfaces shall be used.

3.5.10 If approved systems are extended, prove of trouble-free operation of the complete system shall be provided.

3.6 Additional requirements for wireless data links

3.6.1 These requirements are in addition to the requirements of 5. Data communication links apply to requirement class 2 using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

3.6.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

3.6.3 Wireless data communication shall employ recognised international wireless communication system protocols that incorporate the following:

- Message integrity:

  Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

- Configuration and device authentication:

Shall only permit connection of devices that are included in the system design;

- Message encryption. Protection of the confidentiality and or criticality the data content;

- Security management. Protection of network assets, prevention of unauthorised access to network assets.

Note

The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements. Consideration should be given to system operation in the event of national local port regulations.

3.7 Integration of systems

3.7.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

3.7.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

3.7.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

3.8 User interface

3.8.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

3.8.2 The status of the computer system shall be recognisable.

3.8.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

3.8.4 For using computer systems, a general comprehensible user guide shall be provided.

3.9 Input devices

3.9.1 The feedback of control commands shall be indicated.

3.9.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognise which of the assigned functions are active.

3.9.3 Operator panels located on the bridge shall be individually illuminated. The lighting shall be adapted nonglare to the prevailing ambient conditions.

3.9.4 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices.

3.9.5 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

3.9.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

3.9.7 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

3.10 Output devices

3.10.1 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.

3.10.2 Information shall be displayed in a logical priority.

3.10.3 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.

3.11 Graphical user interface

3.11.1 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.

3.11.2 When general-purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

3.11.3 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.

3.12 Remote access

3.12.1 Remote access during a voyage of a ship shall be used for monitoring purposes and the prior acknowledgment by the ship's responsible crew member only.

3.12.2 If remote software maintenance is arranged for onboard, the installation of software requires the following items and or actions to be fulfilled:

- No modification shall be possible without the acceptance and acknowledgement by the ship's responsible crew member (for example the captain) and shall be carried out in a harbour only;

- Any revision which may affect compliance with the rules shall be approved by **TL** and evidence of such shall be available onboard;

- An installation procedure shall be available;

- The security of the installation process and integrity of the changed software shall be verified after the software update is complete;

- A test program for verification of correct installation and correct functions shall be available;

- Evidence for the reason for updating a software shall be documented in a software release note;

- In case that the changed software has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

4. Testing of computer systems

4.1 General

4.1.1 Computer systems of requirement class 3 and higher are subject to mandatory type approval.

4.1.2 Evidence, tests and assessments of computer systems have to be carried out in accordance to the requirement class.

4.1.3 By the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

4.1.4 If other proofs and tests are provided by the manufacturer which are of an equivalent nature, they may be recognized.

4.1.5 The test schedule of system testing has to be specified and submitted before the hardware and software test will be carried out.

4.1.6 Modifications after completed tests which have influence on the functionality and/or the safety of the system have to be documented and retested in accordance to the requirement class.

4.2 Tests in the manufacturer's works

Following tests shall be carried out in the manufacturer's works:

- Function tests

- Simulation of the operating conditions

- Fault simulation

- Simulation of the application environment

4.3 Tests on board

4.3.1 Complete system tests

4.3.1.1 Integration tests

For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self fail as a result of external electromagnetic interference during expected operating conditions.

Note

Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for requirement class 3, 4 and 5 systems, the layout and / or equipment shall be changed to prevent further failures occurring.

Q. Tests on Board

1. General

The tests are divided into:

- Tests during construction
- Tests during commissioning
- Tests during trial voyages

2. Tests during construction

2.1 During the period of construction of the vessel, the installations shall be checked for conformity with the documents reviewed by **TL** and with the Rules for construction.

2.2 Test certificates for tests which have already been performed shall be presented to the Surveyor on request.

2.3 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 A.

c) Measures of explosion protection

2.4 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

3. Testing during commissioning of the electrical equipment

3.1 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 **TL**'s Surveyor in accordance with the specific characteristics of the subject equipment.

3.2 Generators

A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on appropriate form.

3.3 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

3.4 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

TL reserves the right to demand the proof of selective arrangement of the vessel supply system.

3.5 Power electronics

The following items shall be tested:

a) Ventilation of the place of installation

b) Function of the equipment and protection devices

3.6 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 protectiondevices

b) 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

3.7 Control, monitoring and vessel's safety systems

For these systems operational tests shall be performed.

3.8 Electrical propulsion plant

Functioning of the propulsion plant shall be proved by a dock trial before river trials.
At least the following trials/measurements shall be carried out in the presence of **TL** 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

3.9 Computer systems

Regarding scope of tests see P.

4. Testing during trial voyages

4.1 General

Proof is required that the power supply meets the requirements under the various operating conditions of the vessel. All components of the system shall function satisfactorily under service conditions, i.e. at all main engine speeds and during all manoeuvres.

4.2 Electrical propulsion plant

4.2.1 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 3 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

R. Additional Requirements with Regard to the Application of the Directive of the European Parliament and of the Council 82/14/EEC (2006/87/EC)

1. Electronic equipment

1.1 Electronic equipment shall be in line with Directive 2006/87/EC, Article 9.20.

2. Electromagnetic compatibility

2.1 The operation of the electric and electronic systems shall not be impaired by electromagnetic interference. General measures shall, with equal importance, extend to:

a) disconnection of the transmission paths between the source of interference and affected devices.

b) reducing the causes of disturbance at their source.

c) reducing the sensitivity of affected devices to interference.

SECTION 14

ADDITIONAL REQUIREMENTS for NOTATIONS – CARGO VESSELS

A. Single Side Cargo Vessels

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth, in [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Net thickness [mm] of plating

A_{sh} = Net web sectional area [cm^2]

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

S, s = Stiffener spacing [m]

ℓ = Stiffener span [m]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

β_b, β_S = Bracket coefficients defined in Section 5, B.5.2

n = Navigation coefficient defined in Section 6, B.

= $0{,}85 \cdot h$

h = Significant wave height [m]

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service Notation **General Cargo Ship**, as defined in, Section 2, B.3.1.1.

2.1.2 Vessels dealt with in this Section are to comply with the requirements stipulated in Sections 1-13, as applicable, and with the requirements of this Section, which are specific to single hull cargo vessels.

2.2 Stability

Depending on the vessel's design and operating conditions, proof of sufficient stability may be required by **TL**.

3. Vessel arrangement

3.1 General

3.1.1 Application

The requirements of this Section apply to open deck vessels of single side construction, with or without double bottom, intended primarily to carry uniform or 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 Section 11, B.

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 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 spacings to the side frames by an appropriate system.

3.3 Accesses

3.3.1 Access to double bottom

Manholes may be cut in the floors and side girders to provide convenient access to all parts of the double bottom.

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.

As a rule, the manholes height is not to be more than 0,5 times the floor height or girder height.

Manholes in the floors are to be located at half the floor height and in a region extending on 0,2.B from the axis of the vessel, on both sides. When a central girder exits, its distance to the nearest side of cutting is not to be less than the double bottom height.

Manholes in the side girders are to be located at half the girder height and midway between two successive web frames.

3.3.2 Access to cargo hold

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. Structure design principles

4.1 Bottom structure

4.1.1 Single bottom vessels are to be fitted with girders in compliance with Section 8, B.3.2 or B.4.2.

4.1.2 Transversely framed single bottom

A single bottom transversely framed is to be fitted with floors at every frame.

4.1.3 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, which is the lesser.

4.2 Double bottom structure

4.2.1 Double bottom arrangement

Where it is not possible to visit the double bottoms, they are to be well protected against corrosion.

Where the height of the double bottom varies, the variation is generally to be made gradually and 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.

4.2.2 All double bottom vessels are to have a centre girder. A centre girder is not required where the vessel breadth measured on the top of floors or bottom transverses does not exceed 6 m.

The intercostal centre girder is to extend over the full length of the vessel or over the greatest length consistent with the lines.

4.2.3 Transversely framed double bottom

Where the double bottom is transversely framed, 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

4.2.4 Longitudinally framed double bottom

The spacing of transverses [m] is generally to be not greater than 8 frame spacing nor than 4 m, whichever is the lesser.

Additional transverses are to be fitted in way of transverse watertight bulkheads.

Bottom and inner bottom longitudinal ordinary stiffeners are generally to be continuous through the transverses.

In case the longitudinals are interrupted in way of a transverse, brackets on both sides of the transverse are to be fitted in perfect alignment.

In general, intermediate brackets are to be fitted connecting the centre girder to the nearest bottom and inner bottom ordinary stiffeners.

4.3 Transversely framed side

4.3.1 Connection of frames with floors

The frames are to be connected to the floors, generally by means of a lap weld the length of which is to be not less than:

– The frame depth, in case of frames made of a welded flat

– 1,5 times the frame depth, in case of frames made of a bulb profile or toe welded angle

The weld throat is to be not less than half the frame web thickness.

4.3.2 Connection with deck structure

At the upper end of frames, connecting brackets are to be provided, in compliance with Section 8, C.7. Such brackets are to extend to the hatch coaming.

4.3.3 Web frames

Web frames are to be fitted with a spacing [m] not exceeding 5 m.

Their scantling is to be performed according to 5.2.2 herebelow.

4.3.4 Connection of frames to bottom longitudinals

In the case of a longitudinally framed single bottom, the side frames are connected to the bottom longitudinal 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 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 spacings, nor than 4 m.

Their scantling is to be performed according to 5.2.2 herebelow.

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.

Table 14.1 Net scantlings of transverse rings

Primary supporting member	w	A_{sh}
Side webs Floors	$w = k\ MAX\ (w_1, w_2)$ $w_1 = 1{,}96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$ $w_2 = 0{,}58 \cdot \beta_b \cdot p_{\gamma E} \cdot s \cdot B^2$	$A_{sh} = k\ MAX\ (A_1, A_2)$ $A_1 = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$ $A_2 = 0{,}045 \cdot \beta_s \cdot p_{\gamma E} \cdot s \cdot B$
Side transverses Bottom transverses	$w = k\ MAX\ (w_1, w_2)$ $w_1 = 1{,}96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$ $w_2 = 0{,}58 \cdot \beta_b \cdot p_{\gamma E} \cdot S \cdot B^2$	$A_{sh} = k\ MAX\ (A_1, A_2)$ $A_1 = 0{,}063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$ $A_2 = 0{,}045 \cdot \beta_s \cdot p_{\gamma E} \cdot S \cdot B$
Strong box beams	Section 5, D.2.4.4	

P = side primary supporting members design load [kN/m^2]

= $4{,}9 \cdot (T + 0{,}6 \cdot n)$

$p_{\gamma E}$ = bottom primary supporting members design load [kN/m^2]

= $9{,}81.(\gamma \cdot T + 0{,}6 \cdot n)$

γ = 1,0 for loading/unloading in one run

= 0,575 for loading/unloading in two runs

ℓ_0 = $T + 0{,}6 \cdot n$

k_0 = $1 + (H - \ell_0) / \ell_0$

4.5 Topside structure

4.5.1 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 accomodation spaces.

5. Hull scantlings

5.1 General

The hull scantlings are to be as specified in Section 8, unless otherwise specified.

5.2 Transverse rings

5.2.1 General

Where necessary, transverse rings are to be fitted to provide additional supports of the stringer plate.

5.2.2 Scantlings of transverse ring components

The ring component scantlings are not to be less than required in Table 14.1.

5.3 Transverse hold bulkhead structure

5.3.1 General

The number and location of transverse bulkheads are defined in Section 8, E.

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 required in Section 5, E.

5.3.2 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.

5.3.3 Horizontally framed plate bulkhead

The upper part of horizontally framed bulkheads are to be specially considered by **TL**.

5.3.4 Plate bulkhead end stringer

The net scantlings of the plate bulkhead end stringer is

to be determined using the formula:

$$w = \frac{125 \cdot k}{(214 - \sigma_A)} p \cdot S \cdot \ell^2$$

p = Bulkhead end stringer design load [kN/m²] to be determined using applicable formulas given in Section 6, C.6.

S = Bulkhead stringer spacing [m]

σ_A = Bulkhead end stringer axial stress [N/mm²]

$$= \frac{10 \cdot p \cdot D_1}{A}$$

A = Bulkhead end stringer sectional area [cm²] to be determined in compliance with Section 8, D.10.2.2, where:

$P_S = q \cdot D_1$

q = Distributed transverse load acting on the stringer plate [kN/m] to be determined as stated under Section 8, D.3.4.1

D_1 = Unsupported stringer plate length [m] defined under Section 8, D.3.4.2.

In way of hold end bulkheads D_1 is to be substituted by 0,5 . D_1

5.4 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 Section 17, A.4.

B. Double Hull Cargo Vessels

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m]

t = Net thickness [mm] of plating

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service notation **General Cargo Ship**, as defined in Section 2, B.3.1.1.

2.1.2 Vessels dealt with in the following are to comply with the requirements stipulated in Sections 1-13, as applicable, and with the requirements, which are specific to double hull cargo vessels.

2.2 Stability

Depending on the vessel's design and operating conditions, proof of sufficient stability shall be required by **TL**.

3. Vessel arrangement

3.1 General

3.1.1 Application

The following requirements apply to open deck vessels of double hull construction, intended primarily to carry uniform or 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 Section 11, B.

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.

3.3 Accesses

3.3.1 Access to double bottom

Manholes may be cut in the floors and side girders to provide convenient access to all parts of the double bottom.

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.

As a rule, the manholes height is not to be more than 0,5 times the floor height or girder height.

Manholes in the floors are to be located at half the floor height and in a region extending on 0,2.B from the axis of the vessel, on both sides. When a central girder exits, its distance to the nearest side of cutting is not to be less than the double bottom height.

Manholes in the side girders are to be located at half the girder height and midway between two successive web frames. Their distance from the transverse bulkheads of the side tanks is not to be less than 1,5 m, if there is no web frame. **TL** may wave this rule subject to direct calculation of the shear stresses.

3.3.2 Access to side tanks

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.

3.3.3 Access to cargo hold

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.

3.4 Welding

3.4.1 General

Welding is to comply with the requirements of Section 11, A.

3.4.2 Arrangements applying to the shell plating and the double bottom

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.

3.4.3 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. Structure design principles

4.1 Double bottom structure

4.1.1 Double bottom arrangement

Where it is not possible to visit the double bottoms, they are to be well protected against corrosion.

Where the height of the double bottom varies, the variation is generally to be made gradually and 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.

4.1.2 Girders

A centre girder is to be fitted on all vessels exceeding 6 m in breadth.

This girder is to be formed by a vertical intercostal plate connected to the bottom plating and fitted with an appropriate faceplate.

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 provided into the centre girder.

On vessels with ranges of navigation **I (1,2)** or **I (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.

On vessels with ranges of navigation **I (0,6)** or **I (0)**, 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. 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.

4.1.3 Transversely framed double bottom

Where the double bottom is transversely framed, 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

4.1.4 Longitudinally framed double bottom

The spacing of transverses, in m, is generally to be not greater than 8 frame spacing nor than 4 m, whichever is the lesser.

Additional transverses are to be fitted in way of transverse watertight bulkheads.

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.

In general, intermediate brackets are to be fitted connecting the centre girder to the nearest bottom and inner bottom ordinary stiffeners.

4.1.5 Strength continuity

Adequate strength continuity of floors and bottom transverses is to be ensured in way of the side tank by means of brackets.

4.2 Transversely framed double side

4.2.1 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.

4.2.2 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 that 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.

4.2.3 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 that 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.

4.2.4 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 witch is not to be greater than 1 m.

The scantling of plate webs with large openings is to be examined by **TL** on a case-by-case basis.

4.3 Longitudinally framed double side

4.3.1 Inner side plating

The requirements of 4.2.1 also apply to longitudinally framed double side, with the transverses instead of web frames.

4.3.2 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.

4.3.3 Side transverses

The requirements of 4.2.3 also apply to longitudinally framed double side, with the transverses instead of web frames.

4.3.4 Plate webs

The requirements of 4.2.4 also apply to longitudinally framed double side.

4.4 End structure

4.4.1 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 which is 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.

4.4.2 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 Section 10, F.3.2.

5. Hull scantlings

5.1 General

The hull scantlings and arrangements are to be determined according to Section 8, unless otherwise specified.

5.2 Double bottom structure

5.2.1 General arrangements

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 [cm_2] is not to be less than:

$$A = 0{,}01\ b\ t_F$$

t_F = Net thickness of floor web [mm]

b = Section height [mm]

= $100\ H_D$

H_D = Double bottom height [m]

Where the floors cannot be welded to the inner bottom by means of fillet welds, the attachment may be obtained by plug welds, in compliance with Section 11, A. In that case, the floors are to be fitted with a flange of adequate width in the double bottom area.

As a rule, manholes are not to be provided into the centreline girder.

5.3 Transverse hold bulkhead structure

Arrangements and scantlings of transverse hold bulkheads are to be in compliance with Section 8, E.

5.4 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 Section 17, A.4.

SECTION 15

ADDITIONAL REQUIREMENTS for NOTATIONS - OTHER TYPE and SERVICE NOTATIONS

Page

A. Tanker

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth, in [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

B_2 = Side tank breadth [m]

$B_1 = B - 2 . B_2$

t = Net thickness [mm] of plating

p = Design load [kN/m^2]

p_{PV} = Setting pressure [kN/m^2] of safety valves or maximum pressure [kN/m^2] in the tank during loading/unloading, which is the greater

s = Spacing of ordinary stiffeners [m]

S = Spacing of primary supporting members [m]

ℓ = Span of ordinary stiffeners or primary supporting members [m]

w = Net section modulus of ordinary stiffeners or primary supporting members [cm^3]

A_{sh} = Net web sectional area [cm^2]

k = Material factor defined in Section 5, A. 2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

z_{TOP} = Z co-ordinate [m] of the highest point of the tank

d_{AP} = Distance from the top of air pipe to the top of compartment [m]

H_T = Trunk height [m]

z_L = Z co-ordinate [m] of the highest point of the liquid

ρ_L = Density [t/m^3] of the liquid carried ≥ 1 t/m^3

σ_1 = In-plane hull girder normal stress [N/mm^2]

λ_b, λ_s = Coefficients for vertical structural members, defined in Section 5, B.5.3

β_b, β_S = Bracket coefficients defined in Section 5, B.5.2

n = Navigation coefficient defined in Section 6, B.

= $0{,}85 . h$

h = Significant wave height [m]

η = $1 - s / (2 . \ell)$

2. General

2.1 Application

2.1.1 Vessels complying with the following requirements are eligible for the assignment of the type and service Notation **Tanker**, as defined in Section 2, B.4.1.1

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Section 1-13, as applicable, and with the requirements of this Section, which are specific to tankers.

3. Vessel arrangement

3.1 Basic structural configuration

3.1.1 Single hull tankers

In a single hull tanker, see Fig. 15.1a,Fig. 15.1b and Fig. 15.1c, the cargo tanks are bounded by the vessel's outer shell, i.e. the bottom, the sides of the shell plating and the decks simultaneously act as tank walls.

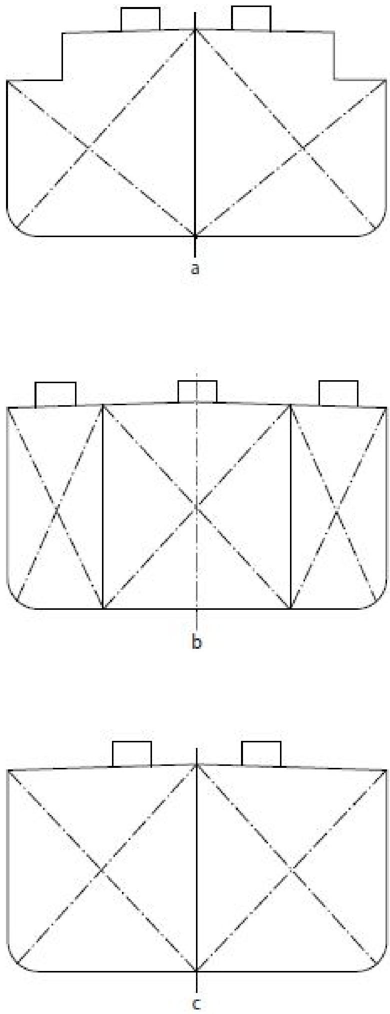


Fig. 15.1 Single hull tankers

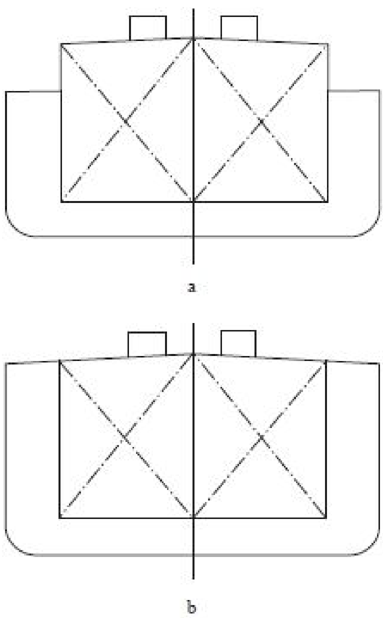


Fig. 15.2 Double hull tankers

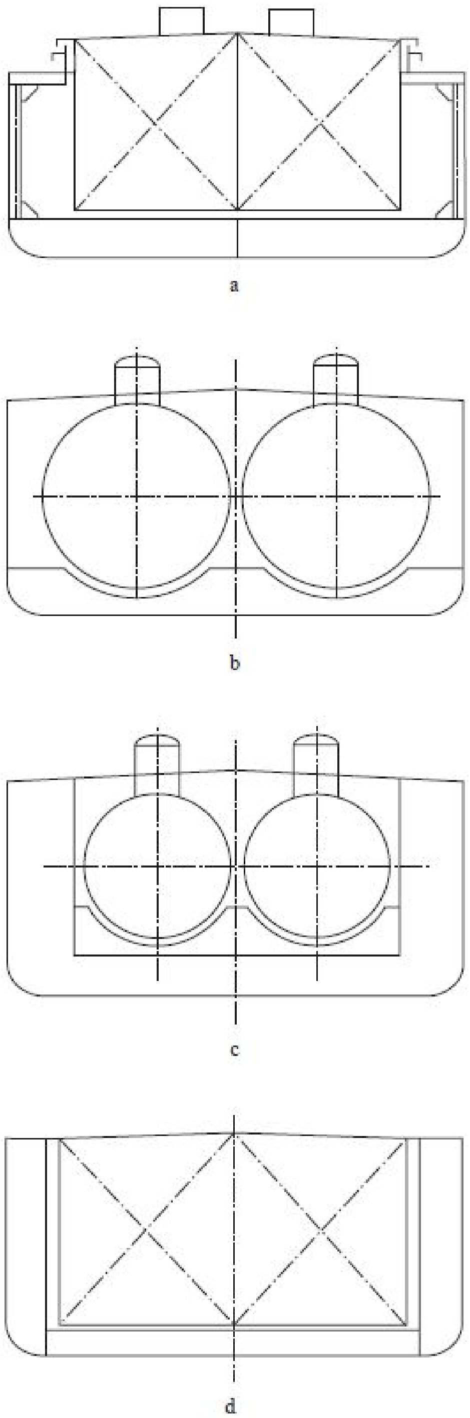


Fig. 15.3 Inserted cargo tank

3.1.2 Double hull tankers

As in the case of the single hull tanker, the cargo tanks form part of the vessel's structure. However, the bottom and side plating does not function simultaneously as tank walls, see Fig. 15.2a and Fig. 15.2b. For certain products minimum distances between tank boundaries and bottom or side plating are to be observed. Accessibility shall, however, 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's structure but are permanently installed, see Fig. 15.3a, Fig. 15.3b, Fig. 15.3c and Fig. 15.3d.

3.2 Stability

3.2.1 Tankers carrying dangerous goods

For vessels carrying dangerous goods, see Section 16.

3.2.2 Other tankers

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 stability has to be shown according to Section 17, F.

4. Hull scantlings

4.1 General

4.1.1 The hull scantlings are to be determined as specified in Section 8, using the adequate design loads, unless otherwise specified in the following.

4.1.2 Additional requirements for Tankers Type C and N

The minimum net thickness, in mm, of strength deck and bulkhead plating of integrated tanks in the cargo area is to be not less than the values given in Table 15.1.

Unless constructed wholly of corrosion-resistant materials or fitted with an approved lining, the plating thickness should take into account the corrosivity of the cargo.

Table 15.1 Minimum net thickness of integrated tanks

Plating	Minimum thickness [mm]
Strength deck	$t = 4{,}4 + 0{,}016 \,.\, L \cdot k^{0{,}5}$
Tank bulkhead	$t = 0{,}8 \,.\, L^{1/3} \cdot k^{0{,}5} + 3{,}6 \cdot s$
Watertight bulkhead	$t = 0{,}68 \,.\, L^{1/3} \cdot k^{0{,}5} + 3{,}6 \cdot s$
Wash bulkhead	$t = 0{,}64 + 0{,}011 \,.\, L \cdot k^{0{,}5} + 3{,}6 \cdot s$

4.1.3 Independent tanks

Scantlings of independent tanks are to be determined in compliance with Section 8, E.2.

4.1.4 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 above.

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.

4.1.5 Material factor

When steels with a minimum guaranteed yield stres ReH other than 235 N/mm^2 are used on a vessel, the scantlings are to be determined by taking into account the material factor as follows:

- Thickness:

  see relevant articles in the following

- Section modulus:

  $w = k \cdot w_0$

- Sectional area:

  $A = k \cdot A_0$

w_0, A_0 = Scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

4.2 Bottom and inner bottom structures

4.2.1 Minimum net thickness of web plating

The net thickness [mm] of the web plating of ordinary stiffeners is to be not less than:

- for L < 120 m: $t = 1,63 + 0,004 \cdot L \cdot k^{0,5} + 4,5 \cdot s$

- for L ≥ 120 m: $t = 3,9 \cdot k^{0,5} + s$

The net thickness [mm] of the web plating of ordinary stiffeners of tankers type C and N is to be not less than:

$$t = 0,6 \cdot L^{1/3} \cdot k^{0,5} + 3,6 \cdot s$$

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 1,14 \cdot L^{1/3} \cdot k^{0,5}$$

4.2.2 Net scantlings of bottom and inner bottom structural members in service conditions

The net scantlings of bottom and inner bottom structural members in service conditions are to be obtained from Table 15.2 for single bottom structure and Table 15.3 for double bottom structure.

4.2.3 Net scantlings of bottom and inner bottom structural members in testing conditions

The net scantlings of bottom and inner bottom structural members being part of compartments or structures containing liquid are to comply with Section 5, D.

4.2.4 Buckling check

Bottom and inner bottom structural members are to comply with the requirements stated under Section 2, C.

4.3 Side and inner side ordinary stiffeners

4.3.1 Minimum net thickness of web plating

The net thickness of the web plating of ordinary stiffeners is to be not less than:

- for L < 120 m: $t = 1,63 + 0,004 \cdot L \cdot k^{0,5} + 4,6 \cdot s$

- for L ≥ 120 m: $t = 3,9 \cdot k^{0,5} + s$

The net thickness [mm] of the web plating of ordinary stiffeners of tankers type C and N is to be not less than:

$$t = 0,6 \cdot L^{1/3} \cdot k^{0,5} + 3,6 \cdot s$$

4.3.2 Net scantlings of side and inner side ordinary stiffeners in service conditions

The net scantlings of side ordinary stiffeners in service conditions are to be obtained from Table 15.4 or Table 15.5, as applicable.

4.3.3 Net scantlings of side and inner side ordinary stiffeners in testing conditions

The net scantlings of side and inner side stiffeners being part of compartments or structures containing liquid are to comply with Section 5, D.

4.3.4 Buckling check

Side and inner side ordinary stiffeners are to comply with the requirements stated under Section 5, C.

4.3.5 Minimum side tank width

The side tank width is to be not less than 600 mm.

4.4 Side and inner side primary supporting members

4.4.1 Minimum net thickness of web plating

The net thickness of the web plating of primary supporting members is to be not less than:

$$t = 1,14. . L^{1/3} . k^{0,5}$$

Table 15.2 Net scantlings of single bottom structure

Item	w [cm^3]	A_{sh} [cm^2]
Bottom longitudinal	$w = \frac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_E \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p_E \cdot s \cdot \ell$
Floors **(1), (2)**	$w = 0{,}58 \cdot \beta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot s \cdot \ell$
Bottom transverses **(2)**	$w = 0{,}58 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Bottom centre and side girders **(3)**	$w = \frac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Design load [kN/m^2] of bottom primary supporting members:
= MAX ($p_{\gamma E}$; $p_{\gamma I}$)
$p_{\gamma E}$ = Design load [kN/m^2] of bottom primary supporting members:
= $9{,}81 \cdot (\gamma \cdot T + 0{,}6 \cdot n)$
γ = 0,575, in general
= 1,0 for loading/unloading in one run or for vessels fitted with independent tanks
$p_{\gamma I}$ = Design load [kN/m2] of bottom primary supporting members:
= $p_C - p_M$
p_M = Minimum external pressure [kN/m^2]: $p_M \geq 0$:
= $9{,}81 \cdot (0{,}15 \cdot T - 0{,}6 \cdot n)$
p_C = Pressure transmitted to the bottom structure defined in Section 6, C.5.
p_E = Design load [kN/m^2] defined in D.6.1.1

(1) *In way of side ordinary frames, $\beta_b = \beta_S = 1$*
(2) *Scantlings of floors and bottom transverses have to be adequate to those of web frames or side transverses connected to them.*
(3) *The span ℓ is to be taken equal to the web frame spacing or the bottom transverse spacing.*

4.4.2 Net scantlings of side and inner side primary supporting members in service conditions

The net scantlings of side primary supporting members in service conditions are to be obtained from Table 15.4 or Table 15.5, as applicable.

4.4.3 Net scantlings of side and inner side primary supporting members in testing conditions

The net scantlings of side and inner side primary supporting members being part of compartments or structures containing liquid are to comply with Section 5, D.

4.4.4 Buckling check

Side and inner side primary supporting members are to comply with the requirements stated under Section 5, C.

Table 15.3 S Net scantlings of double bottom structure

Item	Parameter	Transverse framing	Longitudinal framing
Double bottom	height [mm]	$d = MAX(d_1;d_2)$ $d_1 = 34{,}2 \cdot A_a \cdot \left(\sqrt{\dfrac{2 \cdot W_0}{3 \cdot A_a^2} + 1} - 1\right)$ $d_2 = 600$	
Floors in the tank **(2)**	Section modulus [cm^3] Thickness [mm] Shear sectional area [cm^2]	$w = MAX\ (w_1;w_2)$ $w_1 = 0{,}58 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell^2$ $w_2 = 0{,}58 \cdot \beta_b \cdot p_{yl} \cdot s \cdot (\ell^2 - 4 \cdot B_3^2)$ $t = MAX\ (t_1;t_2)$ $t_1 = 1{,}14 \cdot L^{1/3} \cdot k^{0,5}$ $t_2 = d/100$ $A_{sh} = MAX\ (A_1;A_2)$ $A_1 = 0{,}067 \cdot \beta_s \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0{,}067 \cdot \beta_s \cdot p_{yl} \cdot s \cdot (\ell - 2 \cdot B_3)$	NA NA NA
Floors in the side tank **(2)**	Section modulus [cm^3] Shear sectional area [cm^2]	$w = MAX\ (w_1;w_2)$ $w_1 = 2{,}32 \cdot \beta_b \cdot p_1 \cdot s \cdot B_2 . (\ell - B_2)$ $w_2 = 2{,}32 \cdot \beta_b \cdot p_{yl} \cdot s \cdot B_2 \cdot (\ell - 2 \cdot B_2)$ $A_{sh} = MAX\ (A_1;A_2)$ $A_1 = 0{,}067 \cdot \beta_s . p_1 . s . \ell$ $A_2 = 0{,}067 \cdot \beta_s \cdot p_{yl} \cdot s \cdot (\ell - 2 \cdot B_3)$	NA NA
Bottom and inner bottom longitudinals	Section modulus [cm^3] Shear sectional area [cm^2]	NA NA	$w = \dfrac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_2 \cdot s \cdot \ell^2$ $A_{sh} = 0{,}045 \cdot \beta_b \cdot \eta \cdot p_2 \cdot s \cdot \ell$
Bottom transverses in the tank	Section modulus [cm^3] Thickness [mm] Shear sectional area [cm^2]	NA NA NA	$w = MAX\ (w_1;w_2)$ $w_1 = 0{,}58 \cdot \beta_b \cdot p_1 \cdot S \cdot \ell^2$ $w_2 = 0{,}58 \cdot \beta_b . p_{yl} \cdot S \cdot (\ell^2 - 4 \cdot B_3^2)$ $t = MAX\ (t_1;t_2)$ $t_1 = 1{,}14 \cdot L^{1/3} \cdot k^{0,5}$ $t_2 = d/90$ $A_{sh} = MAX\ (A_1;A_2)$ $A_1 = 0{,}067 \cdot \beta_s . p_1 \cdot S \cdot \ell$ $A_2 = 0{,}067 \cdot \beta_s \cdot p_{yl} \cdot S \cdot (\ell - 2 \cdot B_3)$

Table 15.3 Net scantlings of double bottom structure-continued-

Item	Parameter	Transverse framing	Longitudinal framing
Bottom transverses in the side tank	Section modulus [cm^3]	NA	$w = MAX(w_1;w_2)$ $w_1 = 2{,}32 \cdot \beta_b . p_1 . S . B_2 .(\ell - B_2)$ $w_2 = 2{,}32 \cdot \beta_b \cdot p_{\gamma I} \cdot S \cdot B_2 \cdot (\ell - 2 \cdot B_2)$
	Shear sectional area [cm^2]	NA	$A_{sh} = MAX(A_1;A_2)$ $A_1 = 0{,}067 \cdot \beta_s . p_1 . S . \ell$ $A_2 = 0{,}067 \cdot \beta_s \cdot p_{\gamma I} \cdot S \cdot (\ell - 2 \cdot B_3)$
Bottom centre and side girders **(1)**	Shear sectional area [cm^2]	$A_{sh} = 0{,}051 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

p = Design load [kN/m^2] of bottom primary supporting members
= $MAX(p_1;p_{\gamma I})$
p_1 = $p_{\gamma E}$
p_2 = Design load of bottom and inner bottom longitudinals [kN/m^2]:
- In way of ballast tanks:
  - for bottom longitudinals: $p_2 = MAX(p_E;(p_B - p_M))$
  - for inner bottom longitudinals: $p_2 = MAX(p_C;p_B)$
- Elsewhere:
  - for bottom longitudinals: $p_2 = p_E$
  - for inner bottom longitudinals: $p_2 = p_C$

$p_{\gamma E}$ = Design load [kN/m^2] of bottom primary supporting members
= $9{,}81 \cdot (\gamma \cdot T + 0{,}6 \cdot n)$
γ = 0,575 in general
= 1,0 for loading/unloading in one run or for vessels fitted with independent tanks
$p_{\gamma I}$ = Design load [kN/m^2] of bottom primary supporting members
= $p_C - p_M$
p_M = Minimum external pressure [kN/m^2], $p_M \geq 0$
= $9{,}81 \cdot (0{,}15 \cdot T - 0{,}6 \cdot n)$
p_E, p_B, p_C = Pressures transmitted to the double bottom structure, defined in D.6.1.1 and in Section 6, C.5.
A_a = Cross sectional area of attached inner bottom plating [cm^2]
w_0 = Section modulus [cm^3] of floors or bottom transverses in the tank
ℓ = Floor or bottom transverse span [m]:
- where no intermediate longitudinal bulkhead is fitted: $\ell = B$
- where intermediate longitudinal bulkheads are fitted, ℓ is the distance between outer side and intermediate longitudinal bulkhead, or the distance between intermediate longitudinal bulkheads

B_3 = Parameter [m] defined as follows:
- where no longitudinal bulkhead is fitted: $B_3 = B_2$
- where intermediate longitudinal bulkheads are fitted:
  - for outer tank: $B_3 = 0{,}5 . B_2$
  - for other tanks: $B_3 = 0$
- on vessels fitted with independent tanks, B_3 is the distance between the hull outer side and the independent tank wall

(1) The span ℓ is to be taken equal to the web frame or side transverse spacing.
(2) In way of ordinary stiffeners, $\beta_b = \beta_s = 1$

Note
NA = not applicable.

Table 15.4 Side single skin structure

Item	**w [cm³]**	**A_{sh} [cm²]**
Side frames	$w = MAX (w_1;w_2)$ $w_1 = 0,58 \cdot \beta_b \cdot \eta . s \; . \; (1,2 \cdot k_0 \cdot p_E \cdot \ell_0^2 + \lambda_t \cdot p_{\gamma E} \cdot \ell_F^2)$ $w2 = 0,58 \cdot \beta_b \cdot \eta \cdot s \cdot (\lambda_b \cdot p_2 \cdot \ell^2. + \lambda_t \cdot p_{\gamma I} \cdot \cdot \ell_F^2)$	$A_{sh} = MAX (A_1;A_2)$ $A_1 = 0,08 \cdot \beta_s \cdot \eta \cdot k_0 . p_E \cdot s \cdot \ell_0$ $A_2 = 0,058 \cdot \lambda_s \cdot \beta_s \cdot p_2 \cdot s \cdot \ell$
Side longitudinals	$w = \dfrac{83,3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames Side transverses **(1)**	$w = MAX (w_1;w_2)$ $w_1 = 1,96 \cdot \beta_b \cdot k_0 \cdot p_E \cdot S \cdot \ell_0^2$ $w_2 = 1,63 \cdot \lambda_b \cdot \beta_b \cdot p_2 \cdot S \cdot \ell^2$	$A_{sh} = MAX (A_1;A_2)$ $A_1 = 0,063 \cdot \beta_s \cdot k_0 \cdot p_E \cdot S \cdot \ell_0$ $A_2 = 0,045 \cdot \lambda s \cdot \beta_s \cdot p_2 \cdot S \cdot \ell$
Sidfe stringers **(2)**	$w = \dfrac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Design load of side structural members [kN/m²]
= $MAX (p_E;p_2)$

p_E = External pressure transmitted to the side structural members, defined in Section 6, C.4.
For vertical structural members: $p_E = 4,9 \cdot (T - H_F + 0,6 \cdot n)$

p_2 = Design load [kN/m²]
= $|p_C - p_M|$
$p_C = 0$ for vessels with independent tanks

$p_{\gamma E}$ = Floor design load [kN/m²]
= $9,81 \cdot (\gamma \cdot T + 0,6 \cdot n)$
γ = 0,575 in general
= 1,0 for loading/unloading in one run or for vessels fitted with independent tanks

$p_{\gamma I}$ = Floor design load [kN/m²]
= $p_C - p_M$

p_M = Minimum external pressure [kN/m²], $p_M \geq 0$:
- for $z \leq 0,15 \cdot T$: $p_M = 9,81 \cdot (0,15 \cdot T - z - 0,6 \cdot n)$.
- for $z > 0,15 \cdot T$: $p_M = 0$

ℓ_0 = $T - H_F + 0,6 \cdot n$

ℓ_F = Floor span [m]

H_F = Floor height or bottom transverse height [m]

k_0 = Coefficient given by the formula:
= $1 + (\ell - \ell_0) / \ell_0$

λ_t = Coefficient
- in transverse framing:

$$= 0,1 \cdot \left(0,8 - \frac{\ell^2}{\ell_F^2} \right), \lambda_t \geq 0$$

- in combination framing: $\lambda_t = 0$

p_C = Pressure transmitted to the double side structure, defined in Section 6, C.5.

(1) *Scantlings of web frames and side transverses at the lower end have to be adequate to those of floors or bottom transverses connected to them, and at the upper end they are to be the same as those of the deck transverses connected to them.*

(2) *The span of side stringers is to be taken equal to the side transverse spacing or the web frame spacing.*

Table 15.5 Side double skin structure

Item	w [cm^3]	A_{sh} [cm^2]
Side frames subjected to external load	$w = 0,7 \cdot \beta_b \cdot k_0 \cdot p \cdot s \cdot \ell_0^2$	$A_{sh} = 0,08 \cdot \beta_s \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side frames (other loading cases) and inner side frames	$w = 0,58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0,058 \cdot \lambda_s \cdot \beta_s \cdot p \cdot s \cdot \ell$
Side longitudinals Inner side longitudinals	$w = \dfrac{83,3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0,045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames and side transverses subjected to external load	$w = 0,7 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0,08 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side web frames, inner side web frames, side transverses and inner side transverses in other loading cases	$w = 0,58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,045 \cdot \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Plate web frames subjected to external load	$w = 1,96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0,063 \cdot \beta_s \cdot p \cdot S \cdot \ell_0$
Plate web frames in other loading cases	$w = 1,63 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,045 \cdot \lambda_s \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell$
Side stringers **(1)** Inner side stringers **(1)**	$w = \dfrac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0,056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Design load of double side structural members [kN/m^2]:
- for inner side structure:
  - in way of ballast tanks: $p = MAX (p_C; p_B)$
  - elsewhere: $p = p_C$
- $p_C = 0$ for vessels with independent tanks
- for side structure:
  - in way of ballast tanks: $p = MAX (p_E; (p_B - p_M))$
  - elsewhere: $p = p_E$

p_E = External pressure transmitted to the side structural members, defined in, Section 6, C.4.
For vertical structural members: $p_E = 4,9 \cdot (T - H_F + 0,6 \cdot n)$

ℓ_0 = $T - H_F + 0,6 \cdot n$

H_F = Floor height or bottom transverse height [m]

k_0 = Coefficient given by the formula:
= $1 + (\ell - \ell_0) / \ell_0$

p_M = Minimum external pressure [kN/m^2], $p_M \geq 0$:
- for $z \leq 0,15 \cdot T$: $p_M = 9,81 \cdot (0,15 \cdot T - z - 0,6 \cdot n)$
- for $z > 0,15 \cdot T$: $p_M = 0$

p_B, p_C = Pressures transmitted to the double side structure, defined in Section 6, C.5.

(1) *The span of side stringers is to be taken equal to the side transverse spacing or the web frame spacing.*

5. Transverse rings

5.1 General

5.1.1 The strength check of the transverse rings is to be performed by direct calculation according to Section 5, E.

In particular, the requirements of 4.2 to 4.4 below, are to be complied with.

5.1.2 The following loading conditions are to be considered:

- Light vessel draught, fully loaded tank subjected to cargo load as per Section 6, C.5.

- Fully loaded tank subjected to test pressure (see Section 6, C.6.)

- Fully loaded vessel draught, empty tank subjected to external pressure, as per Section 6, C.4.

5.2 Floors and bottom transverses in way of rings

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 web

- Continuity of double bottom in the side tank

5.3 Web frames and side transverses in way of rings

For side primary supporting members, the level of bending stresses and shear stresses in way of holes and passage of longitudinals is to be checked.

5.4 Strong beams and deck transverses in way of rings

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 web

- Continuity of structure and lateral support of deck transverses, notably, when the flange of the deck transverse is a round bar

5.5 Pillars

5.5.1 Strong beams and deck transverses in way of rings are to be supported by pillars. The pillar scantlings are to be determined according to Section 8, D.9.

The pillars and their attachments are also to be examined for tensile stressing resulting from the relevant test pressure related to the respective vessel type.

5.5.2 Tubular pillars are to be avoided in the cargo tanks as far as possible. On tank vessels intended to carry flammable liquids or chemicals, tubular pillars are not permitted.

5.5.3 The pillars are to be attached to the girders as well as to the floor plates located below by means of welding.

5.6 Break in the deck

A reinforced deck transverse, pillars or a transverse bulkhead is to be fitted in way of the deck break.

6. Structural arrangements

6.1 Vessels with integrated tanks, transverse framing system

6.1.1 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.

6.1.2 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.

6.1.3 Web frames

The web frames are to be spaced not more than 4m apart, considering the frames are supported at midspan by a stringer.

6.1.4 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.

6.2 Vessels with integrated tanks, longitudinal framing system

6.2.1 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.

6.2.2 Deck longitudinals

The deck longitudinals are to be continuous through expansion tanks, unless efficient compensations are fitted.

6.3 Vessels with integrated tanks, combination system

6.3.1 Web frames

It is recommended to arrange side shell and longitudinal bulkhead web frames in way of bottom and deck transverses.

6.4 Vessels with independent tanks

6.4.1 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 **TL**.

6.4.2 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.

6.4.3 Frames

The side frames 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.

6.5 Fastening of self-supporting tanks

6.5.1 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 a stringer 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.

6.5.2 Antiflotation arrangements are to be provided for independent tanks. The antiflotation 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.

6.5.3 The strength check of the seatings and stays is to be carried out in compliance with Section 5, E., using a partial safety factor γ_R = 1,5.

6.5.4 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 transport temperature.

6.6 Double hull arrangements

6.6.1 General

All parts of the cargo zone are to be well ventilated and accessible to ensure surveys and maintenance.

6.6.2 Access to double bottom

Manholes may be cut in the floors and side girders to provide convenient access to all parts of the double bottom.

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.

As a rule, the manholes height is not to be more than 0,6 times the floor height or girder height.

Manholes in the floors are to be located at half the floor height and in a region extending on 0,2 · B from the axis of the vessel, on both sides. When a central girder exits, its distance to the nearest side of cutting is not to be less than the double bottom height.

Manholes in the side girders are to be located at half the girder height and midway between two successive web frames. Their distance from the transverse bulkheads of the side tanks is not to be less than 1,5 m, if there is no web frame. **TL** may waive this rule subject to direct calculation of the shear stresses.

6.6.3 Access to side tanks

Manholes are to be cut in the stringer plate and plate webs to provide convenient access to all parts of the side tanks.

Openings in the stringer plate are to be arranged clear of the hatch corners. They are to be cut smooth along a well-rounded design and are to be strengthened by thick plates or by doubling plates.

6.6.4 Access to tanks

As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of cargo tanks.

6.6.5 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 [cm2] is not to be less than:

$$A = 0{,}01 \cdot b \cdot t_F$$

b = Section height [mm]: $b = 100 \cdot H_D$

where H_D is the double bottom height [m]

t_F = Net thickness of floor web [mm]

6.7 Expansion tanks

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.

Scantlings of expansion tank covers are to be specially examined by **TL**.

7. Subdivision

7.1 General

7.1.1 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.

7.1.2 The bulkhead scantlings are to be determined in compliance with Section 8, E., taking into account additional requirements stated under 7.2 and 7.3.

7.2 Minimum thickness of bulkhead plating

7.2.1 Minimum plating thickness

The net thickness [mm] of liquid cargo tank bulkheads is to be not less than that obtained from the following formula:

$$t = 1{,}36 + 0{,}011 \cdot L \cdot k^{0{,}5} + 3{,}6 \cdot s$$

In the cargo tank area, including cofferdams, the net thickness of plates and structural members in spaces containing water are to be not less than 4,4 mm.

7.3 Minimum net thickness of structural members

7.3.1 Ordinary stiffeners

The minimum net thickness [mm] of the web plate of ordinary stiffeners is to be obtained from the following formula:

$$t = 0{,}61 \cdot L^{1/3} \cdot k^{0{,}5} + 3{,}6 \cdot s$$

7.3.2 Primary supporting members

The minimum net thickness [mm] of the web plate of primary supporting members is to be obtained using the following formula:

$$t = 1{,}14 \cdot L^{1/3} \cdot k^{0{,}5}$$

7.4 Corrugated bulkheads

7.4.1 General

In place of plane bulkheads provided with stiffeners, corrugated bulkheads, determined according to Section 8, E., may be built in.

7.4.2 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 Section 5, E.

7.5 Ends of cargo zone

The inner longitudinal side has to be extended inside the cofferdam. Moreover, when possible, it is to be extended in the fore and aft vessel by means of brackets.

B. Container Vessels

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Net thickness [mm] of plating

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

2. General

2.1 Application

2.1.1 The type and service notation **Container** is assigned, in accordance with Section 2, B.3.1.2, to vessels intended to carry dry unit cargoes.

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Section 1-13, as applicable, and with the following requirements, which are specific to container vessels.

2.1.3 Applicable requirements stated under Section 14, A. and Section 14, B. are also to be complied with.

2.2 Stability

Compliance with the applicable stability requirements according to Section 17, F. is to be proven.

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.

3.1.2 Structural continuity

In double hull vessels, the inner side is to extend as far aft as possible and be tapered at the ends.

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 that of the container corners (see Fig. 15.4).

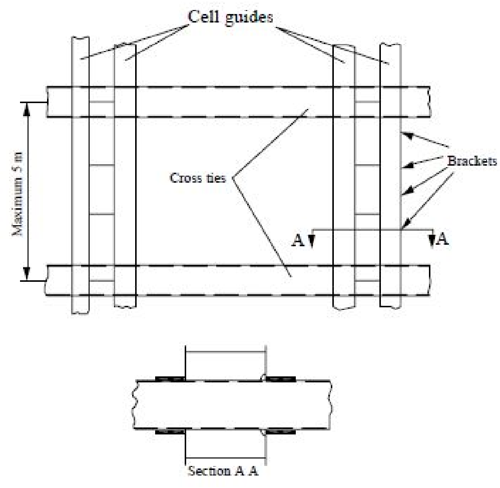


Fig. 15.4 Typical structure of cell guides

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

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.

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.

3.4.2 Documentation to be submitted

A list and/or plan of all the fixed securing devices, indicating their location on board, is to be provided. For each type of fixed securing device, the following information is to be indicated:

- Type designation
- Sketch of the device
- Material
- Breaking load
- Maximum securing load

3.5 Hatch covers carrying containers

Efficient retaining arrangements are to be provided to prevent translatory motion 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 translatory motion of the stacks by means of special intermediate parts arranged between the supports of the corners and the container corners.

4. Design loads

4.1 Design torsional torque

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 [kNm] from the following formula:

$$M_T = 31{,}4 \cdot n_S \cdot n_T \cdot B$$

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)

4.2 Force on containers

4.2.1 The force F_i applied to one container located at the level "I", as defined in Fig. 15.5, is to be determined in compliance with Section 6, C.6.5

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

4.2.2 Stacks of containers

The force transmitted at the corners of such stack is to be obtained [kN] using the following formula:

$$P = F/4$$

$$F = \sum_{i=1}^{N} F_i$$

N = number of containers in a stack

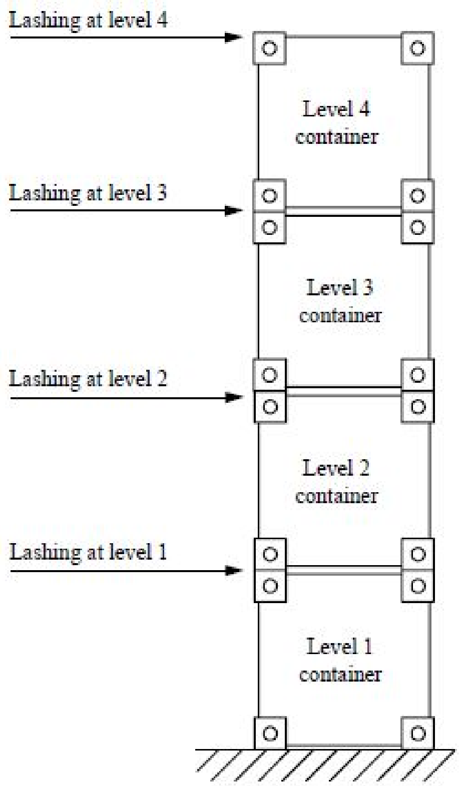


Fig. 15.5 Container levels in a stack

4.2.3 Securing load

The scantling load of securing devices is to be determined assuming an angle of list of 12°.

5. Hull scantlings

5.1 General

5.1.1 In general, the hull scantlings and arrangements are to be in compliance with Section 8.

5.1.2 Scantlings of structural members subjected to concentrated loads are to be determined by direct calculation according to Section 5, E. In particular, the requirements of 6. are to be complied with.

5.1.3 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 4.1.

5.2 Container seating

The net thickness [mm] of container seating, if fitted, is to be not less than that of the adjacent inner bottom plating nor than the thickness obtained from the following formula:

$$t_{WL} = 0{,}8 \cdot C_{WL} \cdot \sqrt{k \cdot n_C \cdot P}$$

C_{WL} = Coefficient

$$2{,}15 - \frac{0{,}05 \cdot \ell}{s} + 0{,}02 \cdot \left(4 - \frac{\ell}{s}\right) \cdot \alpha^{0{,}5} - 1{,}75 \cdot \alpha^{0{,}25}$$

Where ℓ/s is to be taken not greater than 3

$$\alpha = \frac{A_T}{\ell \cdot s}$$

A_T = Area of a stack of container corner [m^2]

n_C = Number of stacks of container corners on the seating

ℓ = MAX (a, b)

s = MIN (a, b)

a, b = Spacings [m] of container supporting members

6. Direct calculation

6.1 General

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 Section 5, E.

6.2 Loading cases

6.2.1 Bottom structure

The following loading conditions are to be considered in the analysis of the bottom primary supporting members:

- Full container load and scantling draught equal to $0{,}575 \cdot T$
- Maximum vessel draught T, without containers

6.2.2 Deck structure

Where containers are loaded on the deck, the analysis of the deck structure is to be carried out taking into account a full container load.

6.3 Structure checks

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 web
- continuity of double bottom in the side tank, for bottom structure

C. Ro-Ro Vessels

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

σ_1 = Hull girder normal stress [N/mm^2]

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web shear sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

z = Z co-ordinate [m] of the calculation point

M_H = Design bending moment [kNm] in hogging condition

M_S = Design bending moment [kNm] in sagging condition

F = Wheeled force [kN] defined in Section 6, C.6.6

2. General

2.1 Application

2.1.1 The type and service Notation **Ro-Ro Vessel** is assigned, in accordance Section 5, B.3.1.3 to vessels intended to carry wheeled vehicles.

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Section 1-13, as applicable, and with the requirements of this Section, which are specific to Ro-Ro vessels.

2.1.3 Applicable requirements stated under Section 14, A. and Section 14, B. are also to be complied with.

2.2 Stability

Depending on the vessel's design and operating conditions, proof of sufficient stability may be required by **TL**.

3. Vessel arrangements

3.1 Sheathing

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 ro-ro cargo 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 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.

Where a transverse framing system is adopted for such structures, it is to be considered by **TL** on a case-bycase basis.

4. Hull scantlings

4.1 General

4.1.1 In general, the hull scantlings and arrangements are to be in compliance with Section 8.

4.1.2 Scantlings of plating and structural members subjected to wheeled loads are to be determined in compliance with 4.2 to 4.4.

4.2 Plating

4.2.1 The net thickness [mm] of plate panels subjected to wheeled loads is to be obtained from Table 15.7, where:

t_{WL} = Plating net thickness [mm]

$$t_{WL} = 0{,}8 \cdot C_{WL} \cdot \sqrt{k \cdot n_P \cdot F}$$

C_{WL} = coefficient

$$2{,}15 - \frac{0{,}05 \cdot \ell}{s} + 0{,}02 \cdot \left(4 - \frac{\ell}{s}\right) \cdot \alpha^{0,5} - 1{,}75 \cdot \alpha^{0,25}$$

Where ℓ/s is to be taken not greater than 3

$$\alpha = \frac{A_T}{\ell \cdot s}$$

AT = Tyre print area [m2]. In the case of double or triple wheels, the area is that corresponding to the group of wheels

np = Number of wheels on plate panel, taken equal to:

- 1 in case of a single wheel
- the number of wheels in a group of wheels, in the case of double or triple wheels.

4.2.2 Tyre print area

When the tyre print area is not known, it may be taken equal to:

$$A_T = 9{,}81 \cdot \frac{n_p \cdot Q_A}{n_W \cdot p_T}$$

Q_A = Axle load [t]

n_W = Number of wheels for the axle considered

p_T = Tyre pressure [kN/m^2]. When the tyre pressure is not indicated by the designer, it may be taken as defined in Table 15.6.

Table 15.6 Tyre pressure p_T for vehicles

Vehicle	Tyre pressure p_T [kN/m^2]	
	Pneumatic tyres	**Solid rubber tyres**
Private cars	250	NA
Vans and fork lift trucks	600	NA
Trucks and trailers	800	NA
Handling machines	1100	1600
NA = not applicable		

4.2.3 For vehicles with the four wheels of the axle located on a plate panel as shown in Fig. 15.6, the net thickness of the plating is to be not less than the greater of the values obtained [mm] from the following formulae:

$$t_{WL} = t_1$$

$$= t_2 \cdot [k \cdot (1 + \beta_2 + \beta_3 + \beta_4)]^{0,5}$$

t_1 = Net thickness obtained [mm] from 3.2.1 for n_p = 2, considering one group of two wheels located on the plate panel

t_2 = Net thickness obtained [mm] from 3.2.1 for n_p = 1, considering one wheel located on the plate panel

$\beta_2, \beta_3, \beta_4$ = Coefficients obtained from the following formula, by replacing i by 2, 3 and 4, respectively (see Fig. 15.6):

- for xi / b < 2:

$$\beta i = 0{,}8 \cdot (1{,}2 - 2{,}02 \cdot \alpha_i + 1{,}17 \cdot \alpha_i^2 - 0{,}23 \cdot \alpha_i^3)$$

- for xi / b ≥ 2:

$$\beta i = 0$$

xi = Distance [m] from the wheel considered to the reference wheel (see Fig. 15.6)

b = Dimension [m] of the plate panel side perpendicular to the axle

$$\alpha_i = \frac{x_i}{b}$$

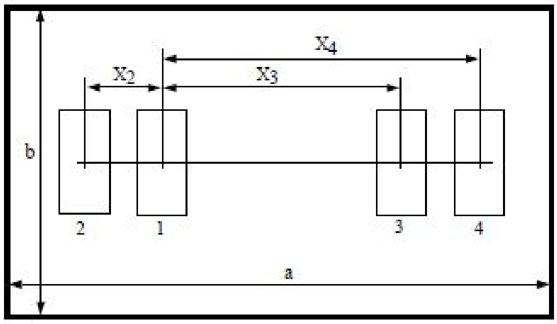


Fig. 15.6 Four wheel axle located on a plate panel

4.3 Primary supporting members

4.3.1 Wheeled loads

The scantlings of primary supporting members subjected to wheeled loads are to be determined according to Table 15.11 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 unfavourable case, i.e. where the maximum number of axles is located on the same primary supporting member according to Fig. 15.8 to Fig 15.10, is to be considered.

The equivalent pressure may be determined using the formula:

$$p_{eq} = 10 \cdot \frac{n_V \cdot Q_A}{\ell \cdot S} \cdot \left(3 - \frac{X_1 + X_2}{S}\right)$$

Table 15.7 Net thickness of plating subjected to wheeled loads [mm]

Item	Transverse framing	Longitudinal framing
Inner bottom plating	t = MAX (t_i) $t_1 = 1{,}5 + 0{,}016.L.k^{0,5} + 3{,}6.s$ $t_2 = t_{WL}$ and, for L ≥ 40 m **(1)**: $t_3 = 68 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{\cdot M_H}{Z_{DB}}}$	t = MAX (t_i) $t_1 = 1{,}5 + 0{,}016.L.k^{0,5} + 3{,}6.s$ $t_2 = t_{WL}$ and, for L ≥ 40 m **(1)**: $t_3 = 39 \cdot s \cdot \sqrt{\frac{\cdot M_H}{Z_{DB}}}$
Deck plating	t = MAX (t_i) $t_1 = 0{,}9 + 0{,}034 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = t_{WL}$ and, for L ≥ 40 m **(1)**: $t_3 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_3/s > 23{,}9 \cdot (k^{0,5} \cdot k_2)$ $t_3 = \frac{7{,}76 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_S}{Z_D}}}$	t = MAX (t_i) $t_1 = 0{,}57 + 0{,}031.L.k^{0,5} + 3{,}6.s$ $t_2 = t_{WL}$ and, for L ≥ 40 m **(1)**: $t_3 = 39 \cdot s \cdot \sqrt{\frac{\cdot M_S}{Z_D}}$ if $t_3/s > 12{,}5/k^{0,5}$. $t_3 = \frac{4{,}1 \cdot k^{0,5} \cdot s}{\sqrt{0{,}21 - \frac{M_S}{Z_D}}}$

k_2 = $1 + \alpha^2$

α = s / b

b = Unsupported plate width in y direction [m]

t_{WL} = Net thickness [mm] defined in 4.2

Z_D = Deck net hull girder section modulus [cm^3]

Z_{DB} = Inner bottom net hull girder section modulus [cm^3]

(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

Table 15.8 Net scantlings of ordinary stiffeners subjected to wheeled loads

	w [cm^3]	**A_{sh} [cm^2]**
L ≥ 40 m	$w = \frac{167 \cdot k}{225 - \sigma 1} \cdot \alpha_W \cdot K_S \cdot F \cdot \ell$	$A_{sh} = 0{,}088 \cdot k \cdot \alpha_W \cdot K_T \cdot F$
L < 40 m	$w = 0{,}74 \cdot k \cdot \alpha_W \cdot K_S . F \cdot \ell$	

α_W = Coefficient taking into account the number of wheels and wheels per axle considered as acting on the stiffener, defined in Table 15.8

K_S, K_T = Coefficient taking into account the number of axles considered as acting on the stiffener, defined in Table 15.10.

n_V = Maximum number of vehicles possible located on the primary supporting member

Q_A = Maximum axle load [t]

X_1 = Minimum distance [m] between two consecutive axles (see Fig. 15.9 and Fig. 15.10)

X_2 = Minimum distance [m] between axles of two consecutive vehicles (see Fig. 15.9)

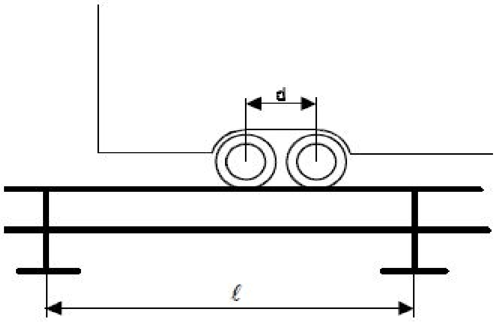


Fig. 15.7 Wheeled load on stiffeners - Double axles

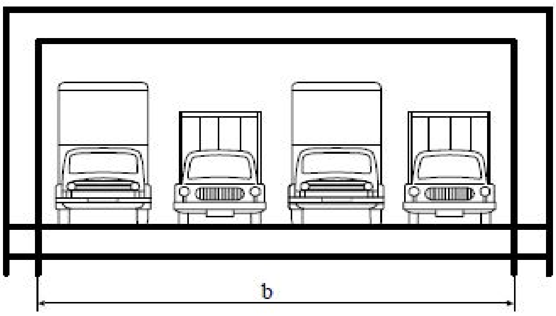


Fig. 15.8 Wheeled loads - Distribution of vehicles on a primary supporting member

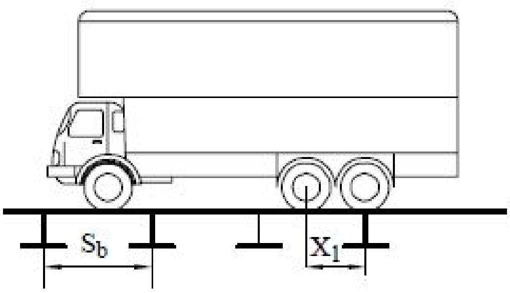


Fig. 15.9 Wheeled loads - Distance between two consecutive axles

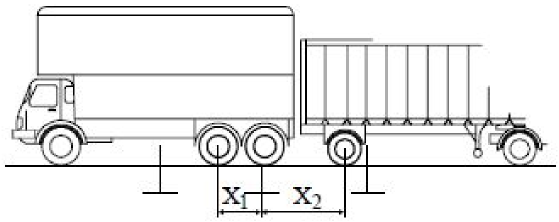


Fig. 15.10 Wheeled loads - Distance between axles of two consecutive vehicles

4.3.2 For arrangements different from those shown in Fig. 15.8 to Fig. 15.10, the scantlings of primary supporting members are to be determined by direct calculation, in compliance with Section 5, E.

4.4 Ordinary stiffeners subjected to wheeled loads

4.4.1 Net scantlings

The net section modulus w [cm^3] and the net shear sectional area A_{sh} [cm^2] of ordinary stiffeners subjected to wheeled loads are to be obtained from formulae given in Table 15.8.

Table 15.9 Wheeled loads - Coefficient α_W

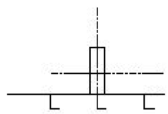
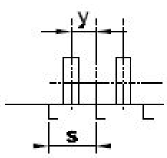
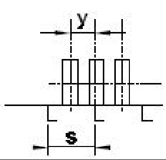
Configuration	α_W
Single wheel 	1
Double wheels 	$2 \cdot \left(1 - \frac{y}{s}\right)$
Triple wheels 	$3 - 2 \cdot \frac{y}{s}$
y = Distance [m] from the external wheel of a group of wheels to the stiffener under consideration, to be taken equal to the distance from the external wheel to the centre of the group of wheels	

Table 15.10 Wheeled loads - Coefficients K_S and K_T

Coefficients	Single axle	Double axles
K_S	1	- if $d < 2\cdot\ell/3$ $\frac{43}{18}\cdot\frac{7\cdot d}{4\cdot\ell}-\frac{d^2}{4\cdot\ell^2}+\frac{9\cdot d^3}{16\cdot\ell^3}$ – if $d \geq 2\cdot\ell/3$ $\frac{9}{4}\cdot\frac{3\cdot d}{8\cdot\ell}-\frac{3\cdot d^2}{2\cdot\ell^2}$
K_T	1	$2-0{,}5\cdot\frac{d}{\ell}-1{,}5\cdot\frac{d^2}{\ell^2}+\frac{d^3}{\ell^3}$
d = Distance [m] between two axles (see Fig.15.7)		

5. Other structures

5.1 Movable decks and inner ramps

The requirements applicable to movable decks and inner ramps are defined in Section 9, F.1.

5.2 External ramps

The requirements applicable to external ramps are defined in Section 9, F.2.

D. Passenger Vessels

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

L_{WL} = Length of the hull [m] measured at the maximum draught

Δ = Displacement of the laden vessel [t]

v = Maximum speed of the vessel in relation to the water [m/s]

KG = Height [m] of the centre of gravity above base line

C_B = Block coefficient

S = Spacing [m] of primary supporting members

n = Navigation coefficient defined in Section 6, B.

= $0{,}85 \cdot h$

h = Significant wave height [m]

σ_1 = Hull girder normal stress [N/mm^2]

z = Z co-ordinate [m] of the calculation point

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service Notation **Passenger vessel**, as defined in Section 2, B.5.1.1

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Section 1-13, as applicable, and with the requirements of this Section, which are specific to passenger vessels.

2.1.3 Various requirements of these Rules are to be applied for safety of passengers and crew according to Table 15.12.

Where available, statutory Regulations in the operating area of the vessel (e.g. Rhine Rules, European directive) are to take precedence over these requirements.

Table 15.11 Net scantlings of primary supporting members

Item	w [cm^3]	A_{sh} [cm^2]
Transverse primary supporting members	$w = 0{,}58 \cdot k \cdot \beta_b \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot k \cdot \beta_s \cdot p \cdot s \cdot \ell$
Deck girders	$w = \dfrac{125}{214 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot k \cdot \beta_s \cdot p \cdot S \cdot \ell$
Double bottom girders	$w = \dfrac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}056 \cdot k \cdot \beta_s \cdot p \cdot S \cdot \ell$
Vertical primary supporting members	$w = \dfrac{125}{214 - \sigma_A} \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0{,}045 \cdot k \cdot \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = Design load [kN/m^2]: $p = p_{eq}$

σ_A = Axial stress, to be obtained [N/mm^2] from the following formula:

$$= 10 \cdot \frac{F_A}{A}$$

F_A = Axial load transmitted to the vertical primary supporting members by the structures above (see calculation of P_S in Section 8, D.9.2.1).

A = Net sectional area [cm^2] of the vertical primary supporting members with attached plating of width b_P

2.2 Definitions

2.2.1 Day trip vessel

A day trip vessel is a passenger vessel without overnight passenger cabins.

2.2.2 Cabin vessel

A cabin vessel is a passenger vessel with overnight passenger cabins.

Table 15.12 Requirements applicable for safety of passengers and crew

Item	Applicable requirements
Subdivision, transverse bulkheads	3.1
Passenger rooms and areas	3.2
Propulsion system	3.3
Fire protection, detection and Extinguishing	4
Electrical installations	5

3. Vessel arrangement

3.1 Subdivision, transverse bulkheads

3.1.1 In addition to the bulkheads called for in Section 8, E., the vessel is to be subdivided by further watertight transverse bulkheads in such a way that the requirements of 6. 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 6.3.3.

3.1.2 The first compartment aft of the collision bulkhead may be shorter than the length of damage stated in 6.3.3 if the total length of the two foremost compartments measured in the plane of maximum draught is not less than this value.

The distance of the collision bulkhead from the forward perpendicular shall be between $0{,}04 \cdot L_{WL}$ and $(0{,}04 \cdot L_{WL} + 2)$ [m].

3.1.3 Passenger spaces are to be separated by watertight bulkheads from cargo, machinery and boiler spaces. Bulkhead doors are not permitted in the bulkheads between passenger and machinery spaces. The number of openings in watertight bulkheads shall be as small as is compatible with the construction and proper operation of the vessel.

3.1.4 Bulkhead doors which are normally in the OPEN position shall be locally operable from both sides of the bulkhead, shall be capable of being closed from an accessible location above the bulkhead deck and shall meet the following conditions:

- The closing time is not to be less than 20 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 shall sound automatically.

- The door drive and signalling systems shall 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 shall be situated outside the penetration depth stated in 6.3.3.

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 lying outside the penetration depth stated in 6.3.3 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.

Note

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 nonwatertight point of the vessel's 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.

3.2 Passenger rooms and areas

3.2.1 Means of escape

Spaces or group of spaces which are provided for 30 or more passengers or are equipped as such or which have beds for 12 or more passengers shall be provided with at least two widely separated and ready means of escape. On board of day trip vessels one of the means of escape may be replaced by two emergency exits.

For spaces below the freeboard deck one of the required means of escape may be a watertight door to the adjacent watertight compartment from which the uppermost deck can be reached. The second means of escape shall lead directly to a safe area above the bulkhead deck or open deck. This does not apply to single cabins.

Means of escape are to be arranged in a practical way and shall have a clear width of at least 0,8 m and a clear height of at least 2 m. The width of doors to cabins may be reduced to 0,7 m.

Spaces and group of spaces provided for more than 80 passengers shall have escape ways with a clear width of at least 0,01 m per passenger. This does also apply to doors within the means of escape.

Doors shall always open in the direction of means of escape and shall be clearly marked as such.

3.2.2 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 opening 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.

3.2.3 Stairs

Stairs and their landings in the passenger areas shall comply with the following requirements:

a) They shall be constructed in accordance with recognized standards.

b) They shall have a clear width of at least 0,80 m or, if they lead to connecting corridors or areas used by more than 80 passengers, at least 0,01 m per passenger.

c) They shall have a clear width of at least 1,00 m if they provide the only means of access to a room intended for passengers.

d) They shall not lie in the damage area, unless there is at least one staircase on each side of the vessel in the same zone.

3.2.4 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 evacuation areas.

c) Escape routes shall not lead through engine rooms or galleys.

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.

3.3 Propulsion system

3.3.1 In addition to the main propulsion system, vessels shall be equipped with a second independent propulsion system so as to ensure that, in the event of a breakdown affecting the main propulsion system, the vessel can continue to make steerageway under its own power.

3.3.2 The second independent propulsion system shall be placed in a separate engine room. If both engine rooms have common partitions, these shall be built according to Section 17, G.2.

4. Fire protection, detection and extinguishing

4.1 Documents for review/approval

The following drawings and documents are to be submitted where applicable, at least in triplicate or in electronic format for review/approval:

- Fire division/insulation plan showing designation of each space, including information on applied materials and constructions
- Ventilation plan
- Escape way plan
- Sprinkler system

4.2 Fire protection in accommodation areas

4.2.1 General

All insulation materials, bulkheads, linings, ceilings and draught stops shall be of at least approved noncombustible material.

Primary deck coverings and surface materials shall be of an approved type.

4.2.2 Integrity of bulkheads and decks

Bulkheads between cabins shall be of approved type B-0 and to corridors of approved type B-15.

Where a sprinkler system is fitted, the corridor bulkheads may be reduced to approved type B-0.

Corridor bulkheads shall extend from deck to deck unless a continuous B-class ceiling is fitted on both sides of the bulkhead in which case the corridor bulkhead may terminate at the continuous ceiling.

All stairways are to be of steel frame or other noncombustible 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.

4.2.3 Internal subdivision

The vessel shall be subdivided into sections of not more than 40 m length by class A divisions. 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.

Galleys and control stations shall be separated from adjacent spaces by class A divisions. Machinery spaces are to be separated from accommodation areas by class A divisions. Doors fitted therein shall have the same fire resistance and shall be self-closing and reasonable gastight.

Air spaces enclosed behind ceilings, panelling or linings shall be divided by close-fitting draught stops spaced not more than 14 m apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., shall be closed at each deck level.

4.2.4 Means of escape

One of the means of escape required by 3.2.1 shall give direct access to a stairway from where the embarkation deck or the open deck can be reached.

Stairways shall have a clear width of at least 0,80 m. Clear width means between bulkheads and/or handrails.

Emergency exits shall have a clear dimension of not less than (0,70 × 0,70) m^2 or diameter of at least 0,7 m. They shall open in the direction of escape and be marked on both sides.

4.2.5 Ventilation system

All parts of the system shall be made of noncombustible 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 (see Note).

Ventilation ducts are to be subdivided by approved fire dampers analogously to the requirements of 4.2.3 (first paragraph). Penetrations through stairway boundaries are also to be provided with approved fire dampers.

Fire dampers are to be so designed that they can be operated locally from both sides of the division.

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 5, adopted by IMO by Resolution MSC. 61(67).

4.3 General water fire extinguishing system

4.3.1 Passenger vessels over 40 m L_{WL} and passenger vessels with cabins for passengers over 25 m L_{WL} are subject to the additional requirements of 4.3.2 to 4.3.5.

4.3.2 It shall 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 shall be at least 12 m with a nozzle diameter of 12 mm.

4.3.3 The minimum capacity of the fire pump is to be 20 m^3/h.

4.3.4 If the fire pump is located in the engine room, a second power-driven fire pump shall be provided outside the engine room. The pump drive shall be independent of the engine room, and the pump capacity shall conform to the preceding requirements 4.3.2 and 4.3.3.

Connections in the piping system with the engine room shall 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.

4.3.5 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.

4.4 Portable fire extinguisher

4.4.1 One additional fire extinguisher is to be provided for:

- Each unit of 120 m^2, or part thereof, of the gross floor area of public rooms, dining rooms and day rooms
- Each group of 10 cabins, or part thereof

4.4.2 Galleys and shops shall depending on their size and contents be provided with additional fire extinguishers.

4.4.3 These additional fire extinguishers are to be located in such a way that a fire extinguisher is at all times accessible in the immediate vicinity of any position.

4.5 Fixed fire extinguishing systems

Machinery spaces containing internal combustion engines used for propulsion and oil fired boilers shall be provided with a fixed fire extinguishing system in compliance with Section 12, H.3

Where installed, automatic pressure water spraying systems for the passenger area shall be ready for operation at all times when passengers are on board. No additional measures on the part of the crew shall be needed to actuate the system.

5. Electrical installations

5.1 General

5.1.1 Application

Cabin vessels and day trip vessels (L_{WL} ≥ 25 m) are required to comply with the following requirements in addition to the requirements stated under Section 13.

Relaxations of these rules may be allowed for ferries and day passenger vessels.

5.2 Generator plant

At least two separate independent main generator plants are to be provided for the supply to the electrical equipment. The prime mover system and the generator output shall be such that, if any generator set fails or is taken out of service, the remaining capacity is sufficient to meet the requirements of running service and manoeuvring.

5.3 Emergency power supply and emergency lighting

5.3.1 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 in special relevant to the safety of passengers and crew:

- Navigation and signalling lights
- Sound devices such as tyfon
- Emergency lighting
- Radio installations
- Alarm systems for vessel's safety
- Public address system (general alarm)
- Telecommunication systems essential to safety and the operation of the vessel
- Emergency searchlights
- Fire detection system
- Sprinkler systems and other safety installations

5.3.2 Emergency source of electrical power

a) A generator set with both fuel supply and cooling system independent of the main engine, which starts automatically in the event of a network failure and can automatically take over the power supply within 30 s.

b) A storage battery which automatically assumes the power supply in the event of a network failure and is capable of supplying the aforementioned consumers for the specified period without recharging and without an inadmissible voltage drop.

5.3.3 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 fire retardant 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.

The emergency power supply shall remain fully serviceable with a permanent list of 22,5° and/or a trim of 10°.

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 shall be possible without interference with other aspects of the vessel's operation.

5.4 Alarm and communication systems

The requirements of Section 13, M. are to be observed.

5.4.1 Fire detection and alarm system

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.

a) 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 passageways, 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.

b) The blowout of a fire and the area concerned are to be signalled automatically to a permanently manned station.

c) The requirements of items a) and b) are deemed to be met in the case of spaces protected by an automatic pressure water-spraying system designed in accordance with Section 12, H.3.1

d) 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.

e) The alarm set off by a manual call point shall be transmitted only to the rooms of the vessel's officers and crew and shall be capable of being cancelled by the vessel's officers. Manual call points are to be safeguarded against unintended operation.

5.4.2 Passenger alarm system

Passenger vessels with cabins shall be equipped with a passenger alarm system. This shall be capable of being actuated from the wheelhouse and a permanently manned station. The alarm shall be clearly perceptible in all rooms accessible to passengers. The alarm actuator has to be safeguarded against unintended operation.

5.4.3 Crew alarm system

Passenger vessels with cabins shall 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.

5.4.4 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.

5.5 Intercommunications

5.5.1 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.

5.5.2 Public address systems

Vessels with a length L_{WL} of 40 m and over and vessels intended for more than 75 passengers shall be equipped with loudspeakers capable of reaching all the passengers.

5.6 Fire door and watertight door closure indicators

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.

5.7 Lighting systems

5.7.1 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 ship normally accessible to the passengers and crew. This system is to be installed in accordance with Section 13, J.

5.7.2 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 b).

The power supply and the duration of the supply shall conform to 5.3.

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 shall be marked as such for ease of identification.

b) Extent

Adequate emergency lighting shall 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 shall 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.

5.7.3 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. Buoyancy and stability

6.1 General

Due to stability approvals are not only classification but also statutory matters, if other criteria are accepted by the Administration concerned, these criteria may be used for the purpose of classification.

General requirements of Section 17, F.2.2 to F.2.5 are to be complied with. All stability calculations have to be based on ship-specific light ship data, to be determined by conducting an inclining experiment.

6.2 Intact stability

6.2.1 General

Proof of appropriate intact stability of the vessel shall be furnished. All calculations shall be carried out free to trim and sinkage.

6.2.2 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 6.2.3, item d), shall be proved 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 %

6.2.3 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 6.2.2, items a) to c):

a) The maximum righting lever arm hmax shall occur at a list angle of $\varphi_{max} \geq (\varphi_{mom} + 3°)$ and shall not be less than 0,20 m. However, in case $\varphi_f < \varphi_{max}$ the righting lever arm at the downflooding angle φ_f shall not be less than 0,20 m.

b) The downflooding angle φ_f shall not be less than φ_{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 Table 15.14, 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 passengers and wind according to 6.2.4 and 6.2.5

- in application of the heeling moment due to passengers and turning according to 6.2.4 and 6.2.6

f) For a heeling moment resulting from moments due to passengers, wind and turning according to 6.2.4, 6.2.5 and 6.2.6, 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 e).

6.2.4 Moment due to crowding of passengers

The heeling moment M_P [kNm] due to one-sided accumulation of persons is to be calculated according to the following formula:

$$M_P = g \cdot P \cdot y = g \cdot \Sigma P_i \cdot y_i$$

P = t otal weight of persons on board [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 [m] of center of gravity of total weight of persons P from center line

g = Acceleration of gravity (g = 9,81 m/s^2)

P_i = Weight of persons accumulated on area A_i, [t]

= $0,075 \cdot n_i \cdot A_i$

A_i = Area [m^2] 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, ni shall be calculated by assuming an area of 0,50 m in width and 0,75 m in seat depth per person.

y_i = Lateral distance [m] of geometrical center of area A_i from center line

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 unfavourable one from the point of view of stability. Cabins shall be assumed unoccupied for the calculation of the person moment.

For the 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 [m]

- for day trip vessels: $P = 1,1 \cdot n_{max} \cdot 0,075$
  for cabin vessels: $P = 1,5 \cdot n_{max} \cdot 0,075$
  n_{max} = maximum permitted number of passengers

6.2.5 Moment due to lateral wind pressure

The moment M_W [kNm] due to lateral wind pressure is to be determined by the following formula:

M_W = P_{WD} . A_W (ℓ_W + T/2)

P_{WD} = Specific wind pressure [kN/m^2] defined in Table 15.13

ℓ_W = Distance [m] of the centre of gravity of area A_W from the plane of draught according to the considered loading condition [m]

Table 15.13 Specific wind pressure P_{WD}

Range of navigation	P_{WD} [kN/m^2]
I (1,2) to I (2)	0,4 · n
I (0), I (0,6)	0,25

6.2.6 Turning circle moment

The moment M_{dr} [kNm] due to centrifugal force caused by the turning circle, is to be determined by the following formula:

$$M_{dr} = \frac{0{,}045 \cdot C_B \cdot v^2 \cdot \Delta}{L_{WL}} \cdot \left(KG - \frac{T}{2} \right)$$

If not known, the block coefficient C_B is to be taken as 1,0.

v = Maximum speed of the vessel [m/s]

KG = Distance of vertical centre of gravity and moulded keel [m]

For passenger vessels with special propulsion systems (rudder propeller, water jet, cycloidal propeller and bow thruster), Mdr shall be derived from full-scale or model tests or else from corresponding calculations.

6.3 Damage stability

6.3.1 Damage stability of the vessel shall be carried out by means of a calculation based on the method of lost buoyancy. All calculations shall be carried out free to trim and sinkage.

6.3.2 Buoyancy of the vessel in the event of flooding shall be proven for the standard load conditions specified in 6.2.2. 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.

6.3.3 Assumptions

In the event of flooding, assumptions concerning the extent of damage given in Table 15.15 shall be taken into account.

a) For 1-compartment status 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) For 2-compartment status each bulkhead within the extent of damage will be assumed to be damaged. This means that the position of the bulkheads shall be selected in such a way as to ensure that the passenger vessel remains buoyant after flooding of two or more adjacent compartmentsin the longitudinal direction.

c) 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.

d) 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 Table 15.16.

e) 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.

Table 15.14 Values of area A under the curve of righting lever arm

Case			A [m.rad]
1	$\varphi_{max} \leq 15°$ or $\varphi_f \leq 15°$		0,05 to angle $\varphi = \varphi_{max}$ or $\varphi = \varphi_f$ whichever is smaller
2	$15° < \varphi max < 30°$	$\varphi_{max} \leq \varphi_f$	$0{,}035 + 0{,}001 \cdot (30 - \varphi_{max})$ to angle φ_{max}
3	$15° < \varphi_f < 30°$	$\varphi_{max} > \varphi_f$	$0{,}035 + 0{,}001 \cdot (30 - \varphi_f)$ to angle φ_f
4	$\varphi_{max} \geq 30°$ and $\varphi_f \geq 30°$		0,035 to angle φ= 30°

Table 15.15 Extent of damage [m]

Dimension of the damage		1-compartment status	2-compartment status
Side damage	longitudinal ℓ	$0{,}1 \cdot L_{WL} \geq 4$	$0{,}05 \cdot L_{WL} \geq 2{,}25$
	transverse b	B/5	0,59
	vertical h	from vessel bottom to top without delimitation	
Bottom damage	longitudinal ℓ	$0{,}1 \cdot L_{WL} \geq 4$	$0{,}05 \cdot L_{WL} \geq 2{,}25$
	transverse b	B/5	
	vertical h	0,59; pipework shall be deemed intact **(1)**	

(1) *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.*

6.3.4 Damage stability criteria

a) For all intermediate stages of flooding referred to in 6.3.2, the following criteria shall be met:

- The angle of heel φ at the equilibrium position of the intermediate stage in question shall not exceed 15°.

- Beyond the inclination in the equilibrium position of the intermediate stage 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 an angle of heel φ of 25° is reached.

- Non-watertight openings shall not be immersed before the inclination in the equilibrium position of the intermediate stage in question has been reached.

- The calculation of 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. 15.11) taking into account the heeling moment due to passengers in accordance with 6.2.4:

- 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 $GZ_R \geq 0{,}02$ 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 $\varphi_m \leq 25°$.

- 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 15.16 Permeability values [%]

Spaces	μ
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

6.3.5 The shut-off devices

- The shut-off devices which shall be able to be closed watertight shall be marked accordingly.

- 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.

6.4 Derogations for certain passenger vessels

6.4.1 As an alternative to proving adequate stability after damage according to 6.3, passenger vessels with a length of not more than 25 m and authorized to carry up to a maximum of 50 passengers shall comply with the following criteria:

a) After symmetrical flooding, the immersion of the vessel shall not exceed the margin line; and

b) The metacentric height GM_0 shall not be less than 0,10 m.

The necessary residual buoyancy shall be assured through the appropriate choice of material used for the construction of the hull or by means of highly cellular foam floats, solidly attached to the hull. In the case of vessels with a length of more than 15 m, residual buoyancy can be ensured by a combination of floats and subdivision complying with the 1-compartment status according to 6.3.

6.4.2 By way of derogation from 6.3.3, passenger vessels not exceeding 45 m in length and authorized to carry up to a maximum of 250 passengers do not need to have 2-compartment status.

6.5 Safety clearance and freeboard

6.5.1 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 6.2.3 e), and

b) The residual safety clearance according to 6.2.3 g).

For vessels without a bulkhead deck, the safety clearance shall be at least 500 mm.

6.5.2 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 6.2.3 e), and

b) The residual freeboard according to 6.2.3 f)

The freeboard shall be at least 300 mm.

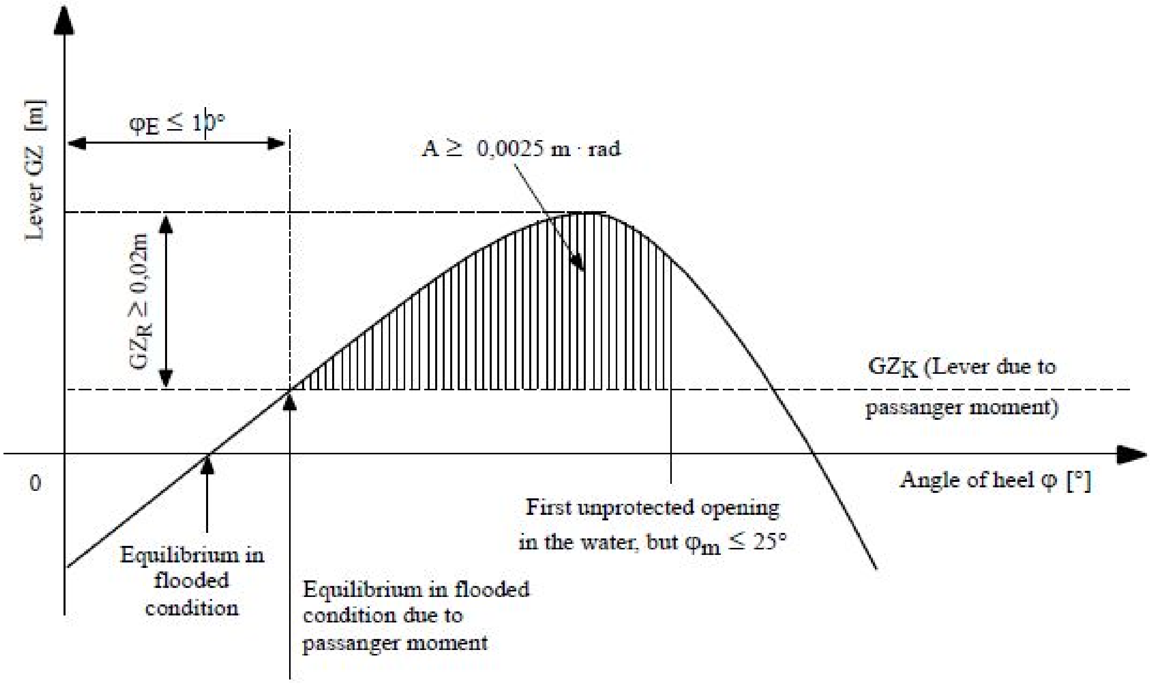


Fig. 15.11 Proof of damage stability (final stage of flooding)

6.5.3 The plane of maximum draught is to be set so as to ensure compliance with the safety clearance according to 6.4.1, and the freeboard according to 6.4.2.

6.5.4 For safety reasons, **TL** may stipulate a greater safety clearance or a greater freeboard.

7. Design loads

7.1 Pressure on sides

The design lateral pressure at any point of the hull sides is to be obtained from the following formulae:

$$p_E = 9{,}81 \,.\, (T - z + 0{,}6 \,.\, n) \qquad \text{for } z \le T$$

$$p_E = \text{MAX}\,(5{,}9 \,.\, n;\, 3) + p_{WD} \qquad \text{for } z > T$$

p_{WD} = Specific wind pressure [kN/m^2] defined in Table 15.13 .

7.2 Pressure on sides and bulkheads of superstructures and deckhouses

The lateral pressure to be used for the determination of scantlings of structure of sides and bulkheads of superstructures and deckhouses is to be obtained [kN/m^2] from the following formula:

$$p = 2 + p_{WD}$$

p_{WD} = Is the specific wind pressure [kN/m^2] defined in Table 15.13.

7.3 Pressure on decks

The pressure due to load carried on decks is to be defined by the Designer and, in general, it may not be taken less than the values given in Table 15.17.

7.4 Loads due to list and wind action

7.4.1 General

The loads inducing the racking in vessel superstructures above deck 1 (see Fig. 15.12) are as follows:

- Structural horizontal load P_S
- Non-structural horizontal load $_{PC}$
- Wind load P_W

Table 15.17 Pressure on decks

Item	P [kN/m²]
Weather deck	3,75 (n + 0,8)
Exposed deck of superstructure or deckhouse: - first tier (non public) - upper tiers (non public) - public	 2,0 1,5 4,0
Accommodation compartments: - large spaces, such as: restaurants, halls, cinemas, lounges, kitchen, service spaces, games and hobbies rooms, hospitals - cabins - other compartments	 4,0 3,0 2,5

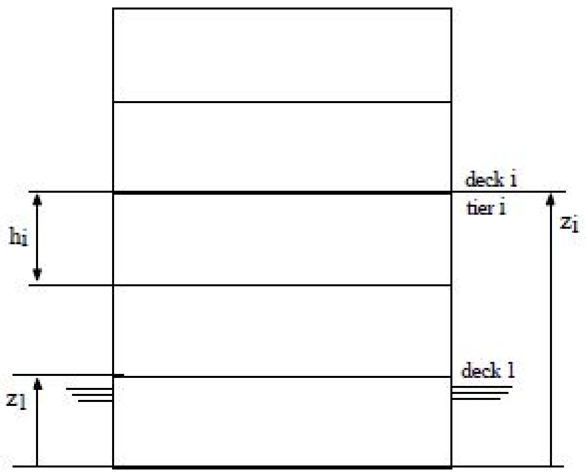


Fig. 15.12 Height and location of tier i

7.4.2 Definitions

The following parameters are used for the determination of loads inducing racking:

φ = Angle of list up to which no non-watertight opening to a non-flooded compartment reaches the water level, to be derived from damaged stability calculation. Where this value is not known, φ is to be taken equal to 12°

p_{WD} = Specific wind pressure [kN/m²] defined in Table 15.13

h_i = Height [m] of tier i of superstructure (see Fig. 15.12)

b_i = Width [m] of tier i of superstructure

7.4.3 Structural horizontal load

The structural horizontal load [kN] between successive gantries or transverse bulkheads, acting on deck i is given by the formula:

$$P_{Si} = 9{,}81 \cdot m_{Si} \cdot \sin\varphi$$

m_{Si} = Structural mass [t] of tier i of superstructure, between successive gantries or bulkheads. The following indicated value may be adopted:

= $0{,}08 \cdot S \cdot h_i \cdot b_i$

7.4.4 Non-structural horizontal load

The non-structural horizontal load [kN] between successive gantries or transverse bulkheads, acting on deck i is given by the formula:

$$P_{Ci} = p_i \,.\, S \cdot b_i \cdot \sin\varphi$$

p_i = Design pressure on deck i [kN/m²] defined in Table 15.17.

7.4.5 Wind load

The wind load [kN] between successive gantries or transverse bulkheads, acting on deck i, is given by the formula:

$$P_W = p_{WD} \cdot S \cdot (h_i + h_{i+1}) / 2$$

7.5 Inertial loads

7.5.1 General

For range of navigation higher than **I (1,2)** the following inertial loads inducing racking in vessel superstructures above deck 1 (see Fig. 15.12) are to be taken into account:

- Structural horizontal load, P_{SR}, induced by roll acceleration
- Non-structural horizontal load, P_{CR}, induced by roll acceleration.

7.5.2 Definitions

Following parameters are used for the determination of inertial loads inducing racking:

h_i = Height [m] of tier i of superstructure (see Fig. 15.12)

b_i = Width [m] of tier i of superstructure

z_i = Height [m] of deck i above base line (see Fig. 15.12)

z_G = Height [m] of rolling centre above base line

z_G may be considered as the vertical centre of gravity when no information is available

T_R = Roll period [s]

$$= \frac{0{,}77 \cdot B}{\sqrt{GM}}$$

GM = Distance [m] from the vessel's centre of gravity to the transverse metacentre, for the loading considered; when GM is not known, its value may be determined using the following formula:

= 0,07 . B

θ_R = Roll angle [rad]

= φ

φ = Angle of list [rad] defined in 7.4.2

a_R = Roll acceleration [m/s²]

$$= \frac{40 \cdot \theta_R \cdot (z_i - z_G)}{T_R^2}$$

7.5.3 Structural horizontal inertial load

The structural horizontal inertial load [kN] between successive gantries or transverse bulkheads, acting on deck i, is given by the formula:

$$P_{SRi} = m_{Si} \cdot a_R$$

m_{Si} = Structural mass [t] defined in 7.4.3.

7.5.4 Non-structural horizontal inertial load

The non-structural horizontal inertial load [kN] between successive gantries or transverse bulkheads, acting on deck i, is given by the formula:

$$P_{CRi} = \frac{p_i \cdot S \cdot b_i \cdot a_R}{9{,}81}$$

p_i = Design pressure on deck i [kN/m²] defined in Table 15.17.

See also Section 6, C.6.6.4

7.6 Loads induced by collision

In the case of sensitive superstructures, **TL** may require the structure to be checked against collision-induced loads. The values of the longitudinal and transverse accelerations [m/s²] are to be taken not less than:

- Longitudinal acceleration: a = 3,0 m/s²

- Transverse acceleration: a = 1,5 m/s^2

7.7 Hull girder loads

The design bending moments in hogging and sagging conditions and the vertical design shear force are to be determined according to Section 7.

8. Hull girder strength

8.1 Basic criteria

8.1.1 Superstructure efficiency

The superstructure efficiency indicating the contribution degree of a superstructure to the hull girder strength, may be defined as the ratio of actual stress at the superstructure neutral axis, σ_1', to the hull girder stress at the same point σ, computed as if the hull and the superstructure behaved as a single beam.

$$\Psi = \frac{\sigma_1'}{\sigma_1}$$

The superstructure efficiency ψ may be determined using the formula:

Ψ = $0{,}425 \cdot \chi - 0{,}0454 \cdot \chi^2$

χ = Dimensionless coefficient defined as:

= $100 \cdot j \,.\, \lambda \le 4{,}5$

λ = Superstructure half length [m]

j = Parameter [cm] defined as:

$$= \sqrt{\frac{1}{\frac{1}{A_{sh1}} + \frac{1}{A_{she}}} \cdot \frac{\Omega}{2{,}6}}$$

A_{sh1}, A_{she} = Independent vertical shear areas [cm^2] of hull and superstructure, respectively

Ω = Parameter [cm^{-4}], defined as:

$$= \frac{(A_1 + A_e) \cdot (i_1 + I_e) + A_1 \cdot A_e \cdot (e_1 + e_e)^2}{(A_1 + A_e) \cdot I_1 \cdot I_e + A_1 \cdot A_e \cdot \left(I_1 \cdot e_e^2 + I_e + e_1^2\right)}$$

A_1, A_e = Independent sectional areas [cm^2] of hull and superstructure, respectively, determined in compliance with Section 7, C.2

I_1, I_e = Independent section moments of inertia, [cm^4] of hull and superstructure, respectively, determined in compliance with Section 7, C.2., about their respective neutral axes

e_1, e_e = Vertical distances [cm] from the main (upper) deck down to the neutral axis of the hull and up to the neutral axis of the superstructure respectively (see Fig. 15.13).

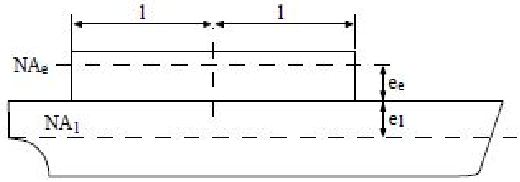


Fig. 15.13 Parameters determining the superstructure efficiency

An erection with large side entrances is to be split into sub-erections. The formulae given above are, therefore, to be applied to each individual sub-erection.

In the case of a multi-tier superstructure, the procedure is to be applied progressively to each tier i until ψ is less than 0,95, considering that the hull girder extends up to the superstructure deck (i − 1).

If the superstructure material differs from that of the hull, the geometric area A_e and the moment of inertia I_e shall be reduced according to the ratio E_e/E_1 of the respective material Young moduli.

8.1.2 Strength deck

The deck of a superstructure extending within the central part of the vessel may be considered as a strength deck if its efficiency, determined according to 8.1.1 is at least ψ = 0,95.

8.1.3 Hull girder section modulus

The hull girder section modulus to be used for the hull scantling is to be determined in compliance with Section 7, C., considering the strength deck located just above the load waterline.

9. Scantlings

9.1 General

9.1.1 The hull scantlings are to be as specified in Section 8.

9.1.2 Double hull

If a double bottom is provided, the height has to be at least 0,60 m and the minimum width of any side void spaces provided has to be at least 0,6 m.

9.2 Additional requirements

9.2.1 Primary supporting members

The design pressure of bottom primary supporting members is to be determined using γ = 1 for the draught coefficient.

9.2.2 Catamarans

Scantlings of primary structural members contributing to the transverse bending strength and torsional strength are to be supported by direct calculations carried out according to Section 5, E.

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 torsional moment is given in Section 5, I.

Any other agreed method of calculation may be accepted by tL.

9.3 Superstructures

9.3.1 The arrangement and scantlings of superstructures are to be in compliance with Section 9, D.

Contributing superstructures are also to be in compliance with applicable requirements of Section 8.

9.3.2 Transverse strength

The existing constructive dispositions shall ensure an effective transverse strength of the superstructures and deckhouses notably the end bulkheads, the partial or complete intermediate bulkheads and the greatest possible number of continuous and complete gantries.

Scantlings of primary structural members contributing to the transverse strength of superstructures are to be supported by direct calculation, according to guidance defined in 9.4.

9.4 Racking analysis

9.4.1 General

The racking analysis is performed for checking strength of structure against lateral horizontal loads due to list and wind action defined in 7.4 and, eventually, to inertial loads induced by vessel motion.

The racking analysis is to be performed where no complete transverse bulkheads efficiently restrain the transverse loads.

9.4.2 Analysis methodology

The following methodology is to be followed for checking strength of structure above the lowest deck (so called deck 1 in Fig. 15.12):

a) Calculation of transverse forces

- Determination of structural horizontal load on each deck above deck 1, according to 7.4.3 and, eventually, 7.5.3
- Determination of non-structural horizontal load on each deck above deck 1, according to 7.4.4 and, eventually, 7.5.4

- Determination of wind load on each deck above deck 1 according to 7.4.5

b) Distribution of transverse forces

- Distribution of these loads on vertical structural members efficiently acting against racking

c) Analysis of transverse structures

9.4.3 Checking criteria

It is to be checked that the normal stress σ, the shear stress τ and the equivalent stress σ_{VM} are in compliance with the following formulae:

$$\frac{0{,}98 \cdot R_{EH}}{\gamma_R} \geq \sigma$$

$$\frac{0{,}49 \cdot R_{EH}}{\gamma_R} \geq \tau$$

$$\frac{0{,}98 \cdot R_{EH}}{\gamma_R} \geq \sigma_{VM}$$

R_{eH} = Minimum yield stress [N/mm^2] of the material

γ_R = Partial safety factor covering uncertainties regarding resistance, to be taken equal to 1,20

9.5 Scantling of window stiles

9.5.1 General

The geometric characteristics of the hull girder to be used for the scantling of window stiles are to be determined in compliance with Section 7, C., assuming that the hull girder extends up to the uppermost contributing superstructure deck.

9.5.2 Forces in the window stile

a) Local shear force [kN]

- In general:

$$F = \frac{100 \cdot \psi \cdot T_S \cdot \mu}{2 \cdot I} \cdot \ell$$

- In way of highest contributing superstructure deck:

$$F = \frac{100 \cdot \psi \cdot T_S \cdot A}{2 \cdot w_1} \cdot \ell$$

b) Maximum local bending moment [kN/m]

$$M_B = \frac{F \cdot h}{2}$$

T_S = Shear force [kN] to be determined according to Section 7, B.3.1.1

I = Net hull girder moment of inertia [cm^4] with respect to the hull girder neutral axis

μ = Net static moment [cm^3] with respect to the hull girder neutral axis, of the part including lateral strip of plate and all contributing tiers of superstructure located above the window considered

w_1 = Net hull girder section modulus in way of the superstructure deck considered [cm^3] with respect to the hull girder neutral axis

A = Net sectional area of the superstructure deck considered [cm^2] including lateral strip of plating above windows

h = Window height [m]

ℓ = Istance [m] between centres of two successive windows

9.5.3 Checking criteria

It is to be checked that the stresses in the window stile are in compliance with 9.4.3.

E. Tugs and Pushers

1. Symbols

L = Rule length [m] defined in Section 4, A.1

t = Net thickness [mm] of plating

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service Notation **Tug** or **Pusher**, as defined in Section 2, B.7.1.1 or Section 2, B.7.1.2.

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Sections 1-13, as applicable, and with the following requirements, 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 Section 16, as applicable.

2.2 Documents to be submitted

In addition to the documentation requested in Section 4, B., a drawing showing the towing devices and their installation is to be submitted for review/ approval to **TL**. The maximum towing force contemplated is to be mentioned on that drawing.

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 Section 10, F.

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 light ship waterline to the fenders themselves.

4. Hull scantlings

4.1 General

The scantlings of the hull structure are to be determined in compliance with Section 8, taking into account additional requirements defined in 4.2.

4.2 Additional requirements

4.2.1 Minimum net thicknesses

The minimum thicknesses are to be obtained from Table 15.18.

Table 15.18 Minimum net thicknesses

Plating	t [mm]
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	$t = 3{,}3 + 0{,}048 \cdot L \cdot k^{0{,}5}$
Keel plate	t = Thickness of adjacent bottom plating

4.2.2 Topside structure

The topside structure scantlings are to be determined according to Section 8, D.4, where the minimum thickness is to be taken equal to 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

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 **I (1,2)**.

6. Hull outfitting

6.1 Rudder

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 **I (1,2)**.

7. Machinery

7.1 Propelling machinery

Propulsion systems under the bottom of the vessel are to be protected against damage by an effective structure around the propulsion system.

F. Pontoons

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

t = Net thickness [mm] of plating

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service Notation **Pontoon**, as defined in Section 2, B.7.1.4

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Sections 1-13, as applicable, and with the requirements of this Section, which are specific to pontoons.

2.2 Documents to be submitted

In addition to the documentation requested in Section 4, B., the following documents are to be submitted to **TL**:

- Cargo weight distribution on the deck

- Equipment weight and distribution

3. Arrangement

3.1 Hull structure

3.1.1 Framing

In general, vessels with service notation **Pontoon** are of flush deck single hull type, built in the longitudinal system. 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 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 position during navigation

For pontoons where a crane is fitted on the deck, the crane boom is to be lowered and efficiently secured to the pontoon during the voyage.

4. Scantlings

4.1 General

The scantlings of the hull structure are to be determined in compliance with Section 8, taking into account additional requirements defined in 4.2.

4.2 Additional requirements

4.2.1 Minimum net thicknesses

The minimum thicknesses are to be obtained from Table 15.19.

Table 15.19 Minimum net thicknesses

Plating	t [mm]
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	- for L ≤ 40 m: $t = 3{,}3 + 0{,}048 \cdot L \cdot k^{0{,}5}$ - for L > 40 m: $t = 4{,}8 + 0{,}019 \cdot L \cdot k^{0{,}5}$
Keel plate	t = Thickness of adjacent bottom plating

4.2.2 Plating and stiffeners subjected to wheeled loads are to comply with C.

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.

In the case of primary supporting members forming a grillage, the scantlings are to be determined by direct calculation as specified in B.5.

4.3 Reinforcements

Reinforcements are to be provided at places where the hull is heavily stressed, as the securing points of the towing ropes.

G. Vessels for Dredging Activities

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

ρ = Density of the water and spoil mixture; as a general rule, the value of ρ may be taken not greater than 1,8 t/m^3

2. General

2.1 Application

2.1.1 Vessels complying with the requirements of this Section are eligible for the assignment of one of the following type and service Notations, as defined in, Section 2, B.6.1.1 to B.6.1.4

- **Dredger**
- **Hopper dredger**
- **Hopper barge**
- **Split hopper barge**

2.1.2 Vessels dealt with in this Section are to comply with the requirements stated under Sections 1-13, as applicable, and with the requirements of this Section, which are specific to vessels for dredging activities.

2.1.3 Only ranges of navigation **I (0,6)**, **I (1,2)** and **I (2)** may be assigned.

2.1.4 Dredging equipment and installations are not covered by these Rules.

2.2 Dredger types

2.2.1 Hopper dredger and hopper barge

Hopper dredger and hopper barge are vessels intended to carry out dredging operations and having one or several hopper spaces in the midship region, or a suction pipe well.

2.2.2 Dredger

A dredger is a vessel intended to carry out dredging operations and that does not carry spoil, such as bucket dredger.

2.2.3 Split hopper barge

A split hopper barge is an hopper barge which opens longitudinally around hinges.

2.3 Documents to be submitted

In addition to the documentation requested in Section 4 B., the following documents are to be submitted to **TL**:

- calculation of the maximum still water bending moments
- dredging equipment weight and distribution
- other equipment weight and distribution

3. Arrangement

3.1 Transverse rings

3.1.1 General

Transverse rings are to be provided abreast the hopper spaces, spaced not more than (1,1 + 0,025 . L) apart.

Rings located in the same cross section are to be connected by means of a deep floor and a strong beam at deck level.

3.1.2 Gusset stays for coamings

Gusset stays for coamings are to be fitted in way of the transverse rings to which they are to be securely fixed.

3.2 Transverse and longitudinal bulkheads

It is recommended to provide a chafing allowance for plates subjected to rapid wear (hopper space bulkheads, weir, ...).

3.3 Suction pipe well

As far as the operation of the vessels permits it, the side compartments are to be firmly connected together unless adequate arrangements are made and approved by **TL**.

Longitudinal strength continuity is to be ensured. The top and bottom of the side compartments are to be correctly connected to elements beyond the transverse bulkheads of the well by means of large horizontal brackets.

3.4 Hopper space structure

At the ends of the hopper space, the transverse bulkheads are to extend from one side to the other of the vessel. Where this is not the case, web rings with special scantlings are to be provided.

3.5 Particular arrangements

3.5.1 Dredgers

Where dredgers are likely to work in association with hopper barges, the sheerstrake is to be protected. This can be accomplished slightly below the deck by a fender efficiently secured to the shell plating and extending at least over two thirds of the vessel length.

The necessary compensations are to be provided in way of the break in the raised deck, if any.

3.5.2 Bucket dredgers

Dangerous flooding in case of damage to shell plating by metal debris (e.g. anchors) is to be avoided. A watertight compartment is to be provided at the lower part of the caissons on either side of the suction pipe well in the area of the buckets. The compartment is to be of sufficient size to allow surveys to be carried out.

3.6 Shifting of the structures at ends of the hopper spaces

Continuity of the longitudinal members is to be ensured at the ends of the hopper spaces.

The ends of the longitudinal bulkheads are to be extended upwards and downwards by large brackets each having, a rule length and width equal to about 0,25 . D.

Under the lower brackets, the bottom is to be stiffened by means of a solid keelson extending beyond the bracket end over three frame spaces at least.

As a general rule, the coaming sides are to extend beyond the hopper space ends over 1,5 times their height approximately.

4. Design loads

4.1 Cargo load

The cargo load transmitted to the hull structure is to be determined in compliance with Section 6, C.5. where the cargo density of the water and spoil mixture, shall not be taken less than 1,8.

5. Hull scantlings

5.1 Split hopper barge

Scantlings and arrangements of vessels with type and service Notation **Split hopper barge** will be considered on a case-by-case basis, considering the applicable requirements of the **TL** Rules.

5.2 Shell plating and topside plating

The net scantlings of the shell plating and the topside plating are to be determined in compliance with the applicable requirements stated under Section 14, B. or F. in this Section.

5.3 Framing structure

5.3.1 The net scantlings of the hull structure are to be determined in compliance with the applicable requirements stated under Section 14, B. or F. in this Section.

5.3.2 Transverse rings

The ring component scantlings are to be considered by tL on a case-by-case basis.

The gusset stays for coamings are to have a section modulus at the lower end level not less than that of the web frames or the side transverses.

5.3.3 Transverse web plates in the side tanks abreast the hopper spaces

The scantlings of these web plates are to be considered by tL on a case-by-case basis.

5.4 Rudders

The rudder stock diameter obtained from Section 10, A. is to be increased by 5 %.

H. Launches

1. Symbols

L = Rule length [m] defined in Section 4, A.1

t = Net thickness [mm] of plating

k = Material factor defined in Section 5, A.2.4 and Section 5, A.3.2

2. Application

2.1 Vessels complying with the requirements of this Section are eligible for the assignment of the type and service Notation **Launch**, as defined in Section 2, B.7.1.3

2.2 Vessels dealt with in this Section are to comply with the requirements stated under Sections 1-13, as applicable, and with the requirements of this Section, which are specific to launches.

3. Hull scantlings

3.1 General

The scantlings of the hull structure are to be determined in compliance with Section 8, taking into account additional requirements defined in 3.2.

3.2 Additional requirements

3.2.1 Minimum net thicknesses

The minimum thicknesses are to be obtained from Table 15.20.

Table 15.20 Minimum net thicknesses

Plating	t [mm]
Decks, sides, bottom, bulkheads, web of primary supporting members, web of ordinary stiffeners and other structures	$t = 3{,}3 + 0{,}048 \cdot L \cdot k^{0{,}5}$
Keel plate	t = Thickness of adjacent bottom plating

3.2.2 Topside structure

The topside structure scantlings are to be determined according to Section 8, D.4., where the minimum thickness is to be taken equal to 5 mm.

3.2.3 Primary supporting members

The design pressure of bottom primary supporting members is to be determined using $\gamma = 1$ for the draught coefficient.

SECTION 16

ADDITIONAL REQUIREMENTS for NOTATIONS - TRANSPORT of DANGEROUS GOODS

Page

A. General

The following requirements apply to vessels intended for the carriage of dangerous goods.

Vessels dealt with carrying dangerous goods are to comply with the requirements stated under Section 1÷13, as applicable, and with the following specific requirements:

– For transport of dangerous liquid cargoes:
Section 15, A. of this Chapter and current ADN Regulations.

– For transport of liquefied gases:
Section 15, A. of this Chapter and current ADN Regulations.

– For transport of dangerous, dry cargoes:
current ADN Regulations.

Additional measures and Regulations varying from country to country or from continent to continent are to be complied with too.

Subject to Administration's approval, **TL** may also approve equivalent arrangements providing the same level of safety.

if the requirements for carriage of dangereous goods are regulated by the Administration, **TL** can apply the regulation of the Administration instead of the ADN requirements stated above.

SECTION 17

ADDITIONAL REQUIREMENTS for NOTATIONS - ADDITIONAL CLASS NOTATIONS

A. Strengthened Construction

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1

T = Draught [m] defined in Section 4, A.1

t = Thickness [mm]

A = Sectional area [cm^2]

N = Rotational speed [rev/min]

P_w = Power transmitted by shaft [kW]

D = Diameter of propeller [mm]

C_{EW} = Strengthening factor for shafts:

= 1,10

C_{EP} = strengthening factor for propeller blades:

= 1,15

K_E = Strengthening factor for gears and couplings:

= 1,08

T_{ice} = Calculated/estimated ice torque [kNm] generated by the propeller working in ice

m = Coefficient for calculation of ice torque

K_A = Calculation factor for gear, defined in Section 12, B.4.3.2

T_{MCR} = Nominal mean torque [Nm] delivered by the engine (referred to installed MCR of engine)

$T_{Nom,\, cpl}$ = Proven nominal torque for coupling [Nm] for continuous operation including an allowance of at least 30 % for namical superimposed torques (catalogue's nominal torque)

$T_{ice,\, cpl}$ = Assumed peak torque [Nm] which the elastic coupling shall transmit safely, including the influence of ice operation

$T_{max1,\, cpl}$ = Maximal permissible peak torque for elastic coupling [Nm] excluding reduction due to thermal loading (catalogue's permissible repetitive peak torque)

σ_H = Calculated tooth flank contact (Hertzian) stress [N/mm^2] without ice load as referred to in **TL** Rules for Machinery Section 7, C.

σ_{HP} = Maximal permissible contact (Hertzian) stress [N/mm^2] depending on material's properties (see **TL**'s machinery Rules for seagoing vessels).

σ_F = Calculated tooth root bending stress without ice load [N/mm^2] as referred to in **TL** Rules for Machinery Section 7, C.

σ_{FP} = Maximal permissible tooth root bending stress [N/mm^2] depending on material's properties (see **TL**'s machinery Rules for seagoing vessels).

t_{bl} = Thickness of the propeller blade [mm] determined in compliance with Section 12, B.5.3 for unstrengthened machinery installations

$t_{bl,\, ice}$ = Strengthened blade thickness of the propeller [mm]

$t_{0,\, ice}$ = Strengthened thickness of blade's tip [mm]

$R_{m,\, pr}$ = Tensile strength of the propeller's material [N/mm^2]

p = Required mean pressure [N/mm^2] in the shrink fit between propeller hub and propeller shaft in accordance Section 12, B.5.6.1

p_{ice} = Required increased mean pressure [N/mm^2] in the shrink fit between propeller hub and propeller shaft

d = Minimum diameter of shaft [mm] determined in compliance with Section 12, B.3.3.2, for unstrengthened machinery installations

d_{ice} = Strengthened minimum diameter of shaft [mm]

d_S = Minimum required diameter [mm] of fitting pin of propeller connection in accordance with Section 12,B.5.6.2, for unstrengthened machinery installations

$d_{S,\,ice}$ = Strengthened minimum diameter of fitting pin [mm]

2. General

2.1 Application

2.1.1 The following additional class notations may be assigned, in accordance with Section 2, B.3.2.8 or B. 9.3.1 to vessels with strengthened construction complying with applicable requirements in the following:

- **Ice**, for vessels complying with 3.

- **Grab loading**, for vessels complying with 4.

2.1.2 Unless otherwise mentioned, these vessels are to comply with the requirements stated under Sections 1-13, as applicable.

3. Navigation in ice

3.1 General

3.1.1 Application

Ice strengthened vessels dealt with in these Rules are assumed to operate in inland navigation conditions corresponding to a low ice level, i.e. brash ice with a thickness not exceeding 0,20 m.

These conditions are lighter than the minimal ice class in accordance to the Finnish-Swedish ice Rules (IC, where m is defined to 1,22).

For vessels intended to operate under more severe ice conditions, **TL**'s Rules for navigation in ice for sea going vessels shall be applied for the corresponding/ required ice class.

The reinforcements as described hereafter are neither compatible nor equivalent to national requirements and ice or polar ice classes as defined and introduced by specific administrations, such as Finnish-Swedish, Canadian or Russian ice Rules.

These Rules are not applicable to vessels intended for ice breaking.

3.1.2 Ice belt

The ice belt is that portion of the side shell which is to be strengthened. Its depth extends between 300 mm below the light waterline and 300 mm above the load waterline.

The side shell is to be strengthened fore, over a length equal to the vessel breadth B, or up to the crosssection with the breadth B that is closest to the fore end if this cross-section is aft of a length equal to B.

3.2 Strengthened plating

3.2.1 Thickness

The strengthened plating net thickness is not to be less than 1,5 times the rule value for the shell plating thickness amidships.

The gross thickness is to be obtained using an abrasion and corrosion addition taken equal to 2 mm. Where a special surface coating, shown by experience to be capable of withstanding the abrasion of ice, is applied, a lower value may be accepted by **TL** on a case-by-case basis.

3.3 Strengthened framing

3.3.1 General

These requirements apply to transversely framed shell. Strengthening of longitudinally framed shell will be considered on a case-by-case basis.

3.3.2 Intermediate framing

Over the length of the strengthened plating, intermediate frames are to be fitted extending from the deck down to the bilge turn.

The net section modulus of intermediate frames is not to be less than 0,75 times the rule value for ordinary frames.

In way of these frames, intermediate floors are to be fitted. Their scantlings are to be determined assuming a span equal to the bottom girder spacing.

3.3.3 Side stringer

A stringer is to be fitted on the frames in the strengthened area, about halfway between the light and load waterlines.

The net section modulus of the side stringer is to be not less than twice the rule section modulus of side frames.

3.4 Fore part

3.4.1 General

A sharp edged stem improves the manoeuvrability of the vessel in ice.

3.4.2 Plate stem

The gross thickness [mm] of the plate stem, where fitted, is to be not less than 1,30 times that derived from Section 9, A.7.2

The horizontal diaphragms foreseen in Section 9, A.7.2.3 are to have a reduced spacing not exceeding 0,5 m. 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 0,5 m 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.

3.4.3 Bar stem

The gross sectional area [cm^2] of the bar stem, where fitted, is to be not less than:

$$A = 1{,}6 \cdot f \cdot (0{,}006L^2 + 12)$$

- $f = 1$ for **I (1,2)** and **I (2)**

  $= 0{,}9$ for **I (0,6)**

  $= 0{,}8$ for **I (0)**.

The gross thickness [mm] is not to be less than:

$$t = 1{,}25 \cdot (0{,}33.L + 10)$$

3.5 Aft part

3.5.1 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 Section 10, A.8.2.

3.6 Rudder stock

3.6.1 Diameter

The rudder stock diameters are not to be less than 1,08 times the rule value laid down in Section 10, A.4.

3.7 Pintles

3.7.1 Pintle diameter

The pintle diameter is not to be less than 1,125 times the rule value laid down in Section 10, A.6.4.1.

3.8 Rudder blade

3.8.1 Thickness

The plate thickness of the streamlined rudder blade and of the single plating rudder blade is not to be less than 1,125 times the values derived from the formulae laid down in Section 10, A.7.2.1 and A.7.5.2.

3.8.2 Section modulus of rudder arms

The section modulus of the arms of single plating rudder blade is to be not less than 1,25 times the value given in Section 10, A.7.5.3.

3.9 Main shafting

3.9.1 General

For the purpose of these Rules, the additional torque due to ice impacts is defined with m = 1,15, in reference to the Finnish-Swedish ice Rules, and minimal requirements for power are not set out.

The ice torque, originating from the propeller working in ice may be calculated using the formula:

$$T_{ice} = m \cdot (0{,}001 \cdot D)^2$$

3.9.2 Diameter of propeller shafts, intermediate shafts and thrust shafts

The minimum diameters d_E of the main shafting strengthened for navigation in ice, are to be obtained using the following formula:

$$d_E = C_{EW} \cdot d$$

The part of the propeller shaft forward of the point 4d (see Section 12, Fig. 12.2) may be reduced by 5 % in diameter, but not less than the diameter d.

In the case that the propeller is running in a nozzle, the value of C_{EW} can be reduced to the value 1.

3.9.3 Connecting bolts

The diameter of fitted and plain bolts determined by applying formulae of Section 12, B.3.5.2 to B.3.5.5 are to be increased proportionally.

3.10 Gears and couplings

3.10.1 Gears

a) Bending strength of tooth root

For adequate bending strength of the tooth root, the following condition shall be satisfied:

$$K_E \cdot \sigma_F \leq \sigma_{FP}$$

b) Contact stress of tooth flanks

For adequate contact stress of the tooth flanks or Hertzian pressure, the following condition shall be satisfied:

$$K_E^{0,5} \cdot \sigma_H \leq \sigma_{HP}$$

3.10.2 Gear shafts

The diameter of gear shafts in accordance with Section 12, B.4.4 is to be increased as required by the relevant design considerations.

3.10.3 Flexible couplings

Flexible couplings in main propulsion installation are to be designed for a torque capacity in accordance to the following condition:

$$T_{MCR} \leq T_{Nom,\ cpl}$$

Further the coupling shall be designed to withstand torque shocks $T_{ice,\ cpl}$ of magnitude [N.m]:

$$T_{ice,\ cpl} = K_E \cdot K_A \cdot T_{MCR} \leq T_{max1,\ cpl}$$

3.11 Propellers

3.11.1 Thickness of propeller blade sections

The minimum thickness $t_{bl,\ ice}$ of the propeller blade strengthened for navigation in ice, is to be obtained using the following formula:

$t_{bl,\ ice} = C_{EP} \cdot t_{bl}$

3.11.2 Thickness of blade tips

The thickness [mm] of blade tips at 95 % radius is to be determined in accordance with the following formula:

$$t_{0,ice} = \sqrt{\frac{500}{R_{m,pr}} \cdot (0{,}002 \cdot D + 12)}$$

3.11.3 Propeller mounting

Where the propeller is mounted on the propeller shaft by the oil shrink fit method, the necessary pressure [N/mm^2] in the area of the mean taper diameter is to be determined using the formula:

$p_{ice} = C_{EW} \cdot p$

In the case of flanged propellers, the required diameter of the fitting pin(s) is to be determined by applying the following formula:

$d_{S,\ ice} = C_{EW}{}^{1,5} \cdot d_S$

3.12 Steering gear

The dimensional design of steering gear components is to take account of the rudderstock diameter specified in 3.6.

4. Grab loading

4.1 Strengthening requirements

4.1.1 General

In the case of grab loading and unloading, the scantlings of structural elements within the cargo hold are to be strengthened in compliance with 4.1.2.

4.1.2 Scantling increase

The scantlings of structural elements within the cargo hold are to be increased as follows:

- Inner side and hold bulkheads

  - plating: $t = t_0 + 1{,}5$ mm

  - ordinary stiffeners: $w = 1{,}4 \cdot w_0$

- inner bottom

  - plating: $t = t_0 + 2$ mm

  - longitudinals: $w = 1{,}4 \cdot w_0$

where t_0 and w_0 are scantlings of corresponding structural elements in case of no grab loading.

B. Transport of Heavy Cargo

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

B = Breadth [m] defined in Section 4, A.1..

H = Depth [m] defined in Section 4, A.1..

T = Draught [m] defined in Section 4, A.1..

t = Net thickness [mm] of plating

s = Spacing [m] of ordinary stiffeners

S = Spacing [m] of primary supporting members

ℓ = Span [m] of ordinary stiffeners or primary supporting members

n = Navigation coefficient defined in Section 6, B.

= $0{,}85 \cdot h$

h = Significant wave height [m]

β_b, β_s = Bracket coefficients defined in Section 5, B.5.2

w = Net section modulus [cm^3] of ordinary stiffeners or primary supporting members

A_{sh} = Net web shear sectional area [cm^2]

k = Material factor defined in Section 5, A.2.4 and A.3.2

z = Z co-ordinate [m] of the calculation point

M_H = Design bending moment [kNm] in hogging condition

M_S = Design bending moment [kNm] in sagging condition

2. General

2.1 Application

2.1.1 The additional class Notation **heavy cargo** is assigned, in accordance with Section 2, B.3.2.6, to vessels intended to carry heavy unit cargoes or heavy dry bulk cargoes.

2.1.2 Unless otherwise mentioned, these vessels are to comply with the requirements stated under Section 1-13, as applicable.

2.1.3 These rules are applicable to vessels intended to carry heavy bulk dry cargoes. The values of cargo density and angle of repose are to be submitted to **TL**.

2.1.4 Vessels intended for the carriage of heavy unit cargoes are to comply with Section 15, B.

3. Hull scantlings

3.1 General

3.1.1 In general, the hull scantlings are to be not less than required in Section 8, unless otherwise specified here below.

3.1.2 Grab loading and unloading

In the case of grab loading and unloading, the scantlings of structural elements within the cargo hold are to be strengthened in compliance with A.3.

3.2 Bottom and inner bottom plating

In the central part, the bottom and inner bottom plating net thickness [mm] are not to be less than the values given in Table 17.1.

3.3 Double bottom structure

3.3.1 Minimum thickness of web plating

The net thickness [mm] of plating which forms the web of primary supporting members is to be not less than the value obtained from the following formula:

$$t = 3{,}8 + 0{,}016 \cdot L \cdot k^{0,5}$$

3.3.2 Net scantlings of bottom primary supporting members in service conditions

The scantlings of the double bottom primary supporting structural members are to be obtained from Table 17.2.

4. Hull arrangement

4.1 General

4.1.1 Hull arrangement is to be in compliance with requirements of Section 14, A. or B. as applicable.

C. Equipped for Transport of Containers

1. General

1.1 Application

1.1.1 Cargo 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 Section 2, B.3.2.1

1.1.2 These vessels are to comply with the requirements stated under Section 14, A. or B., as applicable.

Table 17.1 Bottom and inner bottom plating net thickness [mm]

Item	Transverse framing	Longitudinal framing
Bottom plating	t = MAX (t_i) $t_1 = 1{,}85 + 0{,}03 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 68 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{M_H}{Z_B}}$ if $t_3/s > 22/(k^{0,5} \cdot k_2)$ $t_3 = \frac{7{,}1 \cdot k^{0,5} \cdot s}{k_2 \cdot \sqrt{0{,}21 - \frac{M_H}{Z_B}}}$ See **(1)**	t = MAX (t_i) $t_1 = 1{,}1 + 0{,}03 \cdot L \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p)^{0,5}$ $t_3 = 39 \cdot s \cdot \sqrt{\frac{M_H}{Z_B}}$ if $t_3/s > 12{,}5/k^{0,5}$ $t_3 = \frac{4{,}1 \cdot k^{0,5} \cdot s}{\sqrt{0{,}21 - \frac{M_H}{Z_B}}}$ See **(1)**
Inner bottom plating	t = MAX (t_i) $t_1 = 2 \cdot L^{1/3} \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}6 \cdot s \cdot (k \cdot p_{MS})^{0,5}$ $t_3 = 1{,}25 \cdot t_{bottom}$	t = MAX (t_i) $t_1 = 2 \cdot L^{1/3} \cdot k^{0,5} + 3{,}6 \cdot s$ $t_2 = 1{,}2 \cdot s \cdot (k \cdot p_{MS})^{0,5}$ $t_3 = 1{,}25 \cdot t_{bottom}$

P = Design load [kN/m^2] of bottom plating:
- in way of ballast tanks: p = MAX [p_E; ($p_B - p_M$)]
- elsewhere: p = p_E

p_M = Minimum external pressure [kN/m^2]
= 9,81 · (0,15·T − 0,6·n)

p_E = External pressure [kN/m^2]
= 9,81 · (T + 0,6 · n)

p_B = Ballast pressure defined in Section 6, C.5.

p_{MS} = Inner bottom design pressure [kN/m^2], defined in Section 6, C.5.3.2

k_2 = 1 + α^2

α = b_2 / b_1

b_1 = Unsupported plate width in y direction [m]

b_2 = Unsupported plate width in x direction [m]

Z_B = Bottom net hull girder section modulus [cm^3]

(1) *A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Section 5, C.*

Table 17.2 Double bottom structure

Item	Parameter	Transverse framing	Longitudinal framing
Floors in the hold **(1)**	Section modulus [cm^3]	$w = 0{,}58 . k \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot (\ell^2 - 4 \cdot B_3^2)$	NA
	Thickness [mm]	$t = MAX\ (t_1;\ t_2)$	NA
		$t_1 = 3{,}8 + 0{,}016 . L . k^{0,5}$	
		$t_2 = d / 90$	
	Shear sectional area [cm^2]	$A_{sh} = 0{,}067 . k \cdot \beta_s \cdot p_{\gamma l} \cdot s \cdot (\ell - 2 \cdot B_3)$	NA
Floors in the side tank **(1)**	Section modulus [cm^3]	$w = 2{,}32 . k \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot B_2 \cdot (\ell - 2 \cdot B_2)$	NA
	Shear sectional area [cm^2]	$A_{sh} = 0{,}067 . k \cdot \beta_s \cdot p_{\gamma l} \cdot s \cdot (\ell - 2 \cdot B_3)$	NA
Bottom and inner bottom longitudinals	Section modulus [cm^3]	NA	$w = \dfrac{83{,}3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$
	Shear sectional area [cm^2]	NA	$A_{sh} = 0{,}045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Bottom transverses in the hold	Section modulus [cm^3]	NA	$w = 0{,}58 . k \cdot \beta_b \cdot p_{\gamma l} \cdot S \cdot (\ell^2 - 4 \cdot B_3^2)$
	Thickness [mm]	NA	$t = MAX\ (t_1;\ t_2)$
			$t_1 = 3{,}8 + 0{,}016 . L . k^{0,5}$
			$t_2 = d / 80$
	Shear sectional area [cm^2]	NA	$A_{sh} = 0{,}067 . k \cdot \beta_s \cdot p_{\gamma l} \cdot S \cdot (\ell - 2 \cdot B_3)$
Bottom transverses in the side tank	Section modulus [cm^3]	NA	$w = 2{,}32 . k \cdot \beta_b \cdot p_{\gamma l} \cdot S \cdot B_2 \cdot (\ell - 2 \cdot B_2)$
	Shear sectional area [cm^2]	NA	$A_{sh} = 0{,}067 . k \cdot \beta_s \cdot p_{\gamma l} \cdot S \cdot (\ell - 2 \cdot B_3)$
Bottom centre and side girders **(2)**	Shear sectional area [cm^2]	$A_{sh} = 0{,}051 . k \cdot \beta_s \cdot p_{\gamma l} \cdot S \cdot \ell$	

p = Design load of bottom and inner bottom longitudinals [kN/m^2]:
- in way of ballast tanks:
  - for bottom longitudinals: $p = MAX\ (p_E;\ (p_B - p_M))$
  - for inner bottom longitudinals: $p = MAX\ (p_C;\ p_B)$
- elsewhere:
  - for bottom longitudinals: $p = p_E$
  - for inner bottom longitudinals: $p = p_C$

p_E, p_B, p_C = Pressures transmitted to the hull structure, defined in Section 6, C.4. and C.5.

$p_{\gamma l}$ = Internal load [kN/m^2] taking into account the loading sequence: $p_{\gamma l} = 0{,}55 \cdot \gamma_1 \cdot (p_{MS} - p_M)$

γ_1 = $(\gamma - 0{,}15) / 0{,}85$

γ = Loading sequence coefficient: $\gamma = 1{,}0$ for loading/unloading in one run
$= 0{,}575$ for loading/unloading in two runs

p_M = Minimum external pressure [kN/m^2]: $p_M = 9{,}81 \cdot (0{,}15 \cdot T - 0{,}6 \cdot n)$

p_{MS} = Inner bottom design load defined in Section 6, C.5.3

ℓ = Floor or bottom transverse span [m]

B_2 = Breadth of the side tank [m]

B_3 = Parameter [m] to be derived from following formula: $B_3 = 0.5 \cdot \ell - \dfrac{P_{MS}}{9.81 \cdot \rho \cdot \tan\varphi}$

w_0 = Section modulus [cm^3] of floors or bottom transverses in the hold

A_a = Cross sectional area of attached inner bottom plating [cm^2]

ρ = Cargo density [t/m^3]: $\rho \geq 2{,}5$

φ = Angle of repose of the bulk cargo considered: $\varphi \geq 35°$

d = Double bottom height [mm]

(1) *In way of ordinary stiffeners, $\beta_b = \beta_S = 1$*

(2) *The span ℓ is to be taken equal to the web frame or side transverse spacing.*

NA = not applicable.

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 applying on the fixed cargo securing devices are to be indicated by the designer.

2.1.2 Structural continuity

In 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 equivalent reinforcements.

2.3 Hatch covers carrying containers

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

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 [kN/m] from the following formula:

$$M_T = 31{,}4 \cdot n_S \cdot n_T \cdot B$$

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).

3.2 Force on containers

3.2.1 The force applied to one container located at the level "I", as defined in Fig. 17.1, is to be determined in compliance with Section 6, C.6.5

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:

- in the case of empty steel containers :
  0,14 times the weight of a loaded container

- in the case of empty aluminium containers:
  0,08 times the weight of a loaded container

3.2.2 Stacks of containers

The force transmitted at the corners of such stack is to be obtained [kN] using the following formula:

$$P = F / 4$$

$$F = \sum_{i}^{N} F_i$$

N = Number of containers in a stack

3.2.3 Securing load

The scantling load of securing devices is to be determined assuming an angle of list of 12°.

4. Hull scantlings

4.1 General

4.1.1 In general, the hull scantlings are to be not less than required in Section 8

4.1.2 Scantlings of structural members subjected to concentrated loads are to be determined by direct calculation according to Section 5, E. 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 Section 15, B.3.1.1.

5. Direct calculation

5.1 General

These requirements apply for the grillage analysis of primary supporting members subjected to concentrated loads.

Direct calculation is to be carried out in compliance with Section 5, E.

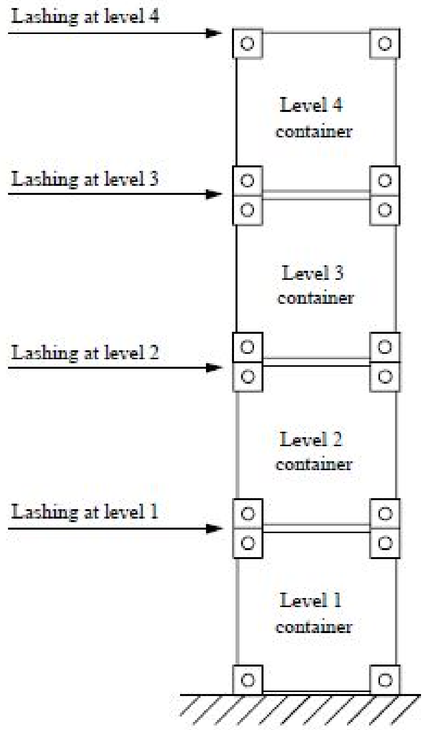


Fig. 17.1 Container levels in a stack

5.2 Loading cases

5.2.1 Bottom structure

The following loading conditions are to be considered in the analysis of the bottom primary supporting members:

- Full container load and scantling draught equal to 0,575 · T

- Maximum vessel draught T, without containers

5.2.2 Deck structure

Where containers are loaded on the deck, the analysis of the deck structure is to be carried out taking into account a full container load.

5.3 Structure checks

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 web

- Continuity of double bottom in the side tank, for bottom structure

D. Equipped for Transport of Wheeled Vehicles

1. General

1.1 Application

1.1.1 Cargo 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 Section 2, B.3.2.2.

1.1.2 These vessels are to comply with the requirements stated under Section 14, A. or B., as applicable.

2. Vessel arrangements

2.1 Sheathing

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, ro-ro cargo decks or platforms are to be longitudinally framed.

Where a transverse framing system is adopted, it is to be considered by **TL** on a case-by-case basis.

2.3 Drainage of ro-ro cargo 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 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 Ro-ro cargo spaces

3.1.1 Design loads

The wheeled loads induced by vehicles are defined in Section 6, C.6.6.

3.1.2 The scantlings of ro-ro cargo spaces are to be in compliance with Section 15, C.3.

3.2 Movable decks and inner ramps

The requirements applicable to movable decks and inner ramps are defined in Section 9, F.1.

3.3 External ramps

The requirements applicable to external ramps are defined in Section 9, F.2.

E. 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 Section 2, B.5.2.1

1.1.2 These vessels are to comply with the requirements stated under Section 15, D., as far as applicable.

2. Vessel arrangements

2.1 Sheathing

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 **TL** on a case-by-case basis.

2.3 Drainage of ro-ro cargo 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 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 Ro-ro cargo spaces

3.1.1 Design loads

The wheeled loads induced by vehicles are defined in Section 6, C.6.6.

3.1.2 The scantlings of ro-ro cargo spaces are to be in compliance with Section 15, C.4.

3.2 Movable decks and inner ramps

The requirements applicable to movable decks and inner ramps are defined in Section 9, F.1.

3.3 External ramps

The requirements applicable to external ramps are defined in Section 9, F.2.

4. Electrical installations

4.1 Protective measures on car decks

4.1.1 Special category spaces: definition

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.

4.1.2 Installations in special category spaces situated 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 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 least 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 Section 13, A.1.4.6 and to have minimum explosion group IIA and temperature class T3.

Electrical equipment is to be as stated in Section 13, A.1.4.7.

4.1.3 Installations in special category spaces situated below the bulkhead deck

An electrical equipment installed is to be as stated in Section 13, A.1.4.6 and to have minimum explosion group IIA and temperature class T3.

4.1.4 Ventilation

Electrical equipment and cables in exhaust ventilation ducts are to be as stated in Section 13, A.1.4.6 and to have minimum explosion group IIA and temperature class T3.

F. Stability

1. Symbols

L = Rule length [m] defined in Section 4, A.1.

L_{WL} = Length of the hull [m] measured at the maximum draught

B = Breadth [m] defined in Section 4, A.1.

H = Depth [m] defined in Section 4, A.1.

T = Draught [m] defined in Section 4, A.1.

Δ = Displacement of the laden vessel [t]

v = Maximum speed of the vessel in relation to the water [m/s]

KG = Height [m] of the centre of gravity above base line

n = Navigation coefficient defined in Section 6, B.

= $0,85 \cdot h$

h = Significant wave height [m]

C_B = Block coefficient

2. General

2.1 Application

Vessels complying with the requirements of E.4.4 are eligible for the assignment of the following additional class Notation, as defined in Section 2, B.9.4:

- Damage stability

Due to stability approvals are not only classification but also statutory matters, if other criteria are accepted by the Administration concerned, these criteria may be used for the purpose of classification.

2.2 Definitions

2.2.1 Plane of maximum draught

Plane of maximum draught is the water plane corresponding to the maximum draught at which the vessel is authorized to navigate.

2.2.2 Bulkhead deck

Bulkhead deck is the deck up to which the required watertight bulkheads are carried and from which the freeboard is measured.

2.2.3 Freeboard (f)

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.

2.2.4 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.

2.2.5 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.

2.2.6 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.

2.2.7 Weathertight

Weathertight is the term used to describe 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 **TL** before installing.

2.2.8 Watertight

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).

2.3 Documents to be submitted and to be used on board

2.3.1 Documents to be given on board

The following information is to be given on board of the vessel and has to be prepared in a clear and understandable form, as a working document for the master.

- General description of the vessel

- 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 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

- Light ship data from the inclining test, including light ship displacement, centre of gravity coordinates, place and date of the inclining test, as well as **TL** 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 abovementioned 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, possibilities for alternate loading of 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 crossflooding, when applicable

- Damage control plan (in case a damage stability calculation is required) showing the watertight subdivision used for damage stability calculation, giving guidance on how to reduce a heeling angel resulting from water ingress, and showing all closing devices to be kept closed while sailing.

2.3.2 Documents to be submitted for examination

All information/documents mentioned under 2.3.1, to be given on board, and a lines plan respectively a hull definition such as offset table.
TL may require further necessary guidance for the safe operation of the vessel.

2.4 Basic data for the stability calculation

2.4.1 Definitions

- Light ship

  The light ship 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.

- 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.

2.4.2 The light ship displacement and the location of the centre of gravity shall be determined either by means of an inclining experiment (see H.) or by detailed mass and moment calculation. In this latter case the light weight of the vessel shall be checked by means of a light weight test with a tolerance limit of about 5 % between the mass determined by calculation and the displacement determined by the draught readings.

The weight and centre of gravity calculation has to be submitted before the light weight survey will be performed.

2.5 Effects of free surfaces of liquids in tanks

2.5.1 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.

2.5.2 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. Tankers

3.1 General

3.1.1 Application

3.1.2 The following requirements apply to tankers:

3.1.3 The centre longitudinal bulkhead may be dispensed with only if sufficient stability is guaranteed.

3.2 Intact stability

3.2.1 Proof of sufficient intact stability is to be provided for all loading/unloading stages and for the final loading stage.

3.2.2 For vessels with cargo tanks of more than 0,70.B in width, the following intact stability requirements are to be complied with:

- A minimum righting lever GZ value of 0,10 m is to be reached within the range of positive stability, limited by the angle at which unprotected openings become submerged

- The area below the GZ curve within the range of positive stability, limited by the angle at which unprotected openings become submerged or 27 degrees whichever is the lesser, is to be not less than 0,024 m.radians

- The initial metacentric height GM_0 value is to be at least 0,10 m.

The stability reducing free surface effect shall be taken into account according to 2.5.

4. Container vessels

4.1 General

4.1.1 Application

The following requirements apply to container vessels which have to comply with the Intact stablity requirements and Damage stability requirements which are intended to receive additional class Notation **FS**.

4.1.2 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.

4.1.3 In 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.

4.2 Methods of calculations

The following two methods of calculation of stability of vessels carrying containers shall be considered as equally acceptable.

Method A

4.2.1 Stability in case of non-secured containers

4.2.1.1 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.

4.2.1.2 The heeling lever [m] resulting from the centrifugal force caused by the vessel turning shall be determined in accordance with the following formula:

$$h_{KZ} = 0.04 \cdot \frac{v^2}{L_{WL}} \cdot \left(KG - \frac{T}{2} \right)$$

KG = Height [m] of centre of gravity of the loaded vessel above its base

v = Maximum speed of the vessel [m/s]

4.2.1.3 The heeling lever [m] resulting from the wind thrust is to be determined in accordance with the following formula:

$$h_{KW} = p_{WD} \cdot \frac{A_W}{\Delta} \cdot \left(\ell_W + \frac{T}{2} \right)$$

p_{WD} = Specific wind pressure [t/m^2]:

- for **I (0)** and **I (0,6)** : P_{WD} = 0,025

- for **I (1,2)** and **I (2)** : P_{WD} = 0,04.n

A_W = Side surface above the water of the loaded vessel [m^2]

l_W = Height [m] of the centre of gravity of the side surface A_W above the water related to the waterline.

4.2.1.4 The heeling lever [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:

$$h_{KFO} = \frac{0.015}{\Delta} \cdot \Sigma\left[b \cdot \ell \cdot \left(b - 0.55 \cdot \sqrt{b}\right)\right]$$

b = Width of hold or section of the hold in question [m]

ℓ = Length of hold or section of the hold in question [m]

4.2.1.5 Half of the fuel and fresh water supply shall be taken into account for each load condition.

4.2.1.6 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 resulting from the formula below mentioned.

The KG_Z shall be calculated for various displacements covering all of the possible draught variations.

$$KG \le KG_Z$$

KG = Effective height [m] of vessel centre of gravity above its base

KG_Z = Maximum permissible height [m] of the loaded vessel's centre of gravity above its base, given by the formula:

$$= \frac{KM + \frac{B_{WL}}{2 \cdot F} \cdot \left(Z_Z \cdot \frac{T_m}{2} - h_{KW} - h_{KFO}\right)}{\frac{B_{WL}}{2 \cdot F} \cdot Z_Z + 1}$$

or

$$KG_Z = KM - 1$$

whichever is the lesser,

B_{WL} /2.F > 11,5

KM = Height of the metacentre above the base [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

$$= \frac{B_{WL}^2}{\left(12{,}5 - \frac{T_m}{D}\right) \cdot T_m} + \frac{T_m}{2}$$

- other vessels

$$= \frac{B_{WL}^2}{\left(12{,}7 - 1{,}2 - \frac{T_m}{H}\right) \cdot T_m} + \frac{T_m}{2}$$

F = Effective freeboard at 0,5 · L

B_{WL} = Vessel waterline breadth [m]

T_m = Average draught [m]

Z_Z = Parameter for the centrifugal force resulting from turning:

$$= 0{,}04 \cdot \frac{v^2}{L_{WL}}$$

4.2.2 Stability in the case of secured containers

4.2.1.1 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 be not to 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 water.

4.2.1.2 The heeling moments resulting from the wind thrust, centrifugal force due to the vessel's turning and free surfaces of water are to be determined in accordance with 4.2.

Half of the supply of fuel and fresh water for each load condition shall be taken into account.

4.2.1.3 The stability of a vessel carrying secured containers shall be considered to be adequate if the effective KG does not exceed the KG_Z resulting from the formula that has been calculated for the different displacements resulting from the possible height variations.

$KG \le KG_Z$

KG = Effective height [m] of vessel centre of gravity above base line

KG_Z = Maximum admissible height [m] of vessel centre of gravity above its base line, given by:

$$= \frac{KM - KM_1 + KM_2}{0{,}75 \cdot \frac{B_{WL}}{F^*} \cdot Z_Z + 1}$$

or

$KG_Z = KM - 0{,}5$

whichever is the lesser,

$$KM_1 = \frac{1-i}{2 \cdot \nabla} \cdot \left(1 - 1{,}5 \cdot \frac{F}{F^*}\right) \ge 0$$

$$KM2 = 0{,}75 \cdot \frac{B_{WL}}{F^*} \cdot \left(Z_Z \cdot \frac{T_m}{2} - h_{KW} - h_{KFO}\right)$$

$$B_{WL}/F^* \ge 6{,}6$$

F* = Ideal freeboard [m]

= MIN (F_1^*, F_2^*)

F_1^* = $H^* - T_m$

$$F_2^* = \frac{a \cdot B_{WL}}{2 \cdot b}$$

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 [m]

b = Distance of the same opening as above from the centre of the vessel [m]

H* = Ideal depth [m]:

$$= H + \frac{q}{0{,}9 \cdot L \cdot B_{WL}}$$

q = Sum of the volumes [m3] of the deckhouses, hatchways, trunk decks and other super structures 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 from the extremities of the vessel shall not be taken into account.

∇ = Displacement of the vessel at T_m [m^3]

i = Transverse moment of inertia [m^4] of waterline parallel to the base, at height [m] equal to:

$h = T_m + 2 \cdot F^* / 3$

I = Transverse moment of inertia [m^4] of waterline T_m

If there is no curve diagram the value needed for calculating lateral moment of inertia I of the water line may be obtained from the following approximation formulae:

- vessels in the form of a pontoon:

$$= \frac{\nabla \cdot B_{WL}^2}{\left(12{,}5 - \frac{T_m}{H}\right) \cdot T_m}$$

- other vessels:

$$= \frac{\nabla \cdot B_{WL}^2}{\left(12,7 - 1,2 \cdot \frac{T_m}{H}\right) \cdot T_m}$$

Method B

4.2.3 Stability in case of non-secured containers

4.2.3.1 The stability of vessels carrying non-secured containers shall meet the following additional conditions:

a) Metacentric height, GM, shall not be less than 1,00 m.

b) The permissible angle of heel φ_{perm} is compared with the angle of heel $\varphi_{wst/cf}$ resulting from the combined effect of the heeling moments produced by the static pressure of wind M_w (see Section 15, D.6.2.5) and the effect of the centrifugal force on turning M_{dr}. In calculating M_{dr} in accordance with Section 15, D.6.2.6, the speed of the vessel before it begins its turn is taken as 0,8 of the maximum speed. This angle must not be greater than 5° or the critical angle φ_n at which the upper edge of the freeboard deck is submerged, with a view to determining which of these angles is the smaller; in other words, one of the following requirements must be satisfied:

$\varphi_{wst/cf} \leq \varphi_{perm} = 5°$ or

$\varphi_{wst/cf} \leq \varphi_{perm} = \varphi_n$, if $\varphi_n < 5°$.

4.2.3.2 The angle of heel $\varphi_{wst/cf}$ should be determined from the static stability diagram in relation to the value of M_{wst} and M_{cf} as a result of constructions given in figure 17.2A where the origin of the coordinates is transposed to point O' on curve M, corresponding to the static angle of heel ϕ_{wst}, arising as a result of the application of the static moment M_w, determined in accordance with Section 15, D.6.2.5.

The angle of heel $\varphi_{wst/cf}$ is determined by selecting a straight line BD parallel to the ordinates axis, assuming that the hatched areas O'CA above the curve up to the moment M_{dr} and ABD below the curve are equal.

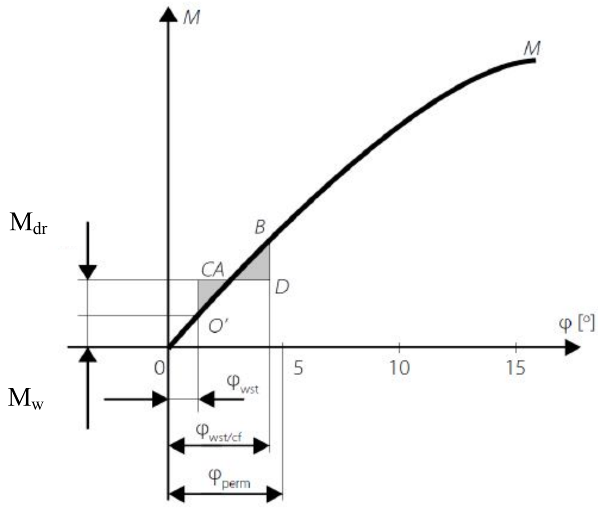


Figure 17.2 A

4.2.3.3 In determining the permissible moment produced by the dynamic inclinations M_{perm}, the permissible angle of heel ϕ_{perm} must be no greater than that given in paragraph 4.2.3.1.b).

4.2.3.4 If the requirements laid down in paragraphs 4.2.3.1.b) and 4.2.3.3 are not satisfied containers must be secured.

4.2.4 Stability in the case of secured containers

4.2.4.1 The requirement regarding the stability of vessels carrying fixed containers is considered to be met, if the criteria for the stability of cargo vessels.

4.3 Damage stability

4.3.1 Application

In addition to the rules stated under 4.2 and 4.3, the requirements of this subarticle apply to vessels exceeding 110 m in length and to vessels intended for the carriage of dangerous goods according to Section 3, D.

4.3.2 The proof of sufficient stability after damage is to be produced for the most unfavourable loading condition.

The basic values for the stability calculation the vessel's light weight 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 light weight 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

4.3.3 The proof of floatability after damage shall be produced for the fully loaded vessel.

For this purpose, calculated proof of sufficient stability shall be established for the critical intermediate stages of flooding and for the final stage of flooding. For critical intermediate stages of flooding, the righting lever curve has to show, beyond the equilibrium stage, a righting lever ≥ 0,03 m and a positive range ≥ 5°.

4.3.4 The following assumptions shall be taken into account for the damaged condition:

a) Extent of side damage:

- longitudinal extent: at least 0,10 · L
- transverse extent: 0,59 m
- vertical extent: from base line upwards without limit

b) Extent of bottom damage:

- longitudinal extent: at least 0,10 · L
- transverse extent: 3,00 m
- vertical extent: from base line to 0,39 m upwards, the sump excepted

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of the bulkheads shall be chosen that the vessel remains afloat after flooding two or more adjacent compartments in the longitudinal direction.

For the main engine room only a 1-compartment status needs to be taken into account, i.e. the end bulkheads of the engine room shall be assumed not damaged.

For bottom damage, adjacent athwartship compartments shall also be assumed flooded.

d) Permeability:

Permeability shall be assumed to be 95 %.

Differing from the above documented assumption, the values of permeability stated in Table 17.3 may be assumed.

If a calculation proves that the average permeability of any compartment is lower, the calculated value may be used.

e) At the final stage of flooding, the lower edge of any non-watertight opening (e.g. doors, windows, access hatches) shall, at the final stage of flooding, be not less than 100 mm above the damaged waterline.

Table 17.3 Permeability values [%]

Spaces	μ
Engine and sevice rooms	85
Accommodation spaces	95
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

4.3.5 The stability after damage shall be sufficient if, on the basis of the assumptions in 4.3.4, see Fig. 17.2:

a) At the final stage of flooding a safety clearance of not less than 100 mm remains and the angle of heel of the vessel does not exceed 5°; or

b) The positive range of the righting lever curve beyond the stage of equilibrium shall have an area under the curve of ≥ 0,0065 m.rad. The minimum values of stability shall be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel equal to 10° (see Fig. 17.2). If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.

If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly; or

c) For vessels carrying dangerous goods, calculations in accordance with the procedure for damage stability specified in Section 16 or ADN, Part 9, shall produce a positive result.

4.3.6 When cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time for equalization shall not exceed 15 minutes, if during the intermediate stages of flooding sufficient damaged stability has been demonstrated.

4.3.7 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.

4.3.8 Where necessary in order to meet the requirements in 4.3.2 or 4.3.3, the plane of maximum draught shall be re-established.

5. Dredgers and pontoons

5.1 General

5.1.1 Application

The following requirements apply to dredgers and pontoons.

5.1.2 Documentation to be submitted

Stability confirmation shall include the following data and documents:

a) Scale drawings of the floating equipment 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) Curves for the static stability lever arm effects

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

5.2 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.

5.3 Intact stability

5.3.1 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 and the residual safety clearance are adequate, i.e.:

- The residual safety clearance value is, at least:
  - 0,30 m for watertight and weathertight aperture
  - 0,40 m for non-weathertight openings
- The residual freeboard value is at least 0,30 m.

For that purpose the sum of the list and trim angles shall not exceed 10° and the base of the hull shall not emerge.

5.3.2 Stability checking shall take into account the heeling moments defined in 5.3.3 to 5.3.11.

The moments which may act simultaneously shall be added up.

5.3.3 Load induced moment

The load induced moment is to be defined by the designer.

5.3.4 Asymmetric structure induced moment

The asymmetric structure induced moment is to be defined by the designer.

5.3.5 Moment due to wind pressure

The moment caused by the wind pressure [tm] shall be calculated in accordance with the following formula:

$$M_W = c \cdot P_{WD} \cdot A_W \cdot (\ell_W + T / 2)$$

c = Shape-dependent coefficient of resistance, taking account of gusts:

- for frameworks: c = 1,2

- for solid section beam: c = 1,6

P_{WD} = Specific wind pressure [t/m^2]:

- for **I (0)** and **I (0,6)** : P_{WD} = 0,025

- for **I (1,2)** and **I (2)** : $P_{WD} = 0{,}04 \cdot n$

A_W = Side surface area of the floating installation [m^2]

ℓ_W = Distance [m] of centre of gravity of area A_W, from draught mark

5.3.6 Turning circle induced moment

For self-propelled vessels, the moment resulting from the turning of the vessel [tm] is to be determined by the following formula:

$$M_T = \frac{0{,}045 \cdot C_B \cdot v^2 \cdot \Delta}{L_{WL}} \cdot \left(KG - \frac{T}{2}\right)$$

KG = Height [m] of the centre of gravity above base line

5.3.7 Cross-current induced moment

The moment resulting from the cross-current shall only be taken into account for floating equipment which is anchored or moored across the current while operating.

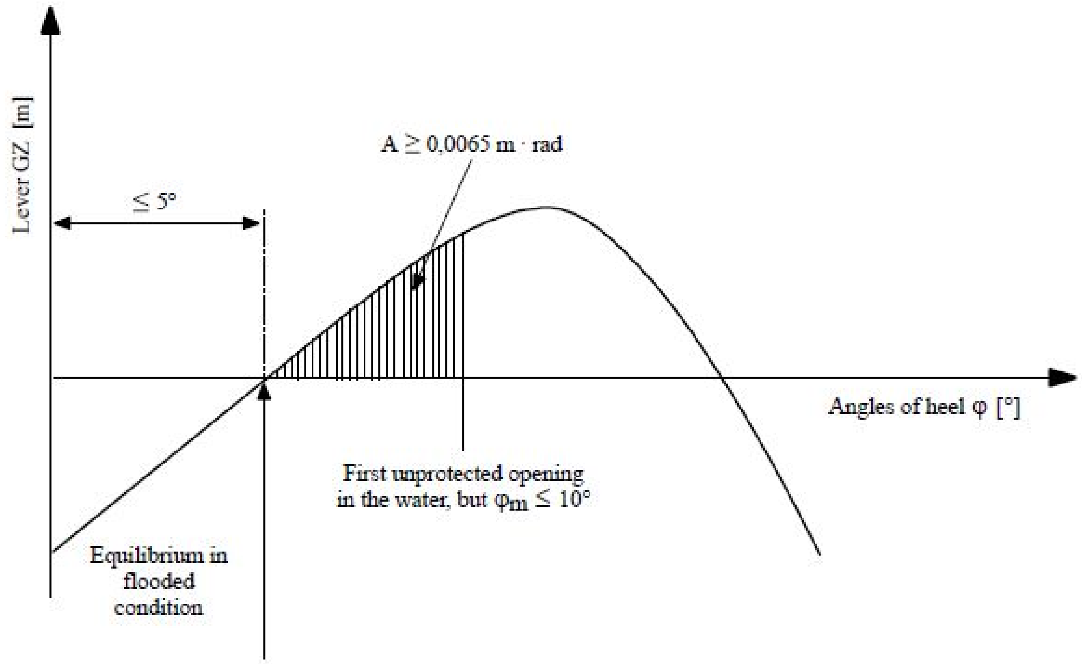


Fig. 17.2 Container vessels: proof of damage stability

5.3.8 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

5.3.9 Moment due to clear surfaces occupied by liquids

The moment [tm] due to clear surfaces occupied by liquids is to be determined in accordance with the following formula:

$$M_{FO} = 0{,}015 \cdot \Sigma b \cdot \ell \cdot (b - 0{,}55 \cdot \sqrt{b})$$

b = Width of the free surface or width of the free surface section considered [m]

ℓ = Length of the free surface or length of the free surface section considered [m]

5.3.10 Moment due to inertia forces

The moment resulting from the inertia forces shall be taken into account if the movements of the load and the working gear are likely to affect its stability.

5.3.11 Moment due to other mechanical equipment

The moment due to other mechanical equipment is to be defined by the designer.

5.3.12 The righting moments [tm] for floating installations with vertical side walls may be calculated via the formula:

$$M_a = \Delta . GM \cdot \sin \varphi$$

GM = Metacentric height [m]

φ = List angle.

That formula 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 floating installation(s) does not permit such simplification the lever-effect curves referred to in 5.1.2 item c) shall be required.

5.4 Intact stability in case of reduced residual freeboard

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 [m] of at least:

$h = 0,30 - 0,28.\varphi_n$

φ_n = list angle [rad] from which the 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 sum of trim and list angles does not exceed 10°

d) The residual safety clearance value is, at least:

- 0,30 m for watertight and weathertight openings
- 0,40 m for non-weathertight openings

e) The residual freeboard is at least 0,05 m

f) For list angles between 0° and 30°, the residual lever arm [m] is at least:

$h = 0,20 - 0,23\ \varphi_n$

φ_n = list angle [rad] from which the lever arm curve displays negative values; this should not be inserted into the Formula for more than 30° or 0,52 rad

Residual lever arm means the maximum difference existing between 0° and 30° list between the righting lever curve and the curve of the heeling lever. If an opening towards the inside of the vessel immerses 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.

5.5 Floating installations without confirmation of stability

The following floating installations may be exempted from requirements of 5.3 and 5.4:

- Those whose working gear may in no way alter their list or trim and
- Those where there can in no way be any displacement of the centre of gravity

However:

- At maximum load, the safety clearance shall be at least 0,30 m and the freeboard at least 0,15 m.
- For apertures which cannot be closed in such a way as to exclude spray and bad weather, the safety clearance shall be at least 0,50 m.

6. Vessels carrying bulk dry cargo

6.1 General

6.1.1 Application

The following requirements apply to bulk dry cargo carriers .

6.2 Heeling moments

6.2.1 Wind pressure induced moment

The moment [tm] due to lateral wind pressure is to be determined by the following formula:

$M_W = P_W \cdot A_W \cdot (\ell_W + T / 2)$

P_W = Specific wind pressure [kN/m^2]:

- for **I (0)** and **I (0,6)**: P_W = 0,025
- for **I (1,2)** and **I (2)**: P_W = 0,04.n

A_W = Lateral area above water [m^2]

ℓ_W = Distance [m] of centre of gravity of area AW, from draught mark

6.2.2 Centrifugal force induced moment

The turning circle moment [tm] is to be determined by the following formula:

$$M_T = \frac{0{,}045 \cdot v^2 \cdot \Delta}{L_{WL}} \cdot \left(KG - \frac{T}{2} \right)$$

KG = Height [m] of centre of gravity above base line

6.2.3 Cargo shift induced moment

For 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, the cargo shifting induced moment is to be taken into account.

The value of this moment 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°.

6.3 Intact stability

The intact stability characteristics of any vessel carrying bulk dry cargo (see Fig. 17.3), are to be shown to meet, throughout the voyage, at least the following criteria after taking into account the total heeling moment (as defined under 6.2):

a) The angle of heel φ_1 is to be not greater than 12°.

b) In the statical stability diagram, the residual area between the heeling arm curve and the righting arm curve up to the angle of heel φ_2 is in all conditions of loading to be not less than 0,0065 mrad.

φ_2 = Angle of heel of maximum difference between the ordinates of the heeling arm curve and the righting arm curve, or 27° or the angle of flooding, whichever is the least.

6.4 Additional requirement

6.4.1 For 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, requirements 6.4.2 to 6.4.4 are to be additionally complied with.

6.4.2 Trimming

All necessary and reasonable trimming is to be performed to level all free cargo surfaces and minimize the effect of cargo shifting.

6.4.3 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.

6.4.4 Longitudinal subdivisions

The proper precaution is to fit one or more temporary longitudinal subdivisions in the holds or compartments to minimize the possibility of shift of cargo.

G. Additional Fire Rules for Passenger Vessels

1. General

1.1 Application

1.1.1 Passenger vessels complying with the following requirements

Vessels are to comply with the requirements stated under Section 12, H. and Section 13, D.3. as far as applicable, to passenger vessels.

2. Fire integrity of bulkheads and decks

2.1 The minimum fire integrity of all bulkheads and decks shall be as shown in Table 17.4 and Table 17.5.

2.2 The following requirements shall govern the application of the tables:

- Table 17.4 shall apply to spaces without an installed sprinkler installation.

- Table 17.5 shall apply to spaces in which a sprinkler installation is provided on both sides of bulkheads and deck.

2.3 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 stations

wheelhouse, spaces containing the vessel's radio equipment, spaces containing centralized fire alarm equipment, spaces containing centralized emergency public address system stations and equipment

b) Staircases

Interior stairways, lifts, enclosed emergency escape tanks. In this connection, a stairway 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.

c) Assembly stations

d) Accommodation spaces

Cabins, public spaces, sale shops, barber shops and beauty parlours, saunas, pantries containing no cooking appliances, small lockers (deck area < 4 m^2)

e) Machinery spaces

Main propulsion machinery room, auxiliary machinery spaces

f) Galleys

g) Store rooms

Miscellaneous stores, lockers having deck area exceeding 4 m^2, air conditioning rooms

3. Protection of stairways and lifts in accommodation and service spaces

3.1 All stairways in accommodation and service spaces are to be arranged within enclosures formed by division as stipulated in Table 17.4 and Table 17.5, with effective means of closure for all openings.

3.2 The following exceptions are admissible:

a) A stairway connecting only two decks need not be enclosed, provided that the integrity of the pierced deck is maintained by division/doors as stipulated in Table 17.4 and Table 17.5 at one of the two decks.

b) Stairways fitted within accommodation spaces need not be enclosed subject to the following:

- the space extends over two decks only

- the space reaching more than two decks is protected with a sprinkler installation, equipped with a smoke extraction system, and the space has at each level access to a stairway.

4. Openings in class A and B divisions

4.1 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.

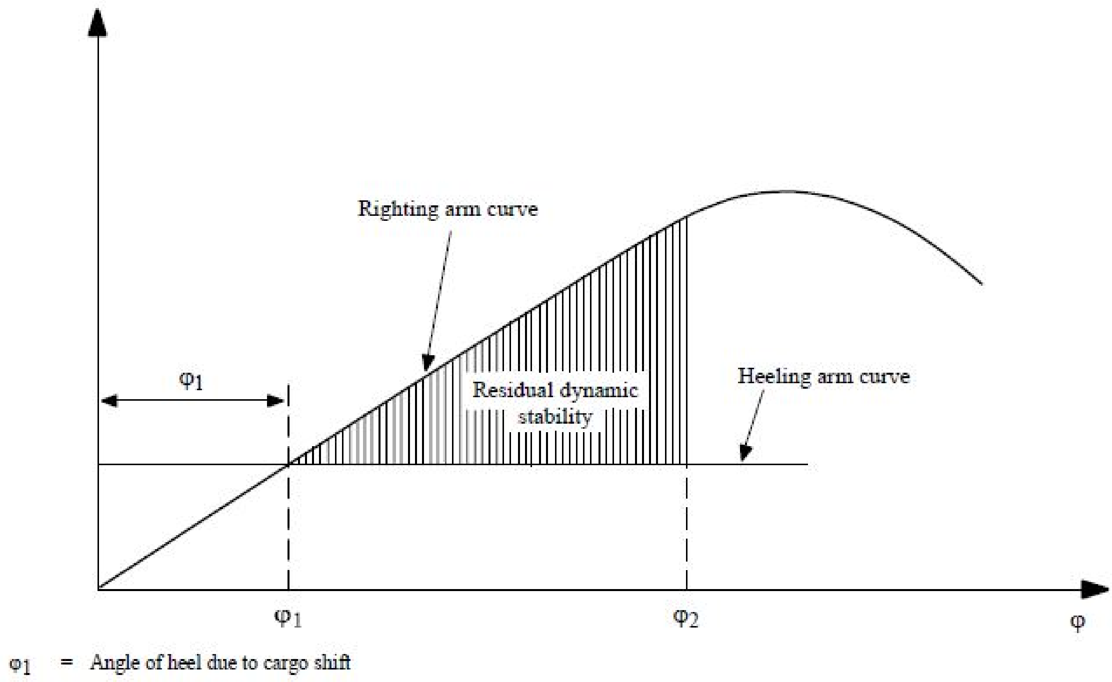


Fig. 17.3 Stability curve

4.2 Fire doors in divisions required by Table 17.4 and Table 17.5 to machinery spaces, to galleys and to staircases shall be of self-closing type.

4.3 It shall be possible for each door to be opened and closed from each side of the bulkhead by one person only.

4.4 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.

5. Fire protection materials

5.1 Insulation materials shall be noncombustible, except insulation of pipe fittings for cold service systems.

5.2 Ceilings and linings in accommodation spaces including their substructures shall be of noncombustible material, unless the space is protected with a sprinkler installation.

5.3 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

5.4 Paints, varnishings and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke and toxic gases (see Note).

Table 17.4 Fire integrity of bulkheads and decks in spaces without sprinkler installation

Space	**Control station**	**Staircase**	**Assembly stations**	**Accommodation spaces**	**Machinery spaces**	**Galleys**	**Store rooms**
Control station	-	A0	A0/B15 **(1)**	A30	A60	A60	A30/A60 **(5)**
Staircase		-	A0	A30	A60	A60	A30
Assembly stations			-	A30/B15 **(2)**	A60	A60	A30/A60 **(5)**
Accommodation spaces				A0/B15 **(3)**	A60	A60	A30
Machinery spaces					A60/A0 **(4)**	A60	A60
Galleys						A0	A30/B15 **(6)**
Store rooms							-

Table 17.5 Fire integrity of bulkheads and decks in spaces with sprinkler installation

Space	**Control station**	**Staircase**	**Assembly stations**	**Accommodation spaces**	**Machinery spaces**	**Galleys**	**Store rooms**
Control station	-	A0	A0/B15 **(1)**	A0	A60	A30	A0/A30 **(5)**
Staircase		-	A0	A0	A60	A30	A0
Assembly stations			-	A30/B15 **(2)**	A60	A30	A0/A30 **(5)**
Accommodation spaces				B15/B0 **(3)**	A60	A30	A0
Machinery spaces					A60/A0 **(4)**	A60	A60
Galleys						-	A0/B15 **(6)**
Store rooms							-

(1) *Partitions between control stations and internal assembly stations areas shall correspond to Type A0, but external assembly stations only to Type B15.*

(2) *Partitions between accommodation spaces and internal assembly stations shall correspond to Type A30, but external assembly stations only to Type B15.*

(3) *Partitions between cabins, partitions between cabins and corridors and vertical partitions separating accommodation spaces shall comply with Type B15, for rooms fitted with pressurized sprinkler systems B0. Partitions between cabins and saunas shall comply with Type A0, for rooms fitted with pressurised sprinkler systems – B15.*

(4) *Partitions between engine rooms shall comply with Type A60; in other cases, they shall comply with Type A0.*

(5) *Partitions between store rooms for the storage of flammable liquids and control stations and assembly stations shall comply with Type A60, for rooms fitted with pressurised sprinkler systems – A30.*

(6) *B15 is sufficient for the partitions between galleys and cold-storage rooms or food storage rooms.*

Note

Reference is made to the Fire Test Procedure Code, Annex 1, Part 2, adopted by IMO by Resolution MSC.61 (67)

5.5 Fabrics, curtains and other hanging textiles as well as upholstered furniture and bedding components (see Notes) shall be fire retardant, unless the spaces are protected with a sprinkler installation.

Notes

- *Reference is made to the Fire Test Procedure Code, Annex 1, Part 7, adopted by IMO by Resolution MSC.61(67).*

- *Reference is made to the Fire Test Procedure Code, Annex 1, Part 8, adopted by IMO by Resolution MSC.61 (67).*

- *Reference is made to the Fire Test Procedure Code, Annex 1, Part 9, adopted by IMO by Resolution MSC.61 (67).*

5.6 Furniture and fittings in public spaces, which are also assembly station, shall be made of noncombustible material, unless the public spaces are protected with a sprinkler installation.

6. Means of escape

6.1 General

6.1.1 In case accommodation spaces for disabled passengers will be provided, the escape ways from these cabins should have a clear width of at least 1,3 m. Access doors to and doors from the vessel should have a clear width of not less than 1,5 m.

6.1.2 Dead-end corridors

No dead-end corridors having a length of more than 2 m are acceptable.

6.1.3 Escape routes and emergency exits shall be provided with a suitable safety guidance system.

7. Ventilation systems

7.1 General

7.1.1 They shall be so designed as to prevent the spread of fire and smoke through the system.

7.1.2 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.

7.1.3 Ducts shall be constructed of steel or other equivalent non-combustible material.

7.1.4 Ducts exceeding 0,02 m^2 and passing through class A divisions 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.

7.1.5 Ventilation systems for galleys and machinery spaces shall be independent of the ventilation system serving other spaces.

7.1.6 Exhaust ducts are to be provided with suitably arranged hatches for inspection and cleaning. The hatches shall be located near the fire dampers.

7.1.7 All power ventilation shall be capable of being stopped from a central place outside the machinery space.

7.1.8 Galleys have to be provided with separate ventilation systems and exhaust ducts from galley ranges.

Exhaust ducts from galley ranges shall comply with 7.1.1 to 7.1.7 and shall in addition be provided with a manually operated fire damper located in the lower end of the duct.

7.2 Smoke extraction system

7.2.1 Control stations, stairways and internal assembly stations shall be provided with a natural or a mechanical smoke extraction system.

Smoke extraction systems shall comply with 7.2.2 to 7.2.8

7.2.2 They shall provide sufficient capacity and reliability.

7.2.3 They shall consider the operating conditions of passenger vessels.

7.2.4 When the normal ventilation system is used for this purpose it shall be designed that its function will not be impaired by smoke.

7.2.5 They shall be provided with manual actuation.

7.2.6 It shall be possible to operate mechanical smoke extraction systems from a position permanently occupied by crew.

7.2.7 Natural smoke extraction systems shall be provided with an opening mechanism, operated either manually or by a power source inside the ventilator.

7.2.8 Manually operated actuators and opening mechanism shall be accessible from inside and outside of the protected space.

H. Inclining Test and Light Weight Check

Inclining test and light weight check shall be carried out in accordance with IMO Res. MSC 267 (85).