Indian Register of Shipping

Part 1

Regulations

Contents

Chapter 1  General

Chapter 2  Periodical Surveys
Contents

Chapter 1

General

Section 1

General Information

1.1 Indian Register of Shipping
1.2 Fees
1.3 Technical committee
1.4 Survey reports
1.5 Register Of Ships
1.6 Liability

Section 2

Classification Regulations

2.1 General
2.2 Application of Rules
2.3 Definitions
2.4 Character of classification
2.5 Class Notations - Hull
2.6 Class notations - Machinery
2.7 Materials
2.8 Notice of Surveys
2.9 Repairs
2.10 Alterations
2.11 Appeal from Surveyors' recommendations
2.12 Certificates
2.13 Withdrawal/Suspension of class
2.14 Reclassification of ships

Section 3

Classification of Ships not built under the supervision of Indian Register of Shipping

2.1 General procedure for classification of ships not built under survey of IRS
2.2 Plans and data to be furnished as required in 3.1.1

Chapter 2

Periodical Surveys

Section 1

General Requirements

1.1 General
1.2 Laid up vessels
1.2.1 Survey during lay-up
1.2.2 Survey at re-activation

Section 2

Extent of Hull Surveys

2.1 Special surveys (hull)
2.2 Requirements of special surveys (hull)
<table>
<thead>
<tr>
<th>2.2.1 First and second special surveys</th>
<th>3.2.3 Shafting</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.2 Third and subsequent special surveys</td>
<td>3.2.4 Auxiliary machinery</td>
</tr>
<tr>
<td>2.3 Intermediate surveys</td>
<td>3.2.5 Securing arrangements</td>
</tr>
<tr>
<td>2.4 Annual surveys</td>
<td>3.2.6 Boiler surveys</td>
</tr>
</tbody>
</table>

### Section 3

**Extent of Machinery Surveys**

<table>
<thead>
<tr>
<th>3.2.1 Main engines of internal combustion type</th>
<th>3.2.8 Air receivers and starting air pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.2 Reduction gears, flexible couplings and clutch arrangements</td>
<td>3.2.9 Pumping and piping system</td>
</tr>
<tr>
<td>3.2.3 Shafting</td>
<td>3.2.10 Control systems</td>
</tr>
<tr>
<td>3.2.4 Auxiliary machinery</td>
<td>3.2.11 Electrical equipment survey</td>
</tr>
<tr>
<td>3.2.5 Securing arrangements</td>
<td>3.2.12 Fuel tanks</td>
</tr>
<tr>
<td>3.2.6 Boiler surveys</td>
<td>3.2.13 Examination in drydock</td>
</tr>
<tr>
<td>3.2.8 Air receivers and starting air pipes</td>
<td>3.2.14 Propeller shafts</td>
</tr>
<tr>
<td>3.2.9 Pumping and piping system</td>
<td></td>
</tr>
<tr>
<td>3.2.10 Control systems</td>
<td></td>
</tr>
<tr>
<td>3.2.11 Electrical equipment survey</td>
<td></td>
</tr>
<tr>
<td>3.2.12 Fuel tanks</td>
<td></td>
</tr>
<tr>
<td>3.2.13 Examination in drydock</td>
<td></td>
</tr>
<tr>
<td>3.2.14 Propeller shafts</td>
<td></td>
</tr>
</tbody>
</table>

*End Of Chapter*
Chapter 1

General Information

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Information</td>
</tr>
<tr>
<td>2</td>
<td>Classification Regulations</td>
</tr>
<tr>
<td>3</td>
<td>Classification of Ships not built under the Supervision of Indian Register of Shipping</td>
</tr>
</tbody>
</table>

Section 1

General Information

1.1 Indian Register of Shipping

1.1.1 Indian Register of Shipping (hereinafter referred to as "IRS") was incorporated in 1975 as a Public Limited Company under Section 25 of the Indian Companies Act, 1956 for the purpose of providing amongst other things a faithful and accurate classification of mercantile shipping classed with it, to approve designs of, to survey and to issue reports on mercantile and non mercantile ships, hovercrafts, hydrofoils etc; all within the scope of classification described in the Rules. This Section contains General Regulations which have been adopted by IRS for its governance.

1.1.2 The management of the affairs of IRS are carried out under the direction and control of the Board of Directors (hereinafter referred to as the 'Board'), in accordance with the provisions of its Memorandum and Articles of Association.

1.1.3 The Board of Directors shall consist of representative of the interests of various members of the Company and those concerned with shipping in general as under:

- 3 Directors representing Indian Shipowners
- 2 Directors representing Indian Shipbuilders
- 1 Director representing General Insurance Corporation of India and other Indian underwriters
- 1 Director being the Director General of Shipping, Ministry of Surface Transport, Govt. of India

The composition of the Board as above is to be in accordance with the Articles of Association of IRS (as may be amended from time to time).

1.1.4 The Board shall consist of not less than six and not more than fifteen Directors. The Board of Directors shall elect one of its members to be Chairman of the Board of Directors.

1.1.5 The Board is to appoint a Sub-Committee of Classification representing concerned interests.

1.1.6 The Board is to appoint the Chairman of the Sub-Committee of Classification and the Managing Director, IRS to be 'ex- officio' member of the Sub-Committee of Classification.
1.1.7 The employees of IRS are to be appointed by and be under the direction of the Board.

1.1.8 The Surveyors of IRS are not to be permitted without the special sanction of the Board of Directors to receive any fee, gratuity or reward whatsoever, for their own use or benefit, for any service performed by them in their capacity as Surveyors to IRS, except on pain of immediate dismissal.

1.1.9 The Funds and Accounts are to be under the authority and control of the Board of Directors.

1.2 Fees

1.2.1 Fees will be charged for all surveys and for other services rendered by IRS or any of its publications in accordance with established scales. Traveling expenses incurred by the Surveyors in connection with such services are also chargeable.

1.3 Technical committee

1.3.1 The Board is to appoint a Technical Committee whose function will be to consider:-

a) Formulation of Technical Rules for Classification Surveys, building of ships, their machinery and equipment.

b) Important alterations to Rules once framed as may be required from time to time.

1.3.2 All decisions of the Technical Committee including amendments and/or additions to the Rules for classification surveys and building of ships’ hull, their machinery and equipment to be reported to the Board of Directors.

1.3.3 The Technical Committee to be constituted as follows:

<table>
<thead>
<tr>
<th>Number of Members</th>
<th>Nominees/Representatives of</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Board of Directors of IRS</td>
</tr>
<tr>
<td>1</td>
<td>Maine Engine Unit of M/s Garden Reach Shipbuilders and Engineers Ltd.</td>
</tr>
<tr>
<td>1</td>
<td>Other Marine Engine Builders</td>
</tr>
<tr>
<td>6</td>
<td>Shipbuilders</td>
</tr>
<tr>
<td>1</td>
<td>Indian Institution of Naval Architects</td>
</tr>
<tr>
<td>1</td>
<td>Institution of Marine Technologists</td>
</tr>
<tr>
<td>1</td>
<td>Institute of Marine Engineers (India)</td>
</tr>
<tr>
<td>1</td>
<td>Company of Master Mariners</td>
</tr>
<tr>
<td>1</td>
<td>Directorate General of Shipping</td>
</tr>
<tr>
<td>1</td>
<td>National Ship Design &amp; Research Centre</td>
</tr>
<tr>
<td>4</td>
<td>Indian National Shipowners Association</td>
</tr>
<tr>
<td>1</td>
<td>Institution of Engineers (India)</td>
</tr>
<tr>
<td>1</td>
<td>Ex-Officio - Managing Director of IRS</td>
</tr>
</tbody>
</table>

1.3.4 In addition to the foregoing, the Technical Committee may co-opt to the main body other members of high managerial positions in Ship Building and Engineering, Naval Architecture, Marine Insurance, Steel Making, etc.

1.3.5 Nomination of all members to the Technical Committee to be subject to confirmation by the Board.

1.3.6 The Technical Committee can appoint panels from amongst its body to which representatives of any organisation or industry or individuals specialised in relevant disciplines could be co-opted for the purpose of considering any particular Technical problem or area of Rules.

1.3.7 The Board of Directors to appoint biennially, the Chairman of the Technical Committee and the Technical Committee to appoint from their own body biennially a Vice-Chairman. The same members are not to be eligible to hold office of Chairman or Vice-Chairman, as the case may be, for more than two terms in succession unless on the occasion of the third term, the appointing body approves of their continuation by a majority of at least three-fourths of the members present. The appointment of Vice-Chairman to be confirmed by the Board of Directors.

1.3.8 The terms of office of all members to be not more than four years, one-fourth of all members (including those co-opted) to retire at the end of each calendar year. The members so retiring being those who have been longest in office since their last nomination and such members to be eligible for re-nomination for a second term. Unless specially so authorised by the Board of Directors, no member other than
Chairman and/or Vice-Chairman, who has served for two periods of nomination, to be eligible for re-nomination for a third term until after the expiration of at least one year. In the event of any vacancy occurring before the expiration of the normal term of office, a representative to be nominated to fill the vacancy from the same group/body/institution and for such nominee the date of his nomination by the respective body to be considered as date of his joining the Technical Committee for purposes of his retirement by rotation.

1.3.9 The meeting of the Technical Committee to be convened as often and at such time and place as may appear necessary, but there shall be at least two meetings in each year.

1.3.10 The members desiring to propose alterations in, or additions to the Rules for the classification, survey or building of ship (hull and machinery) shall give notice of such proposals to the Secretary. Every meeting to be convened by notice from the Secretary, if possible one month before the date of the meeting and the Secretary to send to each member an Agenda paper as soon as possible thereafter.

1.3.11 The Board of Directors reserves to themselves the right of altering, adding to or rescinding any/or all of the above terms of reference including the dissolution of the Technical Committee.

1.4 Survey reports

1.4.1 All reports of survey are to be made by the Surveyors according to the form prescribed and submitted for consideration of the Board or the Sub-Committee of Classification, but the character assigned by the latter is to be reported to the Board. The Board may, in specified instances, vest in the Managing Director discretionary powers to act on its behalf, and all such actions being reported to the Board at its subsequent meeting.

1.4.2 The reports of the Surveyors shall, subject to the approval of the Managing Director, be open to inspection of the Owner and any other person authorised in writing by the Owner. Copies of the reports will, subject to the approval of the Managing Director, be supplied to Owners or their representatives.

1.5 Register of Ships

1.5.1 A Register Of Ships is available on-line on IRCLASS Website which contains the names of ships, character of class and notations assigned together with other relevant useful information for ships classed with IRS.

1.6 Liability

1.6.1 Whilst Indian Register of Shipping (hereinafter referred to as IRS) and its Committees use their best endeavours to ensure that the functions of IRS are properly carried out, in providing services, information or advice neither IRS nor any of its servants or agents warrants the accuracy of any information or advice supplied. Except as set out herein neither IRS nor any of its servants or agents (on behalf of each of whom IRS has agreed this clause) shall be liable for any loss damage or expense whatever sustained by any person due to any act or omission or error of whatsoever nature and howsoever caused of IRS its servants or agents or due to any inaccuracy of whatsoever nature and howsoever caused in any information or advice given in any way whatsoever by or on behalf of IRS, even if held to amount to a breach of warranty. Nevertheless, if any person uses services of IRS, or relies on any information or advice given by or on behalf of IRS and suffers loss damage or expenses thereby which is proved to have been due to any negligent act omission or error of IRS its servants or agents or any negligent inaccuracy in information or advice given by or on behalf of IRS then IRS will pay compensation to such person for his proved loss up to but not exceeding the amount of the fee charged by IRS for that particular service, information or advice.

1.6.2 Any notice of claim for loss, damage or expense as referred to in 1.6.1 shall be made in writing to IRS Head Office within six months of the date when the service, information or advice was first provided, failing which all the rights to any such claim shall be forfeited and IRS shall be relieved and discharged from all liabilities.
Section 2

Classification Regulations

2.1 General

2.1.1 These Rules and Regulations apply to ships operating in inland waterways, i.e. lakes and rivers. Noting that waves are experienced in some large lakes and river mouths, these Rules provide for determination of scantlings based on the Zone Notation requested by the Builder or the Owners considering the wave height prevalent in the intended area of operation. (see 2.3 for definition of Zone Notation).

2.1.2 These Rules and Regulations may also be applied to ships which are registered at sea ports under the Inland Vessels Acts of various State Governments or similar local Regulations. The scantlings of such vessels will be specially considered in each case but in general will not be less than that required for operation in Zone 1.

2.1.3 When a ship is assigned a specific Character of Class in Indian Register of Shipping, it implies that IRS has been satisfied that the said ship meets, for this particular class, with these Rules and Regulations or requirements equivalent thereto. The ship will continue to be classed with IRS so long as she is found, upon examination at the prescribed annual and periodical surveys, to be maintained in a fit and efficient condition and in accordance with the Periodical Survey requirements of these Rules. Classification will be conditional upon compliance with IRS requirements and assignment of character of class for both hull and machinery.

2.1.4 The Rules are framed on the understanding that ships will be properly loaded and handled and that ships will not be operated in environmental conditions more severe than those agreed for design basis and approval. They do not, unless stated in the class notation, provide for special distributions or concentrations of loading.

2.1.5 Compliance to applicable Local/National Regulations in respect of the arrangements and equipment is a prerequisite for classification.

2.1.6 Where a vessel holds dual classification with IRS and the periodical survey requirements of the corresponding Society differ from those of the Rules of IRS, IRS may permit the requirements of the other Society being applied, in so far as they are equivalent in purpose or are no less stringent than the IRS rule requirements.

2.2 Application of Rules

2.2.1 Unless directed otherwise by IRS, no new Regulations or amendments to the Rules relating to the character of classification or class notation is to be applied to the existing vessels.

2.2.2 Unless directed otherwise by IRS, all new Rules and Regulations or amendments to the existing Rules & Regulations become applicable 6 months after the date of issue or after the approval of original midship section or equivalent structural plans. Where it is proposed to use existing previously approved plans for a new contract, written application is to be made to IRS.

2.3 Definitions

2.3.1 Type Notation: A notation indicating that the ship has been designed and constructed with applicable Rules to that type of ship, e.g. "Ferry", "Bulk Carrier", etc.

2.3.2 Cargo Notation: A notation indicating that the ship has been designed, modified or arranged to carry one or more particular cargoes, e.g. "Phosphoric Acid". Ships with one or more particular cargo notations are not thereby prevented from carrying other cargoes for which they are suitable.

2.3.3 Zone Notation: A notation indicating that a ship has been classed on the understanding that it will be operated in one of the zones described below:

Zone 1: A zone where the maximum significant wave height does not exceed 2.0 [m].

Zone 2: A zone where the maximum significant wave height does not exceed 1.2 [m].

Zone 3: A zone where the maximum significant wave height does not exceed 0.6 [m].
2.4 Character of classification

2.4.1 The following Characters and symbols are assigned by IRS to indicate classification of Inland Waterways Ships. (For explanation of abbreviations, see Appendix I).

2.4.2 Character IWL indicates that the hull and its appendages and equipment (i.e. anchors, chain cable and hawser) meet the Rule requirements for assignment of this Character of Class.

Guidance Note: Appendages to the hull referred to in 2.4.2, 2.4.3 and 2.4.4 means the rudder & rudder stock, rudder horn, sole pieces, propeller nozzles, shaft brackets, skeg etc. which are covered by the rule requirements.

2.4.3 Character IW- indicates that the hull and its appendages meet the Rule requirements but equipment (i.e. anchors, chain cable and hawser) is not supplied or maintained as per the relevant Rules but is considered by IRS to be acceptable for particular service.

2.4.4 Character IW indicates that the hull and its appendages meet the Rule requirements but where special consideration has been given for reason of particular purpose of service and normal equipment may be unnecessary. In such cases letter 'L' is omitted from the Character IWL.

2.4.5 Character IY assigned to self-propelled vessels indicates that the machinery meets the rule requirements for assignment of this Character of Class.

2.4.6 The distinguishing mark ☐ inserted before Characters of Class (IWL, IW-, IW, IY as appropriate) is assigned to new ships where the hull and its appendages, equipment and the machinery, as appropriate are constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS.

2.5 Class Notations - Hull

2.5.1 When requested by an Owner and agreed to by IRS or when considered necessary by IRS, a class notation will be appended to the character of classification. This class notation will consist of one of, or a combination of - a type notation, a cargo notation and a zone notation or a service restriction notation as given in 2.5.3 below, e.g. ☐ "IWL Oil and Chemical Tanker for carrying Xylene and Lub. Oil, Zone 1".

2.5.2 Details of the ship types and additional class notations are given in Appendix 1 and applicable Chapters in Pt.5 of the Rules.

2.5.3 For vessels described in 2.1.2 a service restriction notation will generally be assigned in the form given below, but this does not preclude the Owners or Shipbuilders from requesting special consideration for other forms of restrictions.

Service within IV Limits at [...name of sea port...]

2.6 Class Notations - Machinery

2.6.1 The class notations that may be assigned by IRS are given in Appendix 1. IRS may prescribe additional notations as found necessary/expedient from time to time.

2.7 Materials

2.7.1 The materials used in the construction of hulls and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be manufactured and tested in accordance with the requirements of Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships. The steel is to be manufactured by an approved process at works recognized* by IRS. Alternatively, tests to the satisfaction of IRS will be required to demonstrate the suitability of the steel.

* Consideration may be given by IRS at their sole discretion to recognize the works on the approved list of Classification Societies with whom IRS currently has Dual Class Agreements for this purpose. Such approval of works is intended for limited periods only and may call for such tests and/or examination to be carried out by the Surveyors of IRS as may be decided by IRS from time to time.

2.8 Notice of Surveys

2.8.1 It is the responsibility of the Owners to notify the Surveyors of IRS in the port at which surveys or repairs are undertaken and to ensure that all surveys necessary for the maintenance of class are carried out at the proper time.

2.9 Repairs

2.9.1 Any repairs to the hull, machinery and equipment either as a result of damage or wear and tear which are required for the maintenance of ship's class are to be carried out under the inspection of and to the satisfaction of the Surveyors.
2.9.2 Where a vessel is damaged to an extent resulting in towage outside port limits, it shall be the Owners' responsibility to notify IRS at the first practicable opportunity.

2.9.3 Where such repairs are effected at a port where there is no Surveyor of IRS, the ship is to be surveyed by one of its Surveyors at the earliest opportunity.

2.10 Alterations

2.10.1 Any alterations proposed to be carried out to approved scantlings and arrangements of the hull, machinery or equipment are to meet with the approval of IRS and for this purpose plans and technical particulars are to be submitted for approval in advance. Such approved alterations are to be carried out under the inspection of, and to the satisfaction of, the Surveyors.

2.11 Appeal from Surveyors' recommendations

2.11.1 If the recommendations of the Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to IRS, who may direct a special examination to be held.

2.12 Certificates

2.12.1 Certificates of Class will be issued to Builders or Owners when the required reports on completion of Special Surveys of new ships or of existing ships submitted for classification have been received from the Surveyors and approved by IRS.

2.12.2 Certificates of class maintenance in respect of completed periodical special surveys of hull and machinery will also be issued to Owners.

2.12.3 The Surveyors are permitted to issue Interim Certificates to enable a ship, classed with IRS, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such Certificates will contain Surveyors' recommendations for continuance of Class, but in all cases are subject to confirmation by IRS.

2.12.4 Individual Certificates can also be issued for propelling machinery, boilers, equipments and fittings which have been manufactured under IRS Survey and in accordance with these Regulations.

2.13 Withdrawal/Suspension of class

2.13.1 When the class of a ship holding IRS class, is withdrawn by IRS in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the Supplement and the notation "Class withdrawn - Owners' request" (with date) will be made in the next reprint of the Register of Ships. After one year, the notation will be altered to "Classed IRS until" (with date).

2.13.2 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be withdrawn and the notation "Class withdrawn" (with date) will be made in the Supplement and the notation "IRS Class withdrawn" (with date) will be made in the next reprint of the Register of Ships. After one year, the notation will be altered to "Classed IRS until" (with date).

2.13.3 When it is found from reported defects in the hull or equipment or machinery that a ship is not entitled to retain her Class in the Register of Ships and the Owners fail to repair such defects in accordance with the IRS requirements, the Class will be withdrawn and the notation "Class withdrawn - Reported defects" (with date) will be made in the supplement and the notation "Class withdrawn - Reported defects" (with date) will be made in the next reprint of the Register of Ships. After one year the notation will be altered to "Classed IRS until" (with date).

2.13.4 The class of a ship is liable to be withheld or, if already granted, may be withdrawn in case of any non-payment of fees or expenses chargeable for the service rendered.

2.14 Reclassification of ships

2.14.1 When Owners request for reclassification of a ship for which the class previously assigned has been withdrawn, IRS will require a Special Survey for Reclassification to be held by the IRS Surveyors. The extent of the survey will depend upon the age of the ship and the circumstances of each case.

2.14.2 If the ship is found or placed in good and efficient condition in accordance with the requirements of the Rules and Regulations at the Special Survey for Reclassification, IRS may decide to reinstate her original class or assign such other class as considered appropriate.

2.14.3 The date of reclassification will appear in the supplement to the Register of Ships and the subsequent issue of Register of Ships.
Section 3

Classification of Ships not built under the Supervision of Indian Register of Shipping

3.1 General procedure for classification of ships not built under survey of IRS

3.1.1 Plans of hull and machinery in duplicate, together with torsional vibration calculations, where applicable, as specified in 3.2.5 are to be submitted for approval. It is preferable to have the plans approved before the classification survey is commenced.

3.1.2 Full special classification surveys would require to be carried out by IRS Surveyors in order to satisfy themselves regarding the workmanship and to verify the approved scantlings and arrangements. The scope of these surveys may, however, be modified in the case of vessels built under the Special Survey and holding valid certificates of class of established classification societies, if prior to commencement of survey by IRS, documentary evidence of all hull and machinery classification surveys held by the other society subsequent to last special survey carried out by them could be produced. In such cases, a special survey notation will not be assigned in conjunction with the classification survey. The next special survey therefore would become due five years from the special survey held by the other society and not five years from classification with IRS.

3.1.3 When the required reports on completion of such surveys have been received from the Surveyors and thereafter approved by IRS, they will be classed. Certificates of Class will be issued and entered in the Register of Ships with the relevant characters of class and notation, but the mark signifying the survey during construction will be omitted.

3.1.4 Once a vessel has been taken into IRS class, periodical surveys are subsequently to be held as per these rules.

3.2 Plans and data to be furnished as required in 3.1.1

3.2.1 Generally following plans of hull and equipment showing the main scantling and arrangements of the actual ship and any proposed alterations are to be submitted.

For approval

- Loading Manual
- Midship section
- Longitudinal section and decks
- Shell expansion plan
- Transverse Bulkheads
- Fore body
- Aft body
- Sternframe
- Rudder and Rudder Stock
- Hatch Covers
- Fire detection, fighting and extinction and such other plans as may be requested.

For information

- General arrangement
- Capacity plan
- Hydrostatic Curves
- Lightweight Distribution

3.2.2 It would normally be expected that particulars of the process of manufacture and testing of material of construction are furnished. Consideration will however be given to waiving this where such particulars are not readily available, provided it can be established that the relevant vessel has been originally built under special survey of an established classification society and continues to be so classed with an established classification society. In the case of vessels which have been originally built under the special survey of an established classification society but subsequently not maintaining class, it should additionally be possible to reasonably ascertain that no changes that would significantly affect the material specifications have taken place.
3.2.3 Following machinery plans together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished:

- Plans to be submitted in case of motorships
- For approval
  - Crank, thrust, intermediate and propeller shafting
  - Pumping and piping arrangements (diagrammatic) including sounding and air pipes
  - Steam pipes, arrangement and dimensions
  - Air receivers
  - Auxiliary boilers
  - Exhaust gas economiser
- Electrical wiring including main switchboard.
- For information
  - General machinery lay-out

3.2.4 Where remote and/or automatic controls are fitted to propulsion machinery and essential auxiliaries, a description of the scheme is to be submitted, particulars are to be given of the spare gear carried for machinery and control gear.

3.2.5 Calculations of torsional vibration characteristics of the main propelling machinery are to be furnished specially for ships which have been in service less than about 2 years.

3.2.6 In addition to the requirements of 3.2.1 to 3.2.5, additional plans would require to be submitted in accordance with applicable Chapters of Pt.5 of the Rules for vessels with additional class notations.

---

**Appendix 1**

**Table of Characters Class and Type Notations of IRS, their Expanded Form and Significance**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characters Of Class</strong></td>
<td></td>
</tr>
<tr>
<td>IWL</td>
<td>Denotes vessels which are classed with Indian Register of Shipping for operation in Inland Waterways where the hull and its appendages and equipment (i.e. anchors, chain cables, hawsers) meet the Rule requirements.</td>
</tr>
<tr>
<td>IW-</td>
<td>Denotes vessels which are classed with IRS for operation in Inland Waterways where the hull and its appendages meet the Rule requirements but the equipment of ship is not supplied or maintained as per the relevant Rules but is considered by IRS to be acceptable for particular service.</td>
</tr>
<tr>
<td>IW</td>
<td>Denotes vessels which are classed with IRS for Inland Waterways but where for reason of their particular purpose or service normal equipment may be unnecessary</td>
</tr>
<tr>
<td>IY</td>
<td>Denotes that for self-propelled vessels the machinery installation complies with the applicable requirements of Indian Register of Shipping</td>
</tr>
<tr>
<td>ज</td>
<td>This distinguishing mark inserted before a Character of Class is assigned to new ships where the hull and its appendages, equipment and the machinery as appropriate, are constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS.</td>
</tr>
<tr>
<td>[ ]</td>
<td>When a Class Notation is enclosed within brackets, it indicates that applicable arrangements exist on board but the notation has been temporarily suspended.</td>
</tr>
</tbody>
</table>
### Appendix 1 (Contd.)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Notations - Hull</strong></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>A zone where the maximum significant wave height does not exceed 2.0 [m].</td>
</tr>
<tr>
<td>Zone 2</td>
<td>A zone where the maximum significant wave height does not exceed 1.2 [m].</td>
</tr>
<tr>
<td>Zone 3</td>
<td>A zone where the maximum significant wave height does not exceed 0.6 [m].</td>
</tr>
<tr>
<td>Specified Operating Area Service</td>
<td>Service within one or more geographical area(s) which will form part of the Class Notation.</td>
</tr>
<tr>
<td>&quot;Strengthened for heavy cargoes&quot;</td>
<td>This will be entered in the Register of Ships where the scantlings and arrangements have been approved for heavier cargo loadings in any hold filled up to the top of the hatch coaming with bulk cargo of density of at least upto 1.0 [t/m³].</td>
</tr>
<tr>
<td><strong>Class Notations - Machinery</strong></td>
<td></td>
</tr>
<tr>
<td>NV</td>
<td>This notation is assigned to ships classed with Indian Register of Shipping intended for (i) carriage of oil in bulk or (ii) carriage of liquid chemicals in bulk. It denotes that the cargo spaces can be inerted by means of an inert gas system which has been approved, installed and tested in accordance with the relevant Rules.</td>
</tr>
<tr>
<td>Bulk Carrier</td>
<td>This notation will be assigned to ships designed for the carriage of dry cargo in bulk and built in accordance with the applicable requirements of Pt.5, Ch.1 of the Rules for carriage of cargoes of density of at least 0.8 [t/m³].</td>
</tr>
<tr>
<td>ORE CARRIER</td>
<td>This notation will be assigned to ships specially designed for the carriage of Ore and built in accordance with applicable requirements of Pt.5, Ch.1 of the Rules.</td>
</tr>
<tr>
<td>OIL TANKER</td>
<td>This notation will be assigned to tankers intended to carry oil in bulk and built in accordance with applicable requirements of Pt.5, Ch.2 of the Rules. Where the scantlings and arrangements have been approved for the carriage of oil having a flash point of 60°C or above (closed cup test) or other liquid cargoes in bulk, the class notation will be suitably modified to show the nature of the cargo.</td>
</tr>
<tr>
<td>CHEMICAL CARRIER</td>
<td>This notation will be assigned to ships specially designed for the carriage of chemicals in bulk and built in accordance with applicable requirements of Pt.5, Ch.3 of the Rules.</td>
</tr>
<tr>
<td>PASSENGER SHIP</td>
<td>This notation will be assigned to vessels intended for the carry more than 12 passengers and built in accordance with Pt.5, Ch.4 of the Rules.</td>
</tr>
<tr>
<td>FERRY</td>
<td>This notation will be assigned to vessels intended for for carriage of passengers and/or vehicles on regular scheduled service and built in accordance with Pt.5, Ch.4 of the Rules.</td>
</tr>
<tr>
<td>Ro-Ro FERRY</td>
<td>This notation will be assigned to ferries intended for for carriage of passengers, vehicles and cargo in pellet form or in containers and loaded/unloaded by wheeled vehicles and built in accordance with Pt.5, Ch.4 of the Rules.</td>
</tr>
<tr>
<td>TUG</td>
<td>This notation will be assigned to all ships built in accordance with applicable requirements of Pt.5, Ch.5 of the Rules.</td>
</tr>
<tr>
<td>BARGE</td>
<td>This notation will be assigned to non-self- propelled, manned or unmanned ships carrying dry cargo in cargo holds and built in accordance with applicable requirements of Pt.5, Ch.6 of the Rules. For special purpose vessels, the Notation will be suitably modified, e.g. Shipborne Barge</td>
</tr>
</tbody>
</table>

Indian Register of Shipping
### Appendix 1 (Contd.)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL BARGE</td>
<td>This notation will be assigned to non-self-propelled, manned or unmanned ships intended to carry oil in bulk and built in accordance with the applicable requirements of Pt.5, Ch.2 &amp; 6 of the Rules. Where the scantlings and arrangements have been approved by IRS for the carriage of oil having a flash point of 60°C or above (closed cup test), or for other liquid cargoes in bulk, the class notation affixed to the Character will be suitably modified to show the nature of the cargo (e.g. water barge, molasses barge, etc.)</td>
</tr>
<tr>
<td>PONTOON</td>
<td>This notation will be assigned to non-self-propelled, manned or unmanned ships designed specifically for the carriage of non-perishable cargo or equipment on deck and built in accordance with the applicable requirements of Pt.5, Ch.6 of the Rules. For special purpose vessels, the Notation will be suitably modified, e.g. Crane Pontoon</td>
</tr>
</tbody>
</table>

*End Of Chapter*
Chapter 2

Periodical Surveys

Contents

Section
1  General Requirements
2  Extent of Hull Surveys
3  Extent of Machinery Surveys

Section 1

General Requirements

1.1 General

1.1.1 All vessels are to be subjected to Periodical Surveys for the purpose of maintenance of class. Survey notations and Survey intervals are given in Table 1.1.1 for main class Surveys.

1.1.2 Vessels with additional class notations for which there are no specific Survey requirements in this Chapter are to have the equipment and/or construction related to this additional class notation examined to the Surveyor's satisfaction at each Special Survey.

1.2 Laid up vessels

1.2.1 Survey during lay-up

1.2.1.1 When a vessel is laid up and IRS is so informed, the Periodical Surveys required by 1.1.1 may be postponed at the discretion of IRS depending upon the vessel's lay-up location, the maintenance and preservative measures taken during the lay-up and subject to Annual Surveys being carried out.

1.2.2 Survey at re-activation

1.2.2.1 Vessels are to be surveyed and tested before re-entering service. The extent of the surveys and tests will be considered in each case by IRS depending upon the time out of commission, the maintenance and preservative measures taken during lay-up and the extent of surveys carried out during this time.

Table 1.1.1 : Periodical Survey intervals for Main class notations

<table>
<thead>
<tr>
<th>Survey</th>
<th>Main class Survey Notation</th>
<th>Survey interval in years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Survey; Hull</td>
<td>SSH</td>
<td>5</td>
</tr>
<tr>
<td>Special Survey; Machinery</td>
<td>SSM</td>
<td>5</td>
</tr>
<tr>
<td>Intermediate Survey</td>
<td>IS</td>
<td>2.5</td>
</tr>
<tr>
<td>Annual Survey</td>
<td>AS</td>
<td>1</td>
</tr>
<tr>
<td>Tailshaft Survey</td>
<td>TS</td>
<td>5</td>
</tr>
<tr>
<td>Auxiliary boilers</td>
<td>ABS</td>
<td>2.5</td>
</tr>
<tr>
<td>Steam pipe Survey</td>
<td>SPS</td>
<td>10</td>
</tr>
</tbody>
</table>

1  Survey may be carried out between second and third annual surveys.
2  Survey may be carried out within 3 months on either side of the due date.
Section 2

Extent of Hull Surveys

2.1 Special surveys (hull)

2.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey becomes due five years after the date of build or date of Special Survey for classification and the subsequent Special Surveys become due 5 years after the assigned date of the previous Special Survey.

2.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if deemed appropriate.

2.1.3 For surveys completed within 3 months before expiry date of Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date.

2.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th Annual Survey.

2.1.5 Record of Special Survey will not be assigned until the Machinery Survey has been completed.

2.1.6 As part of the preparation for Special Survey, the thickness measurement and Survey Programme should be dealt with, in advance of the Special Survey. The thickness measurement is not to be held before the 4th Annual Survey.

2.1.7 Upon satisfactory completion of a Special Survey a record will be entered in the supplement to the Register of Ships indicating the month and the year in which the Survey is completed. In the case where a Special Survey is spread over a period and is not carried out at one time the date assigned for such a Survey will correspond to the date when the principal part of the Survey has been completed. IRS will decide when the principal part of the Survey is deemed to have been completed. Record of Special Survey will not be assigned until the engine Survey has been completed.

2.1.8 IRS may, at the request of the Owners, accept a Special Survey of hull on a continuous basis spread over a period of 5 years. Proposals for such continuous Surveys are to be submitted for the consideration of IRS. In general, approximately one fifth of the Special Survey is to be completed every year. All compartments of the hull should be opened for survey and testing in rotation such that not more than 5 years elapse between consecutive examination of each part.

2.2 Requirements of special surveys (hull)

2.2.1 First and second special surveys

2.2.1.1 The requirements of intermediate survey are to be complied with as applicable. The ship is to be placed in drydock or on a slipway, cleaned and be at a sufficient height above the dockfloor or the ground for examination of shell plating, sternframe, rudders, etc. If necessary, proper staging is to be erected for this examination. Each rudder is to be lifted for examination of pintles if considered necessary by the Surveyor.

2.2.1.2 The holds, tween decks, deep tanks, peaks, bilges and drain wells, engine and boiler spaces, coal bunkers and other spaces are to be cleared out and cleaned as necessary and examined. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath.

Where necessary close and spar ceiling, lining and pipe casings are to be removed for examination of the structure.

2.2.1.3 In ships with single bottom, a sufficient amount of close ceiling is to be lifted to enable examination of the structure below. The ceiling to be lifted is to comprise of at least two strakes on each side of centreline fore and aft and one of these strakes is to be in way of the bilges.

2.2.1.4 In ships having double bottom, a sufficient amount of ceiling is to be lifted from the tank top and the bilges to enable the condition of plating underneath to be ascertained. If the condition of the plating is found to be satisfactory, lifting of the remainder of the ceiling may be dispensed with. All bilges are to be cleaned for examination.

Where the inner bottom plating is covered with cement or asphalt the removal of such covering may be dispensed with provided it is found to be adhering properly to the plating when carefully examined by hammering and chipping.
2.2.1.5 All watertight bulkheads are to be examined.

2.2.1.6 The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes.

2.2.1.7 The Surveyor may require to determine thickness of the material by drilling or other approved means where wastage is evident. Particular attention is to be paid to structure in way of discontinuities. Where thickness measurements are taken by approved means other than drilling, the accuracy of such measurements should be verified by drilling in a few locations.

2.2.1.8 Representative double bottom compartments, peak tanks and all other tanks are to be tested hydrostatically by a head sufficient to give the maximum pressure that can be experienced in service.

2.2.1.9 Tanks, forming part of the main structure, except as stated below, are to be thoroughly cleaned and examined internally, special attention being paid to the tanks under boiler spaces.

Tanks, other than the peak tanks, which are used exclusively for oil fuel or freshwater or lubricating oil need not be examined internally provided upon external examination and testing of the tanks, the Surveyor finds their condition to be satisfactory.

2.2.1.10 All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

Wooden decks or sheathing are to be examined and if decay or rot is found or the wood is excessively worn, the wood should be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck coverings. Removal of such coverings may be dispensed with if they are found to be sound and adhering satisfactorily to the plating.

2.2.1.11 Where holds are insulated for the carriage of refrigerated cargoes and the hull in way was examined by IRS Surveyors prior to the fitting of the insulation, it will be sufficient to remove the limbers and hatches for examination of the structure in way. In all other cases additional insulation will require to be removed as considered necessary to enable the Surveyor to satisfy himself regarding condition of the structure.

2.2.1.12 The masts, standing rigging and anchors are to be examined. Chain cables are to be ranged for examination. Chain cables which are worn to 12 per cent or more of the original rule diameter are to be renewed.

The Surveyor should satisfy himself that there are appropriate mooring ropes on board and also that a towline is provided when this is a Rule requirement.

2.2.1.13 The steering gear, and its connections and control systems (main and alternative) are to be examined.

2.2.1.14 The windlass, hand pumps and suction, watertight doors, air and sounding pipes are to be examined. Whilst examining the tanks internally, the Surveyors are to ensure that striking plates are fitted under the sounding pipes.

2.2.1.15 The Surveyor should satisfy himself regarding the efficient condition of the following.

- Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;
- Means of communication between bridge and engine room and between bridge and alternative steering position;
- Fire protection, detection and extinction arrangements.

2.2.1.16 When ships which are placed in drydock or on a slipway, the propeller(s), sternbushes, water inlets and outlets and gratings are to be examined. The clearance in each sternbush or the efficiency of each sterngland is to be ascertained.

2.2.2 Third and subsequent special surveys

2.2.2.1 In addition to the full requirements as stipulated in 2.2.1 the following are to be complied with.

2.2.2.2 In ships having a single bottom, a sufficient amount of ceiling is to be lifted to allow the examination of the structure underneath. The lifting of the ceiling is to comprise of at least three strakes all fore and aft on each side and one such strake on each side to be in way of the bilges. Where the ceiling is fitted in hatches, the
whole of the hatches and at least one strake of planks in way of the bilges on each side are to be lifted. If the Surveyor considers it necessary the whole of the ceiling and the limber boards are to be lifted.

2.2.2.3 In ships with double bottom, sufficient amount of ceiling is to be lifted for the examination of the inner bottom plating, pillar feet bottom plating of bulkheads, tunnel side plating and the structure in way of the bilges. If the Surveyor considers it necessary the whole of the ceiling is to be lifted.

2.2.2.4 Chain locker is to be cleaned and examined internally.

2.2.2.5 Determination of thickness is to be carried out at the third special survey and every special survey thereafter.

2.2.2.6 In addition to the drilling required as per 2.2.1.7, the shell plating and plating of strength decks are to be gauged by drilling or other approved means to determine the amount of any general diminution in thickness. The gauging is to be done in at least two places in each strake of plating on each side within the midship half-length. The remainder of the shell plating between the light and load waterlines and the strength deck plating outside the line of openings, all within the midship half-length are to be gauged. Gaugings are also to be taken on 'tween decks, inner bottom and continuous girder, stiffeners, bulkheads, side frames, frames and floors in the double bottom tanks, if considered necessary.

For areas where the structure is found to be satisfactory on examination, the extent of thickness measurement may be specially considered by the Surveyor(s).

All paint and rust is to be entirely removed before the plates are gauged by the Surveyor and the actual thicknesses are to be reported in detail to IRS. Where drilled plates are renewed the thickness of adjacent plates in the same strake should be reported.

The thickness of bottom plating in way of cement is to be ascertained unless the Surveyor, after an internal and external examination, is entirely satisfied that this is unnecessary. Selected portions of cement are to be removed from the bottom and bilge if required by the Surveyor.

2.2.3 Tankers

2.2.3.1 In addition to the requirements stipulated in 2.2.1 and 2.2.2 for dry cargo vessels, the following are also to be complied with.

2.2.3.2 All cargo tanks and cofferdams are to be thoroughly cleaned and cleared of gas at each Special Survey before inspection and every precaution is to be taken to ensure safety during inspection. Access is to be arranged to any part of the tank as considered necessary by the Surveyor to enable him to ascertain the condition of the structure within the tanks.

2.2.3.3 Attention is to be given to the inside of the bottom plating for excessive pitting and where extensive pitting is found requisite renewals or repairs are to be carried out to preserve the longitudinal strength of the bottom.

2.2.3.4 The strums of the cargo suction pipes are to be removed to facilitate examination of the shell plating and bulkheads in that vicinity, unless other means for visual inspection of these parts are provided.

2.2.3.5 Where fitted, anodes in tanks and cofferdams within the cargo tank spaces are to be examined together with their attachments to the structure.

2.2.3.6 All cargo tanks are to be tested at Special Surveys by filling with water to the top of hatchways.

Tanks may be tested when the ship is afloat provided the internal examination of the bottom is also carried out afloat.

2.2.3.7 Where extensive repairs have been effected to the shell plating, the tanks should be tested to Surveyor's satisfaction.

2.2.3.8 The requirements of 2.2.2.5 (of dry cargo vessels) are to be complied with at second and subsequent Special Surveys, except that in respect of the deck plating, every deck plate within the midship half-length is to be gauged. All gaugings are to be taken in way of tanks.

2.2.3.9 Where corrosion control arrangements have been adopted, satisfactory evidence of continued effectiveness is to be verified.
2.3 Intermediate surveys

2.3.1 The ship is to be brought in to light condition for internal and external examination afloat. All ships operating at sea ports and other ships over 20 years of age are to be examined in drydock or slipway.

2.3.2 The Surveyor is to thoroughly examine the following parts and also ensure the efficient condition of their respective closing appliances:

2.3.2.1 Inert gas plant overboard discharge when passing through the shell, so far as practicable.

2.3.2.2 Vent piping, including that of inert gas installation, where applicable, within cargo tank area together with associated flame arresters and pressure/vacuum valves and cargo and bunker deck piping of tankers.

2.3.2.3 Watertight bulkhead penetrations as far as practicable.

2.3.3 Gasketted steel hatch covers to be tested or alternatively proven tight.

2.3.4 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

2.3.5 Surveyor is to satisfy himself regarding the efficient condition of the fire protection, detection and extinction arrangements.

2.3.6 Anchoring and mooring equipment is to be examined as far as is practicable.

2.3.7 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested.

2.3.7.1 Steering chains are to be cleaned for ascertaining wear and tear and lengths of chain worn in mean diameter by more than 12 per cent of the original rule diameter are to be renewed.

2.3.8 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the alternative steering position, if fitted, are to be tested.

2.3.9 In case of tankers pump rooms, bunker and vent piping systems on deck and in pump rooms, pressure/vacuum valves and flame arresters and electrical installations are also to be inspected including verification of:

   - The efficiency of any safe type equipment fitted;
   - Insulation resistance.

2.3.10 Inert gas systems, when fitted, are to be tested to demonstrate that it is in good working condition to the satisfaction of the Surveyor.

2.4 Annual surveys

2.4.1 The Surveyor is to satisfy himself regarding the efficient condition of the following:

a) Hatchways on freeboard and superstructure decks, ventilator and air pipe coamings, exposed casings, skylights, deckhouses and companionways, superstructure bulkheads, side scuttles and deadlights, together with all closing appliances.

b) Means of ensuring weathertightness of steel hatch covers.

c) Scuppers and sanitary discharges with valves; guard rails and bulkwarks; freeing ports, gangways and lifelines.

d) Freeboard marks.

e) General examination of machinery and steering gear.

f) Vent piping.

2.4.2 Additionally, following is to be examined in case of tankers:

a) The efficiency of any safe type equipment fitted.

b) The insulation resistance.

c) Effectiveness of earth bonding straps, where fitted.

d) General examination of inert gas system; flame arresters, pressure/vacuum valves; cargo and bunker piping.
Section 3

Extent of Machinery Surveys

3.1 General

3.1.1 The Machinery Special Survey becomes due five years from the date of build or from the last Machinery Special Survey (SSM).

3.2 Requirements of survey

3.2.1 Main engines of internal combustion type

3.2.1.1 All working parts of the engines and their attached pumps are to be opened and examined. These should include all cylinders, cylinder heads, valves and valve gear, pistons, piston rods, cross heads, guides, connecting rods, crankshafts, vibration dampers and all bearings, camshafts and driving gear, fuel pumps and fittings, scavenged pumps, scavenged blowers and their prime movers, superchargers, air compressors, intercoolers, clutches, reverse gears, crankcase door fastenings and explosion relief devices and such other parts of the machinery as may be considered necessary. Integral piping systems are to be examined. The manoeuvring of engines is to be tested under working condition. In case of multi-engine installations, alternative survey proposal may be considered by IRS.

3.2.2 Reduction gears, flexible couplings and clutch arrangements

3.2.2.1 Reduction gears, flexible couplings and clutch arrangements are to be opened as considered necessary by the Surveyor in order to permit the examination of the gears, gear teeth, spiders, pinions, shafts and bearings, reversing gears, etc.

3.2.3 Shafting

3.2.3.1 Intermediate shafts and bearings, thrust bearings and their seating are to be examined. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

3.2.4 Auxiliary machinery

3.2.4.1 All auxiliary machinery for essential services is to be examined as considered necessary by the Surveyor. Opening of machinery may be required if considered necessary by the Surveyor. Alarms and safety devices fitted on these units are to be included in this Survey. The machinery is to include the following:

- Auxiliary engines, air compressors together with all attached coolers, filters, pumps, etc.;
- Steering machinery;
- Windlass(es) and associated equipment.

3.2.5 Securing arrangements

3.2.5.1 Holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings are to be checked.

3.2.6 Boiler surveys

3.2.6.1 At each Survey, the boilers are to be examined internally (water/steam side) and externally (fire side) as considered necessary.

3.2.6.2 Principal boiler mountings and safety valves are to be examined at each Survey. The remaining mountings are to be opened if considered necessary by the Surveyor. Manhole and handhole doors, are to be examined to ensure that the joining faces are in good condition and that the clearances at the spigot are satisfactory.

3.2.6.3 In case where it is considered necessary, the parts subjected to pressure are to be hydraulically tested and the thickness of plates and size of stays ascertained to determine the safe working pressure. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition. The shell plating in way of welded lugs or fabricated feet are to be carefully examined at each Survey. Insulation and sheathing in way are to be removed as considered necessary for this purpose.

In fired boilers employing forced circulation the pumps used for this purpose are to be opened and examined at each boiler Survey.

3.2.6.4 The proper operation of the water level indicators and safety devices are to be confirmed at each Survey and the boiler is to be examined under steam and its safety valves are to be adjusted to a pressure not greater than 3 per cent of the approved working pressure. The oil fuel burning system is to be examined under...
working conditions and a general examination made of the fuel tank valves, pipe, deck control gear and oil discharge pipes between pumps and burners.

3.2.7 Survey of steam pipes

3.2.7.1 At each Survey a selected number of steam pipes over 75 [mm] bore supplying steam for essential services are to be examined internally and tested hydraulically to 1.5 times the working pressure. If these are found satisfactory, the remaining need not be tested. In cases of pipes having welded joints, the lagging in way of the welds is to be removed and the welds examined and if considered necessary crack detected.

3.2.8 Air receivers and starting air pipes

3.2.8.1 All air receivers and other pressure vessels for essential services together with their mountings and safety devices are to be cleaned internally and examined internally and externally. If an internal examination of an air receiver is not practicable it is to be tested hydraulically to 1.3 times the working pressure.

3.2.8.2 Selected pipes in the starting air systems are to be removed for internal examination and hammer tested. If an appreciable amount of lubricating oil is found in the pipes the starting air system is to be thoroughly cleaned by steaming or other suitable means. Some of the pipes selected are to be those adjacent to the starting air valves at the cylinders and to the discharges from the air compressors.

3.2.9 Pumping and piping system

3.2.9.1 The valves, cocks and strainers of the bilge system including bilge injection are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. Non metallic flexible expansion pieces in the main salt water circulating system are to be examined. If non-return valves are fitted in hold bilges, these be opened up for examination.

3.2.10 Control systems

3.2.10.1 Where remote controls such as bridge controls, bilge controls and bilge level alarms, local hand controls, fire detection and prevention, alarms warning systems and shut-offs, electric supply, main controls station, are fitted for essential machinery, they are to be examined and tested to demonstrate that they are in good working order.

3.2.10.2 During such trials the proper operation of the safety devices will be checked, in particular, such as emergency stops, emergency astern movement, standby control of the propelling gear, fire alarm.

3.2.11 Electrical equipment survey

3.2.11.1 Electrical installations including auxiliary and emergency equipment are to be examined in accordance with the following during each Survey cycle.

3.2.11.2 Switch boards (including for emergency use) and their accessories including section-boards and sub-division fuse boards are to be examined as far as possible and over current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

3.2.11.3 All generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily. The generators are to be run under load either separately or in parallel, and the governing of the engines to be tested.

3.2.11.4 The insulation resistance of cables, switch gear, generators, motors, heaters, lighting and other fittings is to be tested and should not be less than 100,000 ohms between all insulated circuits and earth. The installation may be subdivided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

The electric cables are to be examined as far as possible without undue disturbance of fixtures or casings unless deemed necessary by the Surveyor.

3.2.11.5 Transformers are to be examined. Samples of oil are to be taken and tested for breakdown voltage, acidity and moisture in case of oil immersed transformers or electrical apparatus associated with supplies to essential services. The testing is to be carried out by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

3.2.11.6 Motors used for essential services including their starters are to be examined under working conditions.

3.2.11.7 Generators and steering gear motors are to be examined under working conditions. Air gaps are to be checked for excessive wear down.
3.2.11.8 The emergency source of power and its associated circuits are to be tested. In the case of passenger ships, the temporary source of power and its automatic arrangements (if fitted) are also to be tested.

3.2.12 Fuel tanks

3.2.12.1 Fuel tanks which do not form part of the ship's structure are to be examined internally and externally and, if considered necessary by the Surveyor, they are to be tested. These need not be examined at the first and second Engine Surveys if they are found satisfactory on external examination. All mountings, fittings and remote control devices are to be examined as far as practicable.

3.2.13 Examination in drydock

3.2.13.1 When the ship is in drydock the propeller should be examined for erosion, pitting, cracking of blades or possible contact damage. The clearance in the stern bush should be measured. In the case of oil glands, this requirement may be waived if an approved oil gland is fitted so that the oil gland is not disturbed provided the sealing arrangements appear satisfactory. If poker gauges or other devices are provided for ascertaining the wear in an oil lubricated stern bush, the clearance in the bush should be measured.

3.2.13.2 All openings to the sea including sanitary and other overboard discharges in the machinery spaces and pump rooms together with valves and cocks are to be examined internally and externally. The fastenings of valves and cocks to the hull are to be examined and are to be renewed when considered necessary by the Surveyor.

3.2.14 Propeller shafts

3.2.14.1 Propeller shafts are to be drawn periodically for examination by the Surveyors. All propeller shafts become due for Surveys at intervals of 5 years.

End Of Chapter
Indian Register of Shipping

Part 2

Inspection and Testing of Materials

(This part is same as Part 2 of Main Rules)

Contents

Chapter 1  General Requirements
Chapter 2  Mechanical Testing Procedures
Chapter 3  Rolled Steel Plates, Strips, Sections and Bars
Chapter 4  Steel Castings
Chapter 5  Steel Forgings
Chapter 6  Steel Pipes and Tubes
Chapter 7  Iron Castings
Chapter 8  Copper Alloys
Chapter 9  Aluminium Alloys
Chapter 10 Equipment
Chapter 11 Approval of Welding Consumables for use in Ship Construction
Indian Register of Shipping

Part 3

General Hull Requirements

Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>General, Definitions, Documentation</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Materials of Construction</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Principles for Scantlings and Structural Details</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Longitudinal Strength</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Bar Keel, Stem and Sternframes</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Bottom Structure</td>
</tr>
<tr>
<td>Chapter 7</td>
<td>Side Structure</td>
</tr>
<tr>
<td>Chapter 8</td>
<td>Deck Structure</td>
</tr>
<tr>
<td>Chapter 9</td>
<td>Bulkheads</td>
</tr>
<tr>
<td>Chapter 10</td>
<td>Superstructures, Deckhouses and Bulwarks</td>
</tr>
<tr>
<td>Chapter 11</td>
<td>Openings and Closing Appliances, Ventilators, Air Pipes and Discharges</td>
</tr>
<tr>
<td>Chapter 12</td>
<td>Rudders</td>
</tr>
<tr>
<td>Chapter 13</td>
<td>Anchoring and Mooring Equipment</td>
</tr>
<tr>
<td>Chapter 14</td>
<td>Welding</td>
</tr>
<tr>
<td>Chapter 15</td>
<td>Hull Inspection, Workmanship and Testing</td>
</tr>
</tbody>
</table>
## Contents

### Chapter 1

**General, Definitions, Documentation**

<table>
<thead>
<tr>
<th>Section 1</th>
<th>2.2 Structural terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>2.3 Material factor</td>
</tr>
<tr>
<td>1.1 Scope</td>
<td>Section 3</td>
</tr>
<tr>
<td>1.2 Equivalence</td>
<td>Documentation</td>
</tr>
<tr>
<td>1.3 National regulations</td>
<td>3.1 General</td>
</tr>
<tr>
<td>1.4 Loadline and stability</td>
<td>3.2 Plans for information</td>
</tr>
<tr>
<td>1.5 Assumptions</td>
<td>3.3 Additional information</td>
</tr>
</tbody>
</table>

### Chapter 2

**Materials of Construction**

<table>
<thead>
<tr>
<th>Section 1</th>
<th>2.2 Surface preparation, prefabrication primers and paints or coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>2.3 Internal cathodic protection</td>
</tr>
<tr>
<td>1.1 Scope</td>
<td>2.4 Aluminium and magnesium anodes</td>
</tr>
<tr>
<td>1.2 Steel</td>
<td>2.5 Corrosion protection coatings for salt water ballast spaces</td>
</tr>
<tr>
<td>1.3 Grades of steel</td>
<td>Section 3</td>
</tr>
<tr>
<td>1.4 Aluminium</td>
<td>Deck Covering</td>
</tr>
</tbody>
</table>

### Section 2

**Corrosion Protection**

| 2.1 General | 3.1 General |
Chapter 3

Principles for Scantlings and Structural Details

Section 1
General
1.1 Application
1.2 Symbols
1.3 Frame spacing

Section 2
Corrosion Additions
2.1 General

Section 3
Plating
3.1 General

Section 4
Stiffeners and Girders
4.1 Determination of span
4.2 Effective width of attached plating
4.3 Scantlings of stiffeners
4.4 Scantlings of girders

Section 5
End Attachments
5.1 End attachments of stiffeners
5.2 End attachments of girders

Section 6
Buckling
6.1 General
6.2 Ideal elastic buckling stress

Chapter 4

Longitudinal Strength

Section 1
General
1.1 Application
1.2 Symbols

Section 2
Vertical Bending Moments
2.1 Still water bending moment
2.2 Wave load conditions

Section 3
Hull Section Modulus and Moment of Inertia
3.1 Calculation of section properties
3.2 Extent of high tensile steel
3.3 Section modulus requirement
3.4 Moment of inertia requirement
Section 4

Openings in Longitudinal Strength Members

4.1 Locations

4.2 Reinforcements

4.3 Hatchway corners

Chapter 5

Bar Keel, Stem and Sternframes

Section 1

General

1.1 Scope

1.2 Material

1.3 Symbols

Section 2

Bar Keel

2.1 Scantlings

Section 3

Stem

3.1 Bar stem

3.2 Plate stem

Section 4

Stern Frames

4.1 General

4.2 Sternframes

4.3 Sole piece

4.4 Shaft brackets

Chapter 6

Bottom Structure

Section 1

General

1.1 Scope

1.2 Symbols

Section 2

Structural Arrangement and Details

2.1 General

2.2 Access, ventilation and drainage

Section 3

Design Loads

3.1 Bottom shell

3.2 Watertight floors and girders

3.3 Inner bottom

Section 4

Bottom and Inner Bottom Plating

4.1 Keel plate

4.2 Bottom, bilge and inner bottom plating
Section 5

Single Bottom
5.1 Transverse framing
5.2 Longitudinal framing

Section 6

Double Bottom
6.1 General

Section 7

Engine Seatings
7.1 General
7.2 Recommended scantlings

Chapter 7

Side Structure

Section 1

General
1.1 Scope
1.2 Symbols

Section 2

Structural Arrangement and Details
2.1 General
2.2 Sheer strake

Section 3

Design Loads
3.1 External pressure
3.2 Internal tank pressure

Section 4

Side Shell Plating and Stiffeners
4.1 Side shell plating
4.2 Side shell longitudinals
4.3 Main frames
4.4 Superstructure frames
4.5 Peak frames

Section 5

Girders
5.1 General

Chapter 8

Deck Structure

Section 1

General
1.1 Scope
1.2 Symbols

Section 2

Structural Arrangement and Details
2.1 General
<table>
<thead>
<tr>
<th>Section 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Loads</td>
<td></td>
</tr>
<tr>
<td>3.1 Weather deck</td>
<td></td>
</tr>
<tr>
<td>3.2 Accommodation decks</td>
<td></td>
</tr>
<tr>
<td>3.3 Decks forming tank boundaries</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Plating and Stiffeners</td>
<td></td>
</tr>
<tr>
<td>4.1 Deck platings</td>
<td></td>
</tr>
<tr>
<td>4.2 Deck stiffeners</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 5</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Girders and Pillars</td>
<td></td>
</tr>
<tr>
<td>5.1 Girders</td>
<td></td>
</tr>
<tr>
<td>5.2 Cantilevers</td>
<td></td>
</tr>
<tr>
<td>5.3 Pillars</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 6</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decks for Wheel Loading</td>
<td></td>
</tr>
<tr>
<td>6.1 General</td>
<td></td>
</tr>
<tr>
<td>6.2 Wheel loads</td>
<td></td>
</tr>
<tr>
<td>6.3 Deck plating</td>
<td></td>
</tr>
<tr>
<td>6.4 Deck stiffeners</td>
<td></td>
</tr>
<tr>
<td>6.5 Deck girders</td>
<td></td>
</tr>
</tbody>
</table>

Chapter 9

Bulkheads

<table>
<thead>
<tr>
<th>Section 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td></td>
</tr>
<tr>
<td>1.1 Scope</td>
<td></td>
</tr>
<tr>
<td>1.2 Statutory requirements</td>
<td></td>
</tr>
<tr>
<td>1.3 Symbols</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subdivision and Arrangement</td>
<td></td>
</tr>
<tr>
<td>2.1 Number of bulkheads</td>
<td></td>
</tr>
<tr>
<td>2.2 Position and height of bulkheads</td>
<td></td>
</tr>
<tr>
<td>2.3 Openings in watertight bulkheads and closing appliances</td>
<td></td>
</tr>
<tr>
<td>2.6 Cofferdams</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Arrangement and Details</td>
<td></td>
</tr>
<tr>
<td>3.1 General</td>
<td></td>
</tr>
<tr>
<td>3.2 Wash bulkheads</td>
<td></td>
</tr>
<tr>
<td>3.3 Supporting bulkheads</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Loads</td>
<td></td>
</tr>
<tr>
<td>4.1 Watertight bulkhead loads</td>
<td></td>
</tr>
<tr>
<td>4.2 Tank bulkhead loads</td>
<td></td>
</tr>
<tr>
<td>4.3 Wash bulkheads loads</td>
<td></td>
</tr>
</tbody>
</table>
Section 5

Plating and Stiffeners

5.1 Bulkhead plating
5.2 Longitudinals
5.3 Vertical and transverse stiffeners on tank bulkheads, collision bulkheads, dry bulk cargo bulkheads and wash bulkheads

5.4 Vertical and transverse stiffeners on ordinary watertight bulkheads

Section 6

Girders

6.1 General

Chapter 10

Superstructures, Deckhouses and Bulwarks

Section 1

General

1.1 Scope
1.2 Definitions
1.3 Symbols

Section 2

Scantlings

2.1 End bulkheads and exposed sides in deckhouses
2.2 Protected machinery casings

Section 3

Structural Arrangement and Details

3.1 Structural continuity

Section 4

Bulwarks and Guard Rails

4.1 General requirements
4.2 Bulwark construction
4.3 Bulwark scantlings
4.4 Guard rails

Chapter 11

Openings and Closing Appliances, Ventilators, Air Pipes and Discharges

Section 1

General

1.1 Scope

Section 2

Hatch Coamings

2.1 Coaming heights
2.2 Hatch coaming construction

Section 3

Hatch Covers

3.1 General
3.2 Design loads
3.3 Hatchcover plating
3.4 Stiffeners and girders
3.5 Hatch cover edges
3.6 Wooden hatch covers
3.7 Portable hatch beams
3.8 Direct calculations
3.9 Hatch cover securing arrangement

Section 4

Miscellaneous Openings
4.1 Manholes
4.2 Companionways, doors and accesses on weather decks
4.3 Openings on engine casing
4.4 Windows and side scuttles

Section 5

Ventilators
5.1 General
5.2 Coaming heights
5.3 Closing appliances

Section 6

Air and Sounding Pipes
6.1 General
6.2 Height of air pipes
6.3 Closing appliances

Section 7

Scuppers and Sanitary Discharges
7.1 General
7.2 Closing appliances
7.3 Materials for valves, fittings and pipes

Chapter 12

Rudders

Section 1

General
1.1 Scope
1.2 Material
1.3 Testing

Section 2

Arrangement and Details
2.1 General

Section 3

Design Loads
3.1 Rudder force
3.2 Rudder torque
3.3 Bending moments, shear forces and reactions

Section 4

Rudder Blades
4.1 Construction details
4.2 Double plated rudders
4.3 Single plated rudders
Chapter 13

Anchoring and Mooring Equipment

Section 1
General
1.1 Introduction
1.2 Documentation
1.3 Symbols

Section 2
Structural Arrangement for Anchoring Equipment
2.1 General

Section 3
Equipment Specification
3.1 Equipment number
3.2 Equipment

Section 4
Anchors
4.1 General
Chapter 14

Welding

Section 1

General

1. Scope

1.2 Documentation

Section 2

Welding

2.1 Welder and supervision

2.2 Welding electrodes

2.3 Preparation for welding

2.4 Welding procedure

2.5 Approval of procedures

2.6 Inspection of welds

Section 3

Welded Connections

3.1 Butt welds

3.2 'T' connections

3.3 Lap connections

3.4 Slot weld

3.5 End connection

Chapter 15

Hull Inspection, Workmanship and Testing

Section 1

Hull Inspection

1. Approval of works

1.2 Inspection facilities

Section 2

Workmanship

2.1 General

2.2 Plate edges and cut-outs

2.3 Cold forming

2.4 Hammering, bending and straightening

Section 3

Testing

3.1 Definitions

3.2 Application

3.3 Structural testing

3.4 Leak testing

3.5 Hose testing

3.6 Hydropneumatic testing

3.7 Other testing methods

3.8 General testing requirements

3.9 Additional requirements for special type vessels/tanks
Chapter 1

General, Definitions, Documentation

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Scope

1.1.1 The Rules in this part apply to all-welded, single hull steel ships of normal form, proportions and speed for operation in inland waterways.

1.1.2 For additional class notations relating to various ship types, requirements as per Pt.5 are to be complied with.

1.1.3 Ships of unconventional forms and proportions or intended for carriage of cargoes not covered by the Rules or to be engaged in special service will receive individual consideration based on the general principles of the Rules. In these cases, however, additional calculations and/or model testing may be required to be carried out and submitted for approval.

1.1.4 Proposals for use of alternative materials e.g. aluminium, wood, etc. for some parts of the ship shall receive special consideration.

1.2 Equivalence

1.2.1 Alternative arrangements, scantlings and equipment may be accepted provided they can be shown to be equivalent to the overall safety and strength standard of the Rules. Direct calculations for the derivation of the scantlings as an alternative to those derived by the Rule formulae, may be accepted on special consideration. The calculation procedure and the assumptions made are to be submitted for approval.

1.3 National regulations

1.3.1 While the Rules cover requirements for the classification of ships, the attention of all concerned is drawn to requirements of various local or national Regulations, Codes and Recommendations which the vessel may also have to comply with.

1.4 Loadline and stability

1.4.1 All ships will be assigned class only after it has been demonstrated that their intact/damage stability and loadline requirements (where applicable) are in compliance with the standards laid down by the local or National statutory authority.

1.5 Assumptions

1.5.1 It is assumed that significant dynamic excitation of major orders from propellers and machinery do not fall close to any natural frequency of the hull.

1.5.2 It is assumed that the ships will be competently handled and loaded as per the approved loading manuals.
Section 2

Definitions

2.1 Principal particulars

2.1.1 The forward perpendicular, F.P., is the perpendicular drawn at the intersection of the maximum load water line with the fore side of the stem.

In ships with unusual bow arrangement the position of the F.P. will be specially considered.

2.1.2 The after perpendicular, A.P., is the perpendicular drawn at the intersection of the maximum load waterline with the after side of the rudder post or the centreline of the rudder stock if there is no rudder post.

In ships with unusual stern arrangement the position of the A.P. will be specially considered.

2.1.3 Rule length, L, is the distance, [m], between the forward and after perpendiculars. However L is to be not less than 96 per cent, and need not be greater than 97 per cent of the extreme length on the maximum load waterline.

In ships with unusual bow and/or stern arrangement the Rule length, L, will be specially considered.

2.1.4 "Amidship" is at 0.5L aft of the F.P.

2.1.5 Breadth, B, is the greatest moulded breadth [m].

2.1.6 Depth, D, is the moulded depth [m], measured amidships from top of the keel to the moulded deck line of the uppermost continuous deck at side. When a rounded gunwale is arranged the depth is to be measured to the continuation of the moulded deck line.

2.1.7 Draught, T, is the moulded draught amidships corresponding to the maximum load waterline, [m].

2.1.8 The block co-efficient, \( C_{b} \), is the moulded block co-efficient calculated as follows :-

\[
C_{b} = \frac{\text{moulded displacement} \ [m^3] \text{ at draught} \ T}{LBT}
\]

2.1.9 Speed, V, is the maximum service speed in knots on draught T.

2.2 Structural terms

2.2.1 The general terms used in the Rules for various structural parts of the ships are defined as under:

- **Strength Deck** : In general the uppermost continuous deck. Where a superstructure deck has within 0.4L amidships, a continuous length equal to or greater than \((1.5B + 3H)\), it is to be regarded as the strength deck instead of the covered part of the uppermost continuous deck. \((H \text{ is the height of the superstructure, [m]})\).

- **Superstructure** : A decked structure on freeboard deck extending from side to side of the ship or with the side plating not inboard of shell plating by more than 4 per cent of the breadth B.

- **Deckhouse** : A decked structure above the freeboard deck with the side plating being inboard of the shell plating by more than 4 per cent of the breadth B.

- **Bottom Structure** : Shell plating with stiffeners and girders below the upper turn of bilge and all other elements below and including the inner bottom plating in case of the double bottom. Sloping hopper tank top is to be regarded as a bulkhead.

- **Side Structure** : Shell plating with stiffeners and girders between the upper turn of bilge and the uppermost continuous deck at side. A rounded gunwale is included in the side structure.

- **Deck Structure** : Deck plating with stiffeners, girders, and supporting pillars.

- **Girder** : A collective term for the primary supporting members, other terms include :
  - **Transverses** - transverse girders under the deck.
  - **Web frames** - side vertical girders.
  - **Hatch end beams** - transverse deck girders at the ends of the hatch.
  - **Stringers** - horizontal girders.
Indian Register of Shipping

− Cross-ties - girders connecting two vertical girders in a deep tank.
− Floor - bottom transverse girders.
− **Stiffener**: A collective term for secondary supporting members; other terms being:
  − Frames.
  − Bottom, inner bottom, side or deck longitudinals.

− Reverse frame - transverse stiffener on the inner bottom.
− Horizontal or vertical bulkhead stiffeners.
− Other terms are defined in the appropriate Chapters.

### 2.3 Material factor

2.3.1 Material factor, *k*, a factor depending on material strength is defined in Ch.2.

### Section 3

**Documentation**

#### 3.1 General

3.1.1 Documentation is to be submitted as per the following paragraphs. In case of certain ship types additional documentation may be required as per Pt.5.

3.1.2 The documents should be submitted in triplicate, one copy of which shall be returned.

#### 3.2 Plans for information

3.2.1 The following supporting plans and calculations are to be submitted for information:

  − General arrangement.
  − Tank plan.
  − Capacity plan.
  − Lines plan and Hydrostatic curves or tables.
  − Docking plan.

#### 3.3 Additional information

3.3.1 The following additional information is to be submitted as necessary for strength calculations:

  − Maximum values of still water bending moments and shear forces.

  − Lightship weight and its longitudinal distribution.

  − Bonjeans data.

  − Stowage factor and angle of repose of bulk cargoes to be carried.

  − Masses and unbalanced moments of heavy machinery components e.g. engines, cranes, winches etc.

#### 3.4 Plans for approval

3.4.1 Plans as relevant are to be submitted for approval as indicated in Table 3.4.1. These should as far as practicable be complete in all necessary details.

#### 3.5 Plans to be kept on board

3.5.1 A copy of the final approved loading manual and suitable scantlings plans including details of corrosion control system; if any, are to be placed on board the ship.

3.5.2 To facilitate the ordering of materials for repairs, plans showing the disposition and extent of high tensile steel and steel of grades other than Grade A, along with the information relating to their physical and mechanical properties, recommended working, treatment and welding procedures etc. are to be placed on board.
### Table 3.4.1: Plans for approval

<table>
<thead>
<tr>
<th>Plan</th>
<th>Including Information On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading manual</td>
<td>details of loading in all contemplated loading conditions and resulting SWBM, SF &amp; Torsional Moments (TM)</td>
</tr>
<tr>
<td>Midship section</td>
<td>design values of SWBM, SF &amp; TM</td>
</tr>
<tr>
<td>Other transverse sections</td>
<td>main particulars (L,B,D,T,Cb,V)</td>
</tr>
<tr>
<td>Longitudinal sections &amp; decks</td>
<td>equipment specification</td>
</tr>
<tr>
<td>Shell expansion &amp; framing plan</td>
<td>complete class notation applied for</td>
</tr>
<tr>
<td></td>
<td>spacing of stiffeners</td>
</tr>
<tr>
<td></td>
<td>openings on the deck</td>
</tr>
<tr>
<td></td>
<td>openings on the shell</td>
</tr>
<tr>
<td></td>
<td>material grades</td>
</tr>
<tr>
<td>Double bottom</td>
<td>indication of access</td>
</tr>
<tr>
<td></td>
<td>height and location of overflows</td>
</tr>
<tr>
<td></td>
<td>loading on inner bottom</td>
</tr>
<tr>
<td>Watertight subdivision bulkheads &amp; watertight tunnels</td>
<td>openings and their closing appliances</td>
</tr>
<tr>
<td>Aft-end structure</td>
<td>propeller outline</td>
</tr>
<tr>
<td>Stemframe or sternpost</td>
<td>propeller thrust</td>
</tr>
<tr>
<td>Propeller shaft brackets</td>
<td>structural details in way of rudder and propeller bearings</td>
</tr>
<tr>
<td>Aft peak tank</td>
<td>height and location of overflow</td>
</tr>
<tr>
<td>Engine room structure</td>
<td>type, power and r.p.m. of propulsion machinery</td>
</tr>
<tr>
<td>Engine and thrust block seatings</td>
<td>weight of machinery, boilers, etc.</td>
</tr>
<tr>
<td>Fore-end construction</td>
<td>openings on non-watertight bulkheads and diaphragm plates</td>
</tr>
<tr>
<td>Fore peak tank</td>
<td>height and location of overflows</td>
</tr>
<tr>
<td>Oil tight/water tight and partition bulkheads in cargo tanks, ballast tanks and deep tanks</td>
<td>intended tank contents &amp; their densities</td>
</tr>
<tr>
<td></td>
<td>height and location of overflow/air pipes</td>
</tr>
<tr>
<td></td>
<td>tanks intended to be partially filled</td>
</tr>
<tr>
<td></td>
<td>corrosion protection; if any</td>
</tr>
<tr>
<td>Superstructures, deckhouses and machinery casings</td>
<td>height of sills from deck and closing appliances for companion ways</td>
</tr>
<tr>
<td>Hatchways</td>
<td>position and type</td>
</tr>
<tr>
<td>Hatch covers</td>
<td>loads if different from those specified in the rules</td>
</tr>
<tr>
<td></td>
<td>sealing and securing arrangement, spacing of bolts or wedges</td>
</tr>
<tr>
<td>Rudder, stock and tiller</td>
<td>speed of the ship (ahead &amp; astern)</td>
</tr>
<tr>
<td>Steering gear arrangement</td>
<td>material of bearings, coupling bolts, stock and the locking device</td>
</tr>
<tr>
<td></td>
<td>rudder carrier.</td>
</tr>
<tr>
<td>Masts &amp; derrick posts</td>
<td>derrick length and loading</td>
</tr>
<tr>
<td>Support structure for masts, derrick posts &amp; cranes</td>
<td>dimensions and positions of stays and shrouds</td>
</tr>
<tr>
<td></td>
<td>quality of material</td>
</tr>
<tr>
<td>Testing plan of tanks &amp; bulkheads</td>
<td>Welding details</td>
</tr>
<tr>
<td>Notes:</td>
<td></td>
</tr>
<tr>
<td>1) See Chapter 5, Section 6.</td>
<td></td>
</tr>
<tr>
<td>2) One drawing may contain more than one of the items from each group</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 2

Materials of Construction

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
</tr>
<tr>
<td>2</td>
<td>Corrosion Protection</td>
</tr>
<tr>
<td>3</td>
<td>Deck Covering</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Scope

1.1.1 The Rules relate, in general, to the construction of steel ships. Consideration will however be given to the use of other materials also.

1.1.2 The materials used in the construction of the ship are to be manufactured and tested in accordance with the requirements of Pt.2. 'Materials' of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules). Materials for which provision is not made may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

1.2 Steel

1.2.1 Ordinary hull structural steel is a hull structural steel with a minimum yield stress of 235 [N/mm²] and a tensile strength generally in the range of 400-490 [N/mm²].

For ordinary hull structural steel, the material factor 'k' is to be taken as 1.0.

1.2.2 Steels having a yield stress of 265 [N/mm²] and higher, are regarded as higher tensile steels. Where higher tensile steel is used, the hull girder section modulus and the local scantlings may be reduced in accordance with the relevant requirement of the Rules. For this purpose, a material factor 'k', is to be taken as follows:

\[ k = 0.78 \text{ for steel with minimum yield stress of 315 [N/mm}^2\text{]} \]

1.2.3 Where steel castings or forgings are used for sternframes, rudderframes, rudder stocks, propeller shaft brackets and other major structural items, they are to comply with Pt.2 'Materials' of Main Rules as appropriate.

1.3 Grades of steel

1.3.1 The ships covered by these Rules are generally to be constructed of Grade 'A' steel. However, for materials of over 20 [mm] in thickness used in highly stressed areas, grades of steel with higher levels of notch toughness (Grades 'B', 'D' or 'E') may be required dependent on the stress pattern associated with its location.

1.4 Aluminium

1.4.1 Where seawater resisting aluminium alloys manufactured and tested in accordance with the requirements of Pt.2 of the main rules are used for superstructures, deckhouses, hatch covers or other structural components, scantlings equivalent to steel are to be derived as follows:

\[ t_a = t_s \sqrt{k_a} \]

\[ Z_a = Z_s \cdot k_a \]

where,

\[ t_a, t_s = \text{plating thickness of aluminium and mild steel respectively.} \]

\[ Z_a, Z_s = \text{section modulus of aluminium and mild steel stiffeners respectively.} \]
\[ k_a = \frac{235}{\sigma_a} \]

\[ \sigma_a = 0.2\% \text{ proof stress or } 70\% \text{ of the ultimate strength of the aluminium material, whichever is lesser [N/mm}^2\text{].} \]

1.4.2 The smaller modulus of elasticity of aluminium is to be taken into account, when determining the buckling strength of structural elements subjected to compression and the deflections, where relevant.

Section 2

Corrosion Protection

2.1 General

2.1.1 All steelwork, except inside tanks intended for the carriage of oil or bitumen, is to be protected against corrosion by application of suitable coating.

For protection required in salt water ballast spaces, See 2.5.

For protection required in holds of dry bulk cargo carriers, see Pt.5, Ch.1.

For the protection required in tanks carrying chemicals or other special cargoes, see Pt. 5, Ch.3.

2.1.2 Where bimetallic connections are made, measures are to be incorporated to preclude galvanic corrosion.

2.2 Surface preparation, prefabrication primers, and paints or coatings

2.2.1 Steelwork is to be cleared of millscale and suitably cleaned before the application of surface paints and coatings. It is recommended that blast cleaning or other equally effective means be employed for this purpose.

2.2.2 Where a primer is used to coat steel after surface preparation and prior to fabrication, the composition of the coating is to be such that it will have no significant deleterious effect on subsequent welding work and that it is compatible with the paints or other coatings subsequently applied. Unless the primer used is type approved by IRS for this purpose, tests as detailed in Pt.3, Ch.2, Sec.3 of the Main Rules are to be made to determine the influence of the primer coating on the characteristics of the weld.

2.2.3 Paints or other coatings are to be suitable for the intended purpose in the locations where they are to be used. Unless previously agreed, at least two coats are to be applied.

2.2.4 The paint or coating is to be compatible with any previously applied primer, See 2.2.2.

2.2.5 Paints, varnishes and similar preparations having a nitrocellulose or other highly flammable base, are not to be used in accommodation or machinery spaces.

2.2.6 In ships intended for the carriage of oil cargoes having a flash point below 60°C (closed cup test), paint containing aluminium should not in general be used in cargo tanks, adjacent ballast tanks, cofferdams, pump rooms as well as on deck above the mentioned spaces, nor in any other areas where cargo vapours may accumulate, unless it has been shown by appropriate tests that the paint to be used does not increase the incendive sparking hazard.

2.3 Internal cathodic protection

2.3.1 Impressed current cathodic protection systems are not permitted in any tank.

When a cathodic protection system is to be fitted in tanks for the carriage of liquid cargo with flash point not exceeding 60°C, a plan showing details of the locations and attachment of anodes is to be submitted. The arrangements will be considered for safety against fire and explosion aspects only.

2.3.2 Particular attention is to be given to the locations of anodes in relation to the structural arrangements and openings of the tank.

2.3.3 Anodes are to be of approved design and sufficiently rigid to avoid resonance in the anode support. Weldable steel cores are to be fitted, and these are to be so designed as to retain the anode even when the anode is wasted.

2.3.4 Anodes are to be attached to the structure in such a way that they remain secure both initially and during service. The following methods of attachment would be acceptable:
a) Steel core connected to the structure by continuous welding of adequate section.

b) Steel core bolted to separate supports, provided that a minimum of two bolts with lock nuts are used at each support. The separate supports are to be connected to the structure by continuous welding of adequate section.

c) Approved means of mechanical clamping.

2.3.5 Anodes are to be attached to stiffeners, or may be aligned in way of stiffeners on plane bulkhead plating, but they are not to be attached to the shell. The two ends are not to be attached to separate members which are capable of relative movement.

2.3.6 Where cores or supports are welded to the main structure, they are to be kept clear of the toes of brackets and similar stress raisers. Where they are welded to asymmetrical stiffeners, they are to be connected to the web with the welding kept at least 25 [mm] away from the edge of the web. In the case of stiffeners or girders with symmetrical face plates, the connection may be made to the web or to the centreline of the face plate but well clear of the free edges. However, it is recommended that anodes are not fitted to face plates of high tensile steel longitudinals.

2.4 Aluminium and magnesium anodes

2.4.1 Aluminium and aluminium alloy anodes are permitted in tanks used for the carriage of oil, but only at locations where the potential energy does not exceed 275 [J] (i.e. 28 [kgf m]). The weight of the anode is to be taken as the weight at the time of fitting, including any inserts and fitting devices.

2.4.2 The height of the anode is, in general, to be measured from the bottom of the tank to the centre of the anode. Where the anode is located on or closely above a horizontal surface (such as a bulkhead girder) not less than 1 [m] wide, provided with an upstanding flange or face plate projecting not less than 75 [mm] above the horizontal surface, the height of the anode may be measured above that surface.

2.4.3 Aluminium anodes are not to be located under tank hatches or tank cleaning openings unless protected by adjacent structure.

2.4.4 Magnesium or magnesium alloy anodes are permitted only in tanks intended solely for water ballast.

2.5 Corrosion protection coatings for salt water ballast spaces

2.5.1 In case of ships which normally carry salt water for ballast purposes, all ballast spaces, having boundaries formed by the hull envelope, are to have a suitable corrosion protection coating applied in accordance with the manufacturer's requirements.

Section 3

Deck Covering

3.1 General

3.1.1 Where plated decks are sheathed with wood or an approved composition, reductions in plate thickness may be allowed.

3.1.2 The steel deck is to be coated with a suitable material in order to prevent corrosive action, and the sheathing or composition is to be effectively secured to the deck.

3.1.3 Deck coverings in the following positions are to be of a type which will not readily ignite where used on decks:

a) forming the crown of machinery or cargo spaces within accommodation spaces of cargo ships

b) within accommodation spaces, control stations, stairways and corridors of passenger ships.
Chapter 3

Principles for Scantlings and Structural Details

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Application

1.1.1 Scantlings of various platings, stiffeners and girders to meet the local strength requirements are to be determined in accordance with the general principles given in this Chapter.

The design values of loads are given in chapters relevant to the structures under consideration.

1.1.2 Scantlings of hull members contributing to the longitudinal strength are also to comply with the requirements of Ch. 4.

1.1.3 Scantlings of hull members subjected to compressive stresses are also to comply with the requirements of Sec. 6.

1.2 Symbols

\( p \) = design pressure \([\text{kN/m}^2]\) as given in the relevant chapters calculated at the loadpoint as given below:

Loadpoint for plates:

- midpoint of horizontally stiffened plate field
- half the stiffener spacing above the lower support of vertically stiffened plate field, or at the lower edge of plate when the thickness is changed within the plate field.

Loadpoint for stiffeners:

- midpoint of span.

Loadpoint for girders

- midpoint of load area supported by the girder.

\( s \) = stiffener spacing [mm], measured along the plating.

\( l \) = span of the stiffener, [m], in accordance with 4.1.1.

\( r \) = radius of curvature [mm].

\( S \) = span of the girder [m], in accordance with 4.1.2.

\( b \) = mean breadth [m], of the load area supported by the girder.

\( h_w \) = height of web, [mm].

\( b_f \) = width of flange, [mm].

\( \sigma \) = allowable bending stress, \([\text{N/mm}^2]\) as given in the relevant Chapters.

\( \sigma_y \) = minimum yield stress of material, \([\text{N/mm}^2]\), may be taken as 235 \([\text{N/mm}^2]\) for normal strength steel.
1.3 Frame spacing

1.3.1 The normal frame spacing between aft peak and 0.2L from F.P. may be taken as:

\[ 450 + 2L \ \text{[mm]} \] for transverse framing

\[ 550 + 2L \ \text{[mm]} \] for longitudinal framing.

1.3.2 In aft peak and fore peak the frame spacing is not to exceed 600 [mm] or that given in 1.3.1, whichever is less.

1.3.3 Where the actual frame spacing is higher than that mentioned above, the minimum thicknesses of various structural members as given in the Rules may require to be increased.

### Section 2

#### Corrosion Additions

2.1 General

2.1.1 The thickness of plates, stiffeners and girders in tanks for water ballast and/or cargo oil and in holds of dry bulk cargo carriers is to be increased by a corrosion addition \( t_c \) as given in Table 2.1.1.

2.1.2 The required corrosion addition \( Z_c \) to the section modulus of stiffeners and girders due to the thickness addition \( t_c \) mentioned above may be approximated as:

\[
Z_c = \frac{t_c h_w (b + 0.3 h_w)}{1000} \ \text{[cm}^3]\]

<table>
<thead>
<tr>
<th>Item</th>
<th>Space Category</th>
<th>( t_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal members within and plate boundary between spaces of the given category</td>
<td>Ballast tank</td>
<td>1.5 (1)</td>
</tr>
<tr>
<td></td>
<td>Cargo oil tank</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Hold of dry bulk cargo carriers</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Ballast tank/Cargo oil tank</td>
<td>1.5 (1)</td>
</tr>
<tr>
<td></td>
<td>Ballast tank/Hold of dry bulk cargo carrier</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Ballast tank/Other category space</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cargo oil tank/Other category space</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Hold of dry bulk cargo carrier/Other category space</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Notes:

1) Where the relevant ballast or liquid cargo tanks extend up to the exposed weather deck the minimum corrosion addition in the region extending up to 1.5 [m] below the weather deck corrosion addition is to be increased by 0.5 [mm].

2) Hold of dry bulk cargo carriers refers to the cargo holds of vessels with class notation **Bulk Carrier** and **Ore Carrier**.

3) Other category space denotes the hull exterior and all spaces other than water ballast and cargo oil tanks and holds of dry bulk cargo carriers.
Section 3

Plating

3.1 General

3.1.1 Minimum requirements of thickness of various platings are given in relevant chapters.

3.1.2 The thickness 't' of plating subjected to lateral pressure is not to be less than

\[ t = \frac{15.8s \sqrt{\rho}}{\sqrt{\sigma}} \times 10^{-3} + t_c \text{ [mm]} \]

3.1.3 Any tapering of thickness of platings contributing to the longitudinal strength is to be based upon linear variation of stress \( s \) allowed at specified regions.

Section 4

Stiffeners and Girders

4.1 Determination of span

4.1.1 For stiffeners, the span 'l' [m] is to be taken as the length of the stiffener between the two supporting members less the depth of stiffener on crossing panel if any. Where brackets larger than those required in 5.1.2 are fitted, the span may be determined as shown in Fig. 4.1.1.

For curved stiffeners, 'l' may be based on the chord length.

4.1.2 For girders, the span 'S' [m] is to be taken as the length of the girder between the two supporting members, less the web height of in-plane girder if any, and the correction for bracket 'bc', as shown in Fig. 4.1.2.

4.2 Effective width of attached plating

4.2.1 The area of the attached plating, to be used in the calculation of sectional properties of the stiffeners and girders, is to be taken as the cross-sectional area within the effective width of the attached plating.

4.2.2 The effective width of plating attached to a stiffener may be taken as the mean of spacings on either side of the stiffener.

4.2.3 The effective width of plating attached to a girder, 'be' is to be taken as per the following:

\[ b_e = c \cdot b \]

where,

\( c = c_1 \), for girders with uniformly distributed loads or with six or more evenly spaced point loads

\( = c_2 \), for girders with three or less evenly spaced point loads.

<table>
<thead>
<tr>
<th>a/b</th>
<th>0.5</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>6.0</th>
<th>≥ 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c_1 )</td>
<td>0.19</td>
<td>0.38</td>
<td>0.67</td>
<td>0.84</td>
<td>0.93</td>
<td>0.97</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>( c_2 )</td>
<td>0.11</td>
<td>0.22</td>
<td>0.40</td>
<td>0.52</td>
<td>0.65</td>
<td>0.73</td>
<td>0.78</td>
<td>0.80</td>
</tr>
</tbody>
</table>

For intermediate values of a/b and number of point loads, values of 'c' may be obtained by interpolation.

\( a = \) span of the girder, for simply supported girders, [m].

\( = 60 \) per cent of span of the girder, for girders fixed at both ends, [m].

4.2.4 In case of girders on corrugated bulkheads which run across the corrugations, the effective width of attached plating is to be taken as 10% of that obtained from 4.2.3.
Fig. 4.1.1

\[ b_C = b_b \left(1 - \frac{h_w}{a}\right) \]

Fig. 4.1.2
4.2.5 The effective cross sectional area of the attached plating is not to be less than that of the face plate.

4.3 Scantlings of stiffeners

4.3.1 The section modulus 'Z' of stiffeners subjected to lateral pressure is not to be less than:

\[ Z = \frac{s \cdot p \cdot l^2}{m \sigma} + Z_c \text{ [cm}^3\text{]} \]

where,

\begin{align*}
m &= \text{bending moment factor depending on the arrangement at the supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the 'm' value may generally be taken as:} \\
= 12 & \text{ for continuous longitudinal stiffeners} \\
= 10 & \text{ for transverse, vertical and non-continuous longitudinal stiffeners fixed at both ends.} \\
= 8 & \text{ for stiffeners simply supported at both ends.} \\
\end{align*}

4.3.2 Where stiffeners are not perpendicular to the plating, the section modulus as obtained from 4.3.1 is to be increased by the factor \((1/\cos \alpha)\), \(\alpha\) being the angle between the stiffener web and the plane perpendicular to the plating.

4.4 Scantlings of girders

4.4.1 The scantlings of simple girders subjected to lateral pressure which can be considered as conforming to the general beam theory are to satisfy the requirement given in 4.4.2.

4.4.2 The section modulus 'Z' of girders subjected to lateral pressure is not to be less than:

\[ Z = \frac{b \cdot p \cdot S^2 \cdot 10^3}{m \sigma} + Z_c \text{ [cm}^3\text{]} \]

where,

\[ m = \text{bending moment factor depending upon the arrangement at supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the 'm' value may generally be taken as 12 for continuous longitudinal girders and 10 for all other girders.} \]

4.4.3 Where openings are cut in the girder web, they are to be away from the girder ends and scallops for stiffeners; with their centre located as near to the neutral axis of the girder as practicable. Openings of depth exceeding 25% of the girder depth or 300 [mm] and, of length exceeding the depth of the girder or 60% of the secondary stiffener spacing, are to be reinforced all around at the edge; or alternatively by providing horizontal and vertical stiffeners.

4.4.4 Girders are to be provided with adequate lateral stability by tripping brackets fitted generally at every fourth stiffener. Tripping brackets are also to be fitted at the toes of end brackets and in way of concentrated loads such as heels of pillars or cross ties.

Section 5

End Attachments

5.1 End attachments of stiffeners

5.1.1 Continuity of all stiffeners participating in longitudinal strength is to be maintained over transverse members within 0.5L amidships. Longitudinals abutting at transverse members may be accepted provided the brackets connecting the ends of the longitudinals are of adequate size and are either continuous or properly aligned.

5.1.2 Scantlings of brackets fitted on stiffeners not participating in the longitudinal strength are not to be less than the following:

- The arm lengths, 'a and b' (See Fig.4.1.1) are to be such that:
  i) \(a, b \geq 0.8 \, l_b\)
  and
  ii) \(a+b \geq 2.0 \, l_b\).

where,

\[ l_b = 24 \sqrt{Z} + 75 \text{ [mm]} \]

- Thickness of unflanged bracket is to be not less than:
Chapter 3

Page 6 of 7

Principles for Scantlings and Structural Details

$t = (4.0 + 0.3 \sqrt{Z}) + t_c \ \text{[mm]}$

- Thickness of flanged bracket is to be not less than:

$t = (3.0 + 0.25 \sqrt{Z}) + t_c \ \text{[mm]}$

- Width of flange, $w \geq 40 + Z/25 \ [\text{mm}]$, but not to be less than 50 \ [\text{mm}].

where,

$Z$ is the section modulus [cm$^3$], of the smaller stiffener, being connected.

5.2 End attachments of girders

5.2.1 The end attachments and supporting structure of the girders are to provide adequate resistance against rotation and displacement of the joint and effective distribution of the load from the member. Supporting members to which the girders are being connected, may require additional strengthening to provide adequate stiffness to resist rotation of the joint. Where the end attachment provides only a low degree of restraint against rotation, the girder is generally to be extended beyond the point of support by at least two frame spaces before being gradually tapered.

Connections between girders forming a ring system are to be such as to minimize stress concentrations at the junctions. Integral brackets are generally to be radiused or well rounded at the toes.

Section 6

Buckling

6.1 General

6.1.1 The critical buckling stress '$\sigma_{cr}$' of plate panels and other members subjected to compressive loads is to be such that:

$$\sigma_{cr} \geq \frac{\sigma_c}{\eta}$$

where,

$\sigma_c$ = applied compressive stress

$\eta = 1.0$ for deck, longitudinally stiffened side shell and single bottom plating

= 0.9 for bottom, inner bottom plating in double bottom and transversely stiffened side shell plating

$$\frac{0.7}{1 + \frac{l_m}{i}}$$ (need not be taken smaller than 0.3);

- for axially loaded members such as pillars, cross-ties, panting beams etc., in general, to be reduced by 15 per cent where the loads are primarily dynamic in nature.

- for '$l_m$' and '$i'$ See 6.2.2.

6.1.2 The critical compressive buckling stress '$\sigma_{cr}$' determined as follows is not to be less than

Where the face plate of the girder is not continuous over the bracket, the free edge of the bracket is to be stiffened and the face plate of the girder is to be extended well beyond the toe of the bracket.

5.2.2 The thickness 't' of brackets on girder is not to be less than that of the girder web.

The arm length 'a' including the depth of girder is not to be less than:

$$a = 83 \sqrt{(Z/t)} \ \text{[mm]}$$

where,

$Z$ = the section modulus [cm$^3$], of the girder to which the bracket is connected.

The cross sectional area 'A_f' of the face plate on the girder bracket is not to be less than:

$$A_f = 0.001 l_f t \ [\text{cm}^2]$$

where, $l_f$ is the length [mm], of the free edge of the bracket.

Additional stiffeners parallel to the bracket face plate are to be fitted on webs of large brackets. The arm length of an unstiffened triangular end panel of bracket is generally not to exceed 100 t [mm].
the maximum compressive stress developed in the members under consideration.

\[
\sigma_{cr} = \sigma_E \quad \text{when} \quad \sigma_E \leq 0.5 \sigma_y
\]

\[
= \sigma_y \left(1 - \frac{\sigma_y}{4\sigma_E}\right) \quad \text{when} \quad \sigma_E > 0.5 \sigma_y
\]

where,

\[
\sigma_E = \text{ideal elastic buckling stress as per Sec.6.2.}
\]

6.2 Ideal elastic buckling stress

6.2.1 The \(\sigma_E\) value for platings may be taken as:

\[
\sigma_E = 0.9 K E \left(\frac{l - t_c}{s}\right)^2 \quad [\text{N/mm}^2]
\]

where,

\[
K = \frac{8.4}{\psi + 1.1}
\]

- for plating with stiffeners in the direction of the compressive stress

\[
= C \left[1 + \left(\frac{s}{1000 \times l}\right)^2\right] \frac{2.1}{\psi + 1.1}
\]

- for platings with stiffeners in the direction perpendicular to the compressive stress

\[
\psi = \text{ratio between the smaller and the larger values of the compressive stress assuming a linear variation (See Fig.6.2.1)}
\]

\[
C = 1.30 \ \text{when plating is stiffened by floors or deep girders}
\]

\[
= 1.21 \ \text{when stiffeners are angles or T sections}
\]

\[
= 1.10 \ \text{when stiffeners are bulb flats}
\]

\[\text{Fig. 6.2.1}\]

\[= 1.05 \ \text{when stiffeners are flat bars}\]

\[s = \text{shorter side of plate panel, [mm]}\]

\[l = \text{longer side of plate panel, [m]}\]

6.2.2 The value for axially loaded members may be taken as:

\[
\sigma_E = 0.001 C E (i/l_m)^2 \quad [\text{N/mm}^2]
\]

\[
C = 1.0 \ \text{for both ends hinged}
\]

\[
= 2.0 \ \text{for one end fixed}
\]

\[
= 4.0 \ \text{for both ends fixed}
\]

\[i = \text{radius of gyration of the member, [cm]}\]

\[= \sqrt{(I/a)}\]

\[I = \text{moment of inertia of the member, [cm}^4].\]

\[a = \text{cross sectional area of the member, [cm}^2].\]

\[l_m = \text{length of the member, [m]}\]

Where end connections of a member are different with respect to the two principal axes, \(\sigma_E\) is to be found out for both cases using appropriate values of 'C' and 'I'.

\[\text{End Of Chapter}\]
Chapter 4

Longitudinal Strength

Contents

Section
1 General
2 Vertical Bending Moments
3 Hull Section Modules and Moment of Inertia
4 Openings in Longitudinal Strength Members

Section 1

General

1.1 Application

1.1.1 Scantlings of hull members contributing to longitudinal strength are to comply with the requirements given in this Chapter. These members are also to comply with the requirements of buckling strength given in Ch.3, Sec.6 and of local strength given in relevant chapters of Pt.3.

1.1.2 Still water bending moments are to be calculated for all ships with unusual or non-uniform weight or cargo distribution and for other ships of \( L \geq 60 \) m.

Such ships are to be provided with an approved loading manual which describes the loading conditions on which the design is based and also gives the values of still water bending moments and permissible limits.

1.2 Symbols

L, B, T, k as defined in Ch.1, Sec.2.

\( I_n \) = moment of inertia of hull girder, [cm\(^4\)], about the transverse neutral axis at the section under consideration.

\( Z_n \) = vertical distance [m] of the horizontal neutral axis above base line.

\( M_s \) = design still water bending moment [kN-m] as given in 2.1.2.

\( M_w \) = rule wave bending moment [kN-m] as given in 2.2.1.

Section 2

Vertical Bending Moments

2.1 Still water bending moment

2.1.1 Still water bending moments are to be calculated for the following loading conditions as a minimum:

a) Fully loaded condition with design cargo distribution(s)

b) Light condition with full consumables, stores, crew and ballast, if any.

In addition other loading conditions which may be more onerous, e.g. intermediate conditions of special loading or discharging sequences, are to be investigated.

2.1.2 The design value of still water bending moment \( M_s \) at 0.4L amidships is to be taken as the greater of the following:
a) The maximum of sagging or hogging still water bending moments obtained for the loading conditions specified in Sec.2.1.1, and

b) \(0.375 \, L^2 \, B \, [kN \cdot m]\)

At locations outside 0.4L amidships the design value of still water bending moment \(M_s\) may be linearly reduced to zero at perpendiculars.

### 2.2 Wave load conditions

#### 2.2.1 The rule vertical wave bending moment \(M_w\) for 0.4L amidships is to be taken as

\[M_w = C \, L^2 \, B \, [kN \cdot m]\]

where,

\[C = \text{coefficient as per Table 2.2.1.}\]

#### Table 2.2.1

<table>
<thead>
<tr>
<th>Zone</th>
<th>Coefficient (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.30 for (L \leq 20 , m)</td>
</tr>
<tr>
<td></td>
<td>(0.3 + 0.005 , (L-20)) for (20 &lt; L &lt; 60)</td>
</tr>
<tr>
<td></td>
<td>0.5 for (L \geq 60 , m)</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>0.15</td>
</tr>
</tbody>
</table>

At locations outside 0.4L amidships, the value of rule wave bending moment \(M_w\) is to be linearly reduced to zero at perpendiculars.

### Section 3

#### Hull Section Modulus and Moment of Inertia

#### 3.1 Calculation of section properties

3.1.1 When calculating the moment of inertia and section moduli, the net sectional area (after deduction for openings) of all continuous longitudinal strength members is to be taken into account. Small isolated lightening holes in girders need not be deducted.

Superstructures not forming strength deck (See Ch.1, Sec.2.2), deckhouses, bulwarks and non-continuous longitudinal hatch coamings are not to be included in the above calculations.

In case of ships with continuous trunks or longitudinal hatch coamings, their net sectional area may be included in the calculations provided they are effectively supported by longitudinal bulkheads or deep girders. The section modulus at deck however, is then to be calculated as given in 3.1.3.

3.1.2 The main strength members included in the calculation of hull moment of inertia and section moduli are to extend continuously through the cargo region and sufficiently far towards the ends of the ship. Longitudinal bulkheads are to terminate at effective transverse bulkheads and large transition brackets are to be fitted in line with the longitudinal bulkheads.

3.1.3 The midship section modulus \(Z\) at deck or bottom about the transverse neutral axis is to be obtained as follows:

\[Z = \frac{I}{100 \, z} \, [cm^3]\]

where,

\[z = \text{the vertical distance [m] from the horizontal neutral axis upto the strength deck at side or the base line, as relevant.}\]

However, in case of ships where continuous trunks or longitudinal hatch coamings are to be included in the section modulus calculation as per Sec.3.1.1, the distance \(z\) for calculation of modulus at deck is to be taken as the greater of the following:

\[z = z_n \, [0.9 + 0.2 \, y/B]\]

where,

\[z_n = \text{the vertical distance from the horizontal neutral axis top of continuous strength number.}\]

\[y = \text{athwartship distance from the centreline of the ship to the side of the strength member.}\]

\(z_n\) and \(y\) are to be measured to the point giving the largest value of \(z\).

#### 3.2 Extent of high tensile steel

3.2.1 Where high tensile steels are used in the main hull structure in order to reduce the section modulus requirement, the vertical and longitudinal extent of its use is to be such that
adjacent structure made of ordinary hull structural steel is not stressed beyond the stress level permissible for ordinary steel.

3.3 Section modulus requirement

3.3.1 At any transverse section, the hull section modulus \( Z \), about the transverse neutral axis for the still water bending moments \( M_s \) given in 2.1 and wave bending moments \( M_w \) given in 2.2, is not to be less than:

\[
Z = \left( \frac{M_s + M_w}{\sigma_L} \right) \times 10^3 \text{ [cm}^3\text{]}
\]

where,

\[
\sigma_L = 175/k \text{ [N/mm}^2\text{]} \text{ within 0.4L amidships}
\]

\[
= 125/k \text{ [N/mm}^2\text{]} \text{ within 0.1L from A.P. and F.P.}
\]

Between the specified regions \( \sigma_L \) is to be obtained by linear interpolation.

3.3.2 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in 3.3.1 are to be maintained within 0.4L amidships.

In the region outside 0.4L amidships, the scantlings are to be gradually tapered to the local requirements at ends.

3.4 Moment of inertia requirement

3.4.1 The moment of inertia \( I_n \) of the hull section about the transverse neutral axis, at midship, is not to be less than:

\[
I_n = 3L \cdot Z \text{ [cm}^4\text{]}
\]

where,

\[
Z = \text{Hull section modulus amidships as required by 3.3.1.}
\]

Section 4

Openings in Longitudinal Strength Members

4.1 Locations

4.1.1 As far as practicable, openings are to be avoided in the keel plate and in the bilge plate within 0.6L amidships.

4.1.2 Openings in the strength deck within 0.6L amidships are as far as practicable to be located inside the line of large hatch openings. Necessary openings outside this line are to be kept well clear of the ship's side and hatch corners.

4.1.3 Small openings are generally to be kept well clear of other openings in the longitudinal strength members.

4.2 Reinforcements

4.2.1 All openings are to be adequately framed and arrangements in way of corners and openings are to be such as to maintain structural continuity and minimize the creation of stress concentrations.

Corners of hatchways are to be reinforced as given in Ch.8, Sec.2. Smaller openings in the strength deck and outer bottom within 0.6L amidships are to be reinforced as given in 4.2.2 to 4.2.5 below. The area of these reinforcements is not to be included in the sectional areas used in the section modulus calculation.

4.2.2 Circular openings with diameter equal to or greater than 0.325 [m] are to have edge reinforcement having sectional area \( A \) not to less than:

\[
A = 2.5 \cdot b \cdot t \text{ [cm}^2\text{]}
\]

where,

\[
b = \text{diameter of the opening [m]}
\]

\[
t = \text{thickness of the plating [mm]}
\]

4.2.3 Elliptical openings are to have their major axis in the fore and aft direction. Where the ratio of the major axis to minor axis is less than 2, the openings are to be reinforced as given in 4.2.2 taking \( b \) as the breadth of the opening (minor axis).

4.2.4 Rectangular openings are to have their corners well rounded. Where corners are of circular shape the radius is not to be less than 20 per cent of the breadth of the opening and the edges are to be reinforced as given in 4.2.2 taking \( b \) as the breadth of the opening.
Where corners are of elliptical shape as given in 4.2.3 or of streamlined shape as given in 4.3, the reinforcement will generally not be required provided that the transverse extension of the curvature, \( a \), shown in Fig. 4.3.2 is not less than:

\[
a = 0.15b \ [\text{m}]
\]

4.2.5 Openings in side shell subjected to large shear stresses are to be of circular shape and are to be reinforced as given in 4.2.2 irrespective of the size of opening.

4.3 Hatchway corners

4.3.1 Where corners are of circular shape, the radius \( r \) within 0.6L amidships is not to be less than

\[
r = 0.05 \ b \ [\text{m}], \text{ minimum } 0.3 \ [\text{m}]
\]

where,

\( b = \text{breadth of the hatchway} \ [\text{m}] \)

4.3.2 Where corners are of streamlined shape, as given by Fig. 4.3.2, the transverse extension of the curvature, \( a \), is not to be less than

\[
a = 0.05 \ b \ [\text{m}], \text{ minimum } 0.3 \ [\text{m}]
\]

Ordinates of streamlined corner

<table>
<thead>
<tr>
<th>Point</th>
<th>Abscissa, ( x )</th>
<th>Ordinate, ( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.793a</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>1.381a</td>
<td>0.002a</td>
</tr>
<tr>
<td>3</td>
<td>0.987a</td>
<td>0.021a</td>
</tr>
<tr>
<td>4</td>
<td>0.802a</td>
<td>0.044a</td>
</tr>
<tr>
<td>5</td>
<td>0.631a</td>
<td>0.079a</td>
</tr>
<tr>
<td>6</td>
<td>0.467a</td>
<td>0.131a</td>
</tr>
<tr>
<td>7</td>
<td>0.339a</td>
<td>0.201a</td>
</tr>
<tr>
<td>8</td>
<td>0.224a</td>
<td>0.293a</td>
</tr>
<tr>
<td>9</td>
<td>0.132a</td>
<td>0.408a</td>
</tr>
<tr>
<td>10</td>
<td>0.065a</td>
<td>0.548a</td>
</tr>
<tr>
<td>11</td>
<td>0.022a</td>
<td>0.712a</td>
</tr>
<tr>
<td>12</td>
<td>0.002a</td>
<td>0.899a</td>
</tr>
<tr>
<td>13</td>
<td>0.0</td>
<td>1.000a</td>
</tr>
</tbody>
</table>

Fig. 4.3.2: Streamlined deck corner

End Of Chapter
Chapter 5

Bar Keel, Stem and Sternframes

Contents

Section
1 General
2 Bar Keel
3 Stem
4 Stern Frames

Section 1

General

1.1 Scope

1.1.1 This chapter provides requirements for bar keel, bar stem, stern frames and shaft brackets.

1.2 Material

1.2.1 All steel plates and sections, castings and forgings used in the constructions are to be tested and approved in accordance with the requirements of Ch.3, Ch.4 and Ch.5 of Pt.2 ‘Materials’ of the Rules & Regulations for the Construction and Classification of Steel Ships (Main Rules), respectively. Material grades for plates and sections are to be selected as per Pt.3, Ch.2.

1.2.2 Bar keels and stems may either be steel castings or forgings or rolled plates or bars.

1.2.3 Sternframes, rudder horns and shaft brackets may be constructed of cast or forged steel or may be fabricated from plates.

1.3 Symbols

1.3.1 L, T as defined in Ch.1, Sec.2.

Section 2

Bar Keel

2.1 Scantlings

2.1.1 The scantlings of bar keel are not to be less than:

Depth = 75 + 0.75 L [mm]

Thickness = 10 + 0.4 L [mm]

Minor deviations from the above values may be accepted provided the required sectional area is maintained.
Section 3

Stem

3.1 Bar stem

3.1.1 The cross sectional area 'A' of a bar stem, below the summer load waterline, is not to be less than

\[ A = 0.6L \ [\text{cm}^2]; \quad \text{or } 12 \ [\text{cm}^2] \]

- whichever is greater.

3.2 Plate stem

3.2.1 The thickness 't' of the plate stem below the summer load waterline is not to be less than:

\[ t = (0.08L + 5.0) \ [\text{mm}] \]

3.2.2 The thickness of the plate stem may be gradually reduced to that of the side shell at the stem head.

3.2.3 The plate stems are to be supported by horizontal diaphragms spaced not more than 1.0 [m] apart. Where the stem plate radius is large, a centreline stiffener or web is to be provided.

Section 4

Stern Frames

4.1 General

4.1.1 Sternframes, shaft brackets etc. are to be designed such that they are effectively integrated into the ship's structure.

4.1.2 In castings, sudden changes of section or possible constrictions to the flow of metal during castings are to be avoided. All fillets are to have adequate radii, which in general should not be less than 50 to 75 [mm], depending on the size of the casting.

4.1.3 Fabricated and cast steel sternframes are to be strengthened at intervals by webs spaced not more than 700 [mm] apart. In way of the upper part of the sternframe arch, these webs are to line up with the floors.

4.1.4 Rudder posts and propeller posts are to be connected to floors of increased thickness.

4.1.5 It is recommended that the after body of the ship be so shaped as to ensure adequate flow of water to the propeller so as to prevent uneven formation of eddies, as far as possible.

4.2 Sternframes

4.2.1 The scantlings of the propeller posts are not to be less than the following:

Forged propeller posts (see Fig. 4.2.1 (a))

\[ A = (8 + 0.4L)T \ [\text{cm}^2] \text{ for } L < 60 \ [\text{m}] \]

\[ = 32T \ [\text{cm}^2] \text{ for } L > 60 \ [\text{m}] \]

Fabricated propeller posts (see Fig. 4.2.1 (b))

\[ l = 150 \sqrt{T} \ [\text{mm}] \]

\[ w = 100 \sqrt{T} \ [\text{mm}] \]

\[ r = 18 \sqrt{T} \ [\text{mm}] \]

\[ t_1 = 11 \sqrt{T} \ [\text{mm}] \]

\[ t_w = 5 \sqrt{T} \ [\text{mm}] \]

Cast steel propeller posts (see Fig. 4.2.1 (c))

\[ l = 125 \sqrt{T} \ [\text{mm}] \]

\[ w = 85 \sqrt{T} \ [\text{mm}] \]

\[ r = 20 \sqrt{T} \ [\text{mm}] \]

\[ t_1 = 12 \sqrt{T} \ [\text{mm}] \]

\[ t_2 = 14 \sqrt{T} \ [\text{mm}] \]

\[ t_w = 7 \sqrt{T} \ [\text{mm}] \].
Where the sections adopted differ from the above, the section modulus about the longitudinal axis is to be equivalent to that with the Rule scantlings.

On sternframes without solepieces, the modulus of the propeller post, about the longitudinal axis, may be gradually reduced by 15 per cent below the propeller boss, provided the thicknesses are maintained as above.

4.2.2 The wall thickness of the boss 't_b' in the propeller post is not to be less than:

\[ t_b = 0.25 \, d_{ts} + 12 \, [\text{mm}] \]

where,

\( d_{ts} = \) Rule diameter of tail shaft, [mm].

In fabricated stern frames the connection of the propeller post to the boss is to be by full penetration welds.

4.3 Sole piece

4.3.1 The section modulus 'Z_T' of the sole piece against transverse bending is not to be less than

\[ Z_T = \frac{1}{90} \frac{c \, F_r \, x}{b} \, [\text{cm}^3] \]

where,

\( F_r = \) Rudder force [N] as defined in Pt.3, Ch.12, Sec. 3

\( x = \) distance of the cross section under consideration from the centre line of rudder stock, [m]. 'x' is not to be taken as less than a/2.

4.3.2 The section modulus 'Z_v' of the sole piece against vertical bending is not to be less than:

\[ Z_v = \frac{Z_T}{2} \, [\text{cm}^3] \]

4.3.3 The sectional area of sole piece is not to be less than:

\[ A_s = \frac{1}{5400} \cdot \frac{c \, F_r}{b} \, [\text{cm}^2] \]

4.3.4 The sole piece is to extend at least two frame spaces forward of the forward edge of the propeller boss and beyond this, the cross section of the extension is to be gradually
reduced to that necessary for an efficient connection to the keel plate. Fabricated solepieces are to have adequate internal stiffening.

4.4 Shaft brackets

4.4.1 Where the propeller shafting is exposed to the sea for some distance clear of the main hull, it is generally to be supported adjacent to the propeller by independent brackets having two arms. It is recommended that the angle included between the arms differs from the angle included between the propeller blades. In very small ships the use of single arm brackets will be considered.

4.4.2 Fabricated brackets are to be designed to avoid or reduce the effects of hard spots and ensure a satisfactory connection to the hull structure. The connection of the arms to the bearing boss is to be by full penetration welding.

4.4.3 Generally, bracket arms are to be carried through the shell plating and attached to floors or girders of increased thickness. The shell plating in way of shaft brackets is to be increased in thickness to a minimum of 1.5 times the Rule bottom shell plating thickness amidships. In way of the bracket arms an insert plate is to be provided of thickness not less than:

\[ t = 1.6 \sqrt{d_{ts}} \]  

where \( d_{ts} \) is the tailshaft diameter.

The connection of the bracket arms to the shell plating is to be by full penetration welding.

4.4.4 The scantlings of solid or built-up shaft brackets are to comply with the following:

\[ t = 0.4 \, d_{ts} \, [\text{mm}] \]

\[ A = 4.5 \, d_{ts}^2 \times 10^{-3} \, [\text{cm}^2] \]

\[ Z_T = 30 \, d_{ts}^3 \times 10^{-6} \, [\text{cm}^3] \]

where,

\( t \) = thickness of the bracket arms

\( A \) = cross sectional area of the bracket arms

\( Z_T \) = Section modulus of the bracket arms against transverse bending
Chapter 6

Bottom Structure

**Contents**

<table>
<thead>
<tr>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
</tbody>
</table>

**Section 1**

**General**

1.1 Scope

1.1.1 The scantlings and arrangement of bottom structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

1.2 Symbols

$L, B, T, C_b, k$ as defined in Ch.1, Sec.2.

$s = \text{spacing of stiffeners, [mm]}$

$l = \text{span of stiffeners, [m]}$

$b = \text{spacing of girders, [m]}$

$S = \text{span of girders, [m]}$

$t_c, Z_c$ are corrosion additions to the thickness and section modulus respectively, as given in Ch.3, Sec.2.1.

$$ f_B = \frac{Z_R}{Z_B} $$

where,

$Z_R = \text{Rule midship section modulus [cm}^3\text{] as required by Ch.4.}$

$Z_B = \text{Actual midship section modulus [cm}^3\text{] provided at bottom.}$

**Section 2**

**Structural Arrangement and Details**

2.1 General

2.1.1 Depth of wells constructed in the double bottom, in connection with the drainage arrangement of holds, is to be kept in the minimum.

2.1.2 The continuity of the bottom, bilge and inner bottom longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.3 The bilge keel and the ground bar to which it is attached, are to be gradually tapered at ends and arranged to finish in way of suitable internal stiffening. Butt welds in the bilge keel
and the ground bar are to be well clear of each other and those in the shell plating.

2.1.4 The weld connections are to comply with the requirements of Ch.16.

2.2 Access, ventilation and drainage

2.2.1 Adequate access is to be provided to all parts of the double bottom. Where the vertical dimension of the lightening hole exceeds 50 percent of the web height adequate reinforcements are to be provided. The diameter of lightening holes in the bracket floors is not to exceed 1/3 of the breadth of the brackets. Lightening holes or manholes are normally not to be cut in floors or girders towards their ends and under large pillars or supporting structures. Manholes in innerbottom are to have reinforcement rings, and the man hole covers in the inner bottom plating in cargo holds are to be effectively protected. The edges of all holes are to be smooth.

2.2.2 To ensure the free passage of air and water from all parts of the tanks to air pipes and suction pipes, air and drain holes are to be provided in all non-watertight members. The air holes are to be placed as near to the inner bottom as possible and their total area is to be greater than the area of the filling pipes. The drain holes are to be placed as near to the bottom as possible.

2.2.3 The access opening to pipe tunnel is to be visible above the floor plates and is to be fitted with a rigid watertight closing device. A notice board stating that the access opening to the pipe tunnel is to be kept closed, is to be fitted near the opening. The opening is to be regarded as an opening in watertight bulkhead.

Section 3

Design Loads

3.1 Bottom shell

3.1.1 The design pressure ‘p’ [kN/m²] on outer bottom is to be taken as

\[ p = 10 T_1 \] [kN/m²]

\( T_1 \) to be obtained from Table 3.1.1.

<table>
<thead>
<tr>
<th>Zone</th>
<th>( T_1 )</th>
</tr>
</thead>
</table>
| 1    | \( T + 1.0 \text{ [m]} \) for \( L > 60 \text{ [m]} \)  
\( T + 0.6 \text{ [m]} \) for \( L < 20 \text{ [m]} \) |
| 2    | \( T + 0.6 \text{ [m]} \) |
| 3    | \( T + 0.3 \text{ [m]} \) |

For intermediate values of \( L \) in Zone 1, \( T_1 \) to be linearly interpolated

In way of tanks, the design pressure is not to be taken less than internal pressure ‘p’ given in 3.2.1.

3.2 Watertight floors and girders

3.2.1 The design pressure ‘p’ on watertight floors and girders in double bottom tanks is to be taken as the greater of:

\[ p = 6.7 h_p \] [kN/m²]

\[ p = 10 (h_s + 1) \] [kN/m²]

where,

\( h_p = \) vertical distance [m], from the load point to the top of air pipe.

\( h_s = \) vertical distance [m], from the load point to top of the tank.

3.3 Inner bottom

3.3.1 The design pressure ‘p’ on the inner bottom is to be taken as the greater of that given in 3.2.1 and the following:

In way of cargo holds, the design pressure ‘p’ is not to be taken as less than:

\[ p = 12.5 \rho H \] [kN/m²]

where,

\( \rho = \) cargo density [t/m³] normally not to be taken as less than 0.7 [t/m³]

\( H = \) height [m], to deck or top of hatchway coaming.
Section 4

Bottom and Inner Bottom Plating

4.1 Keel plate
4.1.1 The width of the plate keel is not to be less than \((400+10L) \text{ [mm]}\). The thickness is to be 1 [mm] greater than that required for the adjacent bottom plating.

4.2 Bottom, bilge and inner bottom plating
4.2.1 The thickness of the bottom and inner bottom plating is to be not less than:
   - for bottom plating
     \[ t = (t_0 + 0.04L) \sqrt{k} + t_c \text{ [mm]} \]
   - for inner bottom plating
     \[ t = (t_0 + 0.03L) \sqrt{k} + t_c \text{ [mm]} \]
   but not less than 6.0 [mm]

   where,
   \[ t_0 = 4.0 \text{ [mm]}, \text{ in general.} \]

   = 6.0 [mm], for inner bottom plating where ceiling is not fitted.
   = 4.0 [mm] for inner bottom plating where wooden ceiling of 50 [mm] thickness is fitted.

4.2.2 The bottom, bilge and innerbottom plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.2.3 For ships discharged by grabs and where no ceiling is fitted, the plating thickness 't' of the inner bottom and exposed parts of sloping bulkheads is not to be less than:

   \[ t = 0.0085 (s + 800) \sqrt{k} + t_c \text{ [mm]} \]

4.2.5 Where the inner bottom is subjected to wheel loads from cargo handling vehicles, the scantlings are also to comply with the requirements given in Ch.8, Sec.6.

Section 5

Single Bottom

5.1 Transverse framing
5.1.1 Plate floors of following scantlings are to be fitted at every frame

   depth at centreline \( d = 40B \text{ [mm]} \) in general
   thickness of web, \( t = d/100 + 2.5 \text{ [mm]} \)

   Section modulus
   \[ Z = 0.006 s.l_i^2 \cdot T_1 \text{ [cm}^3\text{]} \text{ in cargo holds} \]
   \[ = 0.0072 s.l_i^2 \cdot T_1 \text{ [cm}^3\text{]} \text{ in machinery and other spaces} \]

   where,
   \[ l_i = \text{span of floor, measured on the top of floor plate from side to side} \]
   \[ = \text{longitudinal bulkheads are provided the span,} l_i \text{ not to be taken less than 0.4B.} \]

   \( T_1 \) is as defined in 3.1.1.

   The thickness of face plate is not to be less than 1/15 of the face width.

   The top of floors, in general, is to be level from side to side. However, in ships having considerable rise of floor, the depth of web at 10 per cent of the span from ends, is not to be less than half the depth at centreline.

   If the height of floors between engine girders is reduced in way of crankcase, the face plate area is to be suitably increased, however the reduced height is normally not to be less than 2/3 of 'd' as given above.

5.1.2 On all ships one centre girder is to be fitted and in addition side girders are to be fitted such that the spacing of girders does not exceed 3.0 [m]. The girders are to extend as far forward and aft as practicable and where they are cut at
transverse bulkheads the longitudinal continuity is to be maintained. Where the bottom structure changes into a double bottom structure, the bottom girders are to extend at least 3 frame spaces into double bottom structures.

The scantlings of the centre girders and side girders are to be not less than that of the floors.

The thickness of face plates is not to be less than 1/15 of the face width.

5.1.3 In the after peak of single screw ships, the height of the floors is to be increased such that their upper edge is well above the stern tube.

5.1.4 Where single bottom in the cargo region is stiffened by transverse frames supported by longitudinal girders, the scantlings of the frames and longitudinal girders are to be determined in accordance with 6.2.3 and 5.2.3, 5.2.4 respectively.

5.2 Longitudinal framing

5.2.1 The spacing of bottom transverses is normally not to exceed 3.0 [m]. The bottom transverses are to be supported by primary girders or longitudinal bulkheads. Where the design does not incorporate a centreline bulkhead, at least a docking girder is to be provided. The scantlings of simple girders and transverses are to be obtained in accordance with 5.2.3. The scantlings of a complex girder system are to be based on a direct stress analysis.

5.2.2 The section modulus 'Z' of the bottom longitudinals is not to be less than:

\[ Z = \frac{s p l^2}{12 \sigma} + Z_c [cm^3] \]

where,

\[ p = \text{applicable design pressure [kN/m}^2\text{]}, \text{as given in 3.1.1.} \]

\[ \sigma = \frac{(215 - 140 f_0)}{k}, \text{max.160/k [N/mm}^2\text{]} \]

\[ \text{within 0.4L amidships} \]

\[ = 160/k \text{[N/mm}^2\text{]} \text{within 0.1L from ends.} \]

Elsewhere \( \sigma \) may be obtained by linear interpolation.

5.2.3 The section modulus 'Z' of bottom girders is not to be less than:

\[ Z = \frac{10^3 b p S^2}{m \sigma} + Z_c [cm^3] \]

where,

\[ m = 10 \text{ in general} \]

\[ p = \text{applicable design pressure [kN/m}^2\text{]}, \text{as given in 3.1.1.} \]

\[ \sigma = \frac{(190 - 130 f_0)}{k}, \text{max160/k [N/mm}^2\text{]} \]

\[ \text{for continuous longitudinal girders within 0.4L amidships.} \]

\[ = 160/k \text{[N/mm}^2\text{]} \text{for longitudinal girder within 0.1L from ends and for transverse girders in general.} \]

Elsewhere \( \sigma \) may be obtained by linear interpolation.

5.2.4 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

Section 6

Double Bottom

6.1 General

6.1.1 Where double bottom spaces are used as tanks, the centre girder is to be watertight unless the double bottom is divided by watertight side girders or the tanks are narrow.

The depth 'd' of the centre girder is not to be less than:

\[ d = 250 + 20B + 50T [mm], \text{with a minimum of 650 [mm].} \]

In case of ships with considerable rise of floors the depth 'd' may have to be increased.

6.1.2 The thickness 't' of the bottom girders and floors is not to be less than

\[ t = (0.007d + 3) \sqrt{k} [mm]. \]
6.1.3 The section modulus 'Z' of the stiffeners on girders and floors forming boundaries of double bottom tanks is not to be less than:

\[ Z = \frac{sp^2}{10\sigma} + Z_c \text{ [cm}^3\text{]} \]

where,

\[ p = \text{design pressure [kN/m}^2\text{], as given in 3.2.1;} \]

\[ \sigma = (210 - 130f_B)/k, \text{ max. } 160/k \text{ [N/mm}^2\text{]} \]

for longitudinal stiffeners within 0.4L amidships

\[ = 160/k \text{ [N/mm}^2\text{]} \]

for longitudinal stiffeners within 0.1L from ends and for transverse or vertical stiffeners in general.

Between the regions specified above \( \sigma \) for longitudinal stiffeners may be obtained by linear interpolation.

Longitudinal stiffeners are to have end connections, other stiffeners may be sniped at ends provided the section modulus \( Z \) is increased by 40 per cent.

6.1.4 The longitudinal girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6.

6.2 Transverse framing

6.2.1 The side girders are normally to be fitted at a spacing not exceeding 4.0 [m] and are to be extended as far forward and aft as practicable. The girders are to be stiffened at every bracket floor by a vertical stiffener of depth same as that of reverse frame and thickness of the girder.

6.2.2 Plate floors are to be fitted under bulkheads, pillars, thrust seating, boiler bearers and in way of change of depth of double bottom. In engine room, plate floors are to be fitted at every frame. Elsewhere plate floors are to be fitted at least every fifth frame, the spacing not exceeding 3.0 [m].

6.2.3 Where bracket floors are fitted the section modulus 'Z' of the bottom frames and reverse frames is not to be less than:

\[ Z = \frac{sp^2k}{1.6} \times 10^{-3} + Z_c \text{ [cm}^3\text{]} \]

where,

\( p = \text{applicable design pressure [kN/m}^2\text{], as given in 3.1.1 and 3.3.1 for bottom frames and reverse frames respectively.} \)

\( I = \text{span of frames [m] measured between girder or brackets.} \)

Where vertical struts according to 6.2.4 are fitted, the section modulus of bottom and reverse frames may be reduced by 35 per cent.

6.2.4 The cross sectional area 'A' of the struts is not to be less than

\[ A = c \cdot k \cdot l \cdot s \cdot T \text{ [cm}^2\text{]} \]

where,

\( c = 7 \times 10^{-4} \text{ in way of ballast tanks} \)

\( = 6 \times 10^{-4} \text{ elsewhere} \)

\( l = \text{actual span [m], without considering the strut.} \)

The moment of inertia \( I \) of the struts is not to be less than:

\[ I = 2.5 A \cdot d^2 \times 10^{-6} \text{ [cm}^4\text{]} \]

where,

\( d = \text{depth of double bottom, [mm]}. \)

6.2.5 The bottom frames and reverse frames are to be attached to the centre girder and margin plate by means of brackets of same thickness as that of the plate floors. The breadth of the brackets is not to be less than 0.75 times the depth of the centre girder and the brackets are to be flanged 75 [mm] at their free edges.

6.3 Longitudinal framing

6.3.1 The side girders are normally to be fitted at a spacing not exceeding 5.0 [m] and are to be extended as far forward and aft as practicable.

6.3.2 The plate floors are to be fitted under bulkheads, pillars, thrust seating and boiler bearers. In engine room, plate floors are to be fitted at every second side frames. Additionally, under the main engine seatings, floors extending to the first side girder outside the engine seating, are to be fitted at intermediate frames. The spacing of floors is normally not to exceed 3.0 [m].

6.3.3 The plate floors are to be stiffened at every longitudinal by a vertical stiffener of depth same as that of the inner bottom longitudinal and thickness as that of the floor. Between plate floors, transverse brackets are to be fitted at
every frame at the margin plate and at a spacing not exceeding 1.25 [m] on either side of the centre girder. The thickness of brackets is to be same as that of the plate floors. The brackets are to extend up to the adjacent longitudinal and are to be flanged 75 [mm] at their free edges.

6.3.4 The section modulus \( Z \) of the bottom and inner bottom longitudinals is not to be less than:

\[
Z = \frac{sp^2}{12\sigma} + Z_c \quad [\text{cm}^3]
\]

where,

\[ p = \text{applicable design pressure} \quad [\text{kN/m}^2], \text{as given in 3.1.1 and 3.3.1 for bottom longitudinals and inner bottom longitudinals respectively;} \]

\[ \sigma = \frac{(210 - 140 f_B)}{k} \quad [\text{N/mm}^2], \text{maximum 160}/k \quad [\text{N/mm}^2] \text{ for bottom longitudinals within 0.4L amidships} \]

\[ = \frac{(210 - 100 f_B)}{k} \quad [\text{N/mm}^2], \text{maximum 160}/k \quad [\text{N/mm}^2] \text{ for inner bottom longitudinals within 0.4L amidships} \]

\[ \sigma = 160/k \quad [\text{N/mm}^2] \text{ within 0.1L from ends.} \]

Between the regions specified above, \( s \) may be obtained by linear interpolation.

Where vertical struts according to 6.2.4 are fitted, the section modulus of the bottom and inner bottom longitudinals may be reduced by 35 per cent.

Section 7

Engine Seatings

7.1 General

7.1.1 It is recommended that the depth of the floors or double bottom in way of engine foundations be increased.

7.1.2 Sufficient fore and aft girders are to be arranged in way of the main machinery to effectively distribute its weight and to ensure adequate rigidity of the structure. The girders are generally to extend over the full length of the engine room and are to be suitably scarphed into the bottom structure beyond.

7.1.3 The scantlings of engine seatings are to be adequate to resist gravitational, thrust, torque, dynamic and vibratory forces which may be imposed on them. The recommendations given by the engine manufacturer are also to be taken into account.

7.1.4 Where the top plate of the engine seating is situated above the floors or the inner bottom, adequate transverse strength by means of brackets in line with the floors is to be ensured. In way of the recess for crankcase, brackets as large as practicable are to be fitted.

7.1.5 Lightening holes in engine foundations are to be kept as small as practicable and the edges are to be suitably reinforced.

7.2 Recommended scantlings

7.2.1 For engines of power less than 1500 kW and RPM greater than 1200, the scantlings of engine girder face plate, web and floors in way of engine seatings may be calculated as given below. Scantlings for other engines will be specially considered.

Top plate area; \( A = 20 + 120 \left( \frac{P}{R} \right) \quad [\text{cm}^2] \)

Thickness of top plate; \( t_p = 0.1A + 14 \quad [\text{mm}] \)

Girder web thickness; \( t_g = 0.043A + 7 \quad [\text{mm}] \)

Floor web thickness; \( t_f = 0.02A + 6 \quad [\text{mm}] \)

where,

\[ P = \text{maximum power of the engine} \quad [\text{kW}] \]

\[ R = \text{rpm of engine at maximum power} \]

End Of Chapter
Chapter 7
Side Structure

Contents

Section
1 General
2 Structural Arrangement and Details
3 Design Loads
4 Side Shell Plating and Stiffeners
5 Girders

Section 1
General

1.1 Scope

1.1.1 The scantlings and arrangement of side structure as defined in Ch.1, Sec.2 and also those of sides of the superstructures are to comply with the requirements of this Chapter.

1.2 Symbols

L, B, T, Cb, k as defined in Ch.1, Sec.2.

s = spacing of stiffeners, [mm].

l = span of stiffeners, [m].

b = spacing of girders, [m].

S = span of girders, [m].

tc, Zc = corrosion additions to thickness and section modulus respectively, as given in Ch.3, Sec.2.1

\[ f_D = \frac{Z_R}{Z_D} \]

\[ f_B = \frac{Z_R}{Z_B} \]

fs = fD for side shell area above neutral axis

= fB for side shell area below neutral axis

where,

ZR = Rule midship section modulus [cm3] as required by Ch.4.

ZD, ZB = Actual midship section moduli [cm3] provided at deck and bottom respectively.

Section 2
Structural Arrangement and Details

2.1 General

2.1.1 The ship's side shell may be stiffened longitudinally or vertically.

2.1.2 Where the side shell is stiffened longitudinally, the continuity of the side longitudinals within a distance of 0.15D from bottom or from strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1. The web frames are to be fitted in line with the bottom transverses or plate floors.

2.1.3 The position, shape and reinforcement of sea inlets or other openings in side shell are to be in accordance with the requirements of Ch.4.

2.1.4 In the case of superstructures exceeding 0.15L in length and ending within 0.5L amidships, the side plating of the
Indian Register of Shipping

superstructures is to be increased by 25 per cent in way of the break.

2.1.5 The thickness of the shell plating is to be increased locally by 50 per cent in way of sternframe, propeller brackets and rudder horn. For reinforcements in way of anchor pockets, hawse pipes etc. refer to Ch.13.

2.1.6 The weld connections are to comply with the requirements of Ch.14.

2.2 Sheer strake

2.2.1 The thickness of sheer strake as obtained from 4.1.1 is to be increased by 30 per cent on each side of a superstructure end bulkhead located within 0.5L amidships if the superstructure deck is a partial strength deck.

2.2.2 Where a rounded sheer strake is adopted, the radius in general, is not to be less than 15 times the plate thickness.

2.2.3 Bulwarks are generally not to be welded to the top of the sheer strake within 0.6L amidships.

2.2.4 Where the sheer strake extends above the deck stringer plate, the top edge of the sheer strake is to be kept free from notches and drainage openings if any, are to have smooth transition in the longitudinal direction.

Section 3

Design Loads

3.1 External pressure

3.1.1 The design pressure 'p' on side shell is to be taken as per Table 3.1.1.

3.2 Internal tank pressure

3.2.1 Where the side shell forms a boundary of a tank, the design pressure 'p' is to be taken as the greater of external pressure given by 3.1.1 and the internal tank pressure 'pi' given by 3.2.2.

3.2.2 The internal tank pressure 'pi' is to be taken as the greater of:

\[ p_i = 10 (h_s + 1) \text{[kN/m}^2] \], or
\[ p_i = 6.7 h_o \text{[kN/m}^2] \]

Table 3.1.1

<table>
<thead>
<tr>
<th>Zone</th>
<th>Design pressure 'p' pkN/m(^2) (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For load points below the max. load waterline</td>
</tr>
<tr>
<td>1</td>
<td>(10 h_o + \left(15 - 5 \frac{h_o}{T}\right))</td>
</tr>
<tr>
<td></td>
<td>(10 h_o + \left(9 - 3 \frac{h_o}{T}\right))</td>
</tr>
<tr>
<td>2</td>
<td>(10 h_o + \left(9 - 3 \frac{h_o}{T}\right))</td>
</tr>
<tr>
<td>3</td>
<td>(10 h_o + \left(5 - 2 \frac{h_o}{T}\right))</td>
</tr>
</tbody>
</table>

a) 'p' is not to be taken as less than 5 [kN/m\(^2\)]

b) For intermediate lengths (L) in Zone 1, the value of 'p' is to be linearly interpolated

\( h_o = \text{vertical distance [m], from the maximum load waterline to the loadpoint.} \)
where,

\[ h_s = \text{The vertical distance [m] from the load point to the top of tank} \]

\[ h_p = \text{vertical distance [m], from the load point to the top of air pipe.} \]

For very large tanks which may be partially filled, sloshing pressures may have to be considered.

### Section 4

**Side Shell Plating and Stiffeners**

#### 4.1 Side shell plating

4.1.1 The thickness 't' of side shell is not to be less than:

\[ t = (4 + 0.04L) \sqrt{k + t_c} \text{ [mm]} \]

4.1.2 The side shell plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.1.3 The breadth of the sheer strake is not to be less than 100 D [mm].

Where the thickness of the strength deck plating is greater than that required for side plating, the sheer strake thickness is not to be less than the mean of the two values.

#### 4.2 Side shell longitudinals

4.2.1 The section modulus 'Z' of side longitudinals is not to be less than:

\[ Z = \frac{sp l^2}{12\sigma} + Z_e \text{ [cm}^3]\]

where,

\[ p = \text{applicable design pressure at midpoint of the span [kN/m²].} \]

\[ \sigma = \frac{(215 - 145 f_S)}{k}, \text{maximum 160/k [N/mm²] for side longitudinals at deck/bottom level within } 0.4L \text{ amidships.} \]

\[ = 160/k \text{ [N/mm²] at neutral axis within } 0.4L \text{ amidships} \]

\[ = 160/k \text{ [N/mm²] within } 0.1L \text{ from ends and at the level of short superstructure decks.} \]

Between the regions specified above \( \sigma \) may be obtained by linear interpolation.

#### 4.3 Main frames

4.3.1 The section modulus 'Z' of the main frames bracketed at both ends as per 4.3.2 is not to be less than:

\[ Z = \frac{sp l^2}{2400} + Z_e \text{ [cm}^3] \text{ and} \]

\[ = 5.5 \sqrt{(L.k)} \text{ [cm}^3] \]

where,

\[ p = \text{applicable design pressure at midpoint of the span or mean of the pressures at two ends, whichever is greater, [kN/m²].} \]

4.3.2 Main frame brackets are to be as follows:

- length of the bracket :
  - for upper bracket : 70 l [mm]
  - for lower bracket : 120 l [mm]

- section modulus at end (including bracket) :
  - for upper bracket : 1.7 Z [cm³]
  - for lower bracket : 2.0 Z [cm³]

where,

\[ Z = \text{section modulus of main frame as given in 4.3.1} \]
Where the free edge of the bracket exceeds 40 times the bracket thickness, the brackets are to be flanged. The flange width is to be at least 1/15 of the length of the free edge.

4.3.3 Brackets at ends of the main frame may be omitted provided the frame is carried through the supporting members and the section modulus obtained as per 4.3.1 is increased by 75 per cent.

4.4 Superstructure frames

4.4.1 Superstructure frames located between the collision bulkhead and the after peak bulkhead are to have section modulus 'Z' not less than:

\[ Z = 0.005 \, s \, l^2 \, k \, [\text{cm}^3] \]

4.4.2 The lower end of the superstructure frame is to be connected to the bracket or frame below or else it is to be bracketed above the deck. The upper end is to be bracketed to the deck beam or longitudinal.

4.5 Peak frames

4.5.1 Vertical peak frames forward of the collision bulkhead and aft of the after peak bulkhead are to have section modulus 'Z' not less than:

\[ Z = \frac{sp1^2 \, k \, + \, Z_c \, [\text{cm}^3]}{1600} \]

\[ = 5.5 \sqrt{(L \, k)} \, [\text{cm}^3] \]

where,

\[ p = \text{applicable design pressure} \, [\text{kN/m}^2], \text{as given in Sec.3.} \]

4.5.2 Peak frames are to be bracketed at top and bottom and in way of side stringers, the connection is to provide adequate shear strength.

Section 5

Girders

5.1 General

5.1.1 Web frames are to be fitted in way of hatch end beams and deck transverses.

5.1.2 In the engine room, web frames are to be fitted at the forward and aft end of the engine and every 5th frame in general. The section modulus 'Z' of the web frames and side stringers is to be obtained as per 5.1.5 taking 'b' as the mean of the web frame or stringer spacings respectively, on either side. The depth of the webs and stringers are not to be less than 2.5 times the depth of the ordinary frames.

Adequate deep beams are to be provided in line with the web frames.

5.1.3 In peak spaces, side stringers supporting vertical peak frames are normally to be fitted at every 2.6 [m]. The section modulus 'Z' of the stringers is to be obtained as per Sec.5.1.5. The stringers are to be supported by web frames.

5.1.4 The scantlings of simple girders and web frames supporting frames and longitudinals are to be in accordance with 5.1.5. The scantlings of webs supporting fully effective side stringers are to be based on point loadings and 'σ' values given in 5.1.5. The scantlings of the complex girder system are to be based on a direct stress analysis. The buckling strength of the cross ties, where fitted, is to comply with the requirements given in Ch.3, Sec.6.

5.1.5 The section modulus 'Z' of simple girders and web frames is not to be less than:

\[ Z = \frac{bpS^2 \cdot 10^3}{m \sigma} \, + \, Z_c \, [\text{cm}^3] \]

where,

\[ p = \text{applicable design pressure} \, [\text{kN/m}^2], \text{as given in Sec 3.} \]

\[ m = 12 \text{ for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.} \]

\[ = 10 \text{ for other girders with end attachments in accordance with Ch.3, Sec.5.} \]

\[ \sigma = (190 - 45 \, f_s)/k, \text{max 160}/k \, [\text{N/mm}^2], \text{for continuous longitudinal girders within 0.4L amidships.} \]
Indian Register of Shipping

= $160/k \, [N/mm^2]$ for longitudinal girders within 0.1L from ends and for web frames in general.

Between the regions specified above, $s$ may be obtained by linear interpolation.

5.1.6 The net cross sectional area 'A' of the girder web at ends is not to be less than

$$A = 0.06 \, S_{bpk} + 0.01 \, h \, t_c \, [cm^2]$$

for stringers and upper ends of the web frames.

$$= 0.08 \, S_{bpk} + 0.01 \, h \, t_c \, [cm^2]$$

for lower ends of the web frames.

where,

$h =$ girder height [mm].

5.1.7 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

End Of Chapter
Chapter 8
Deck Structure

Contents

Section
1 General
2 Structural Arrangement and Details
3 Design Loads
4 Deck Plating and Stiffeners
5 Deck Girders and Pillars
6 Decks for Wheel Loading

Section 1
General

1.1 Scope

1.1.1 The scantlings and arrangement of deck structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

1.2 Symbols

$L, B, T, C_b, k$ as defined in Ch.1, Sec.2.

$s = \text{spacing of stiffeners, [mm].}$

$l = \text{span of stiffeners, [m].}$

$b = \text{spacing of girders, [m].}$

$S = \text{span of girders, [m].}$

$t_c, Z_c = \text{corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1.}$

$f_D = \frac{Z_R}{Z_D}$

where,

$Z_R = \text{Rule midship section modulus [cm}^3\text{], as required by Ch.4.}$

$Z_D = \text{actual midship section modulus [cm}^3\text{], provided at deck calculated as per Ch.4.}$

Section 2
Structural Arrangement and Details

2.1 General

2.1.1 In tankers, the deck is normally to be stiffened longitudinally in the cargo tank region, however, where $L$ does not exceed 75 [m], consideration may be given to transversely stiffened decks.

2.1.2 The continuity of the deck longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.3 The deck within the line of hatchway openings is preferably to be stiffened transversely or alternatively the arrangements are to provide adequate transverse buckling strength. Where the deck outside the line of hatchway openings is framed longitudinally, the transverse beams or buckling stiffeners between the hatchways are to extend at least up to the second longitudinal from the hatch side or equivalent.

2.1.4 In ships with large hatch openings, the effective cross-sectional area of the deck
between the hatchways is to be sufficient to withstand the transverse load acting on the ship’s sides.

2.1.5 The weld connections are to comply with the requirements of Ch.14.

2.1.6 Hatchway corners are to be of streamlined, elliptical or circular shape as given in Ch.4. Where shapes other than the streamlined shape or equivalent are adopted, insert plates are to be fitted at the hatch corners in strength deck. The insert plates are to be 25 per cent thicker than the deck plating outside the line of hatchways and are to extend as shown in Fig.2.1.6. The butts of insert plates are to be well clear of those in coaming.

### Section 3

**Design Loads**

#### 3.1 Weather deck

3.1.1 The design pressure ‘p’ on exposed decks is to be taken as:

\[
p = H_1 - 10 h_o \text{ [kN/m}^2\text{]}, \text{ minimum 5 [kN/m}^2\text{]} \]

where,

- \(h_o\) = vertical distance [m], from the maximum load waterline to the deck.
- \(H_1\) = as given in Table 3.1.1.

<table>
<thead>
<tr>
<th>Zone</th>
<th>(H_1)</th>
</tr>
</thead>
</table>
| 1    | 9 for \(L \leq 20\) [m] 
      | \(9 + 0.15\) (L-20) for \(20 < L \leq 60\) 
      | 15 for \(L \geq 60\) [m] |
| 2    | 9       |
| 3    | 5       |

3.1.2 For decks subjected to cargo loading the design pressure is to be taken as:

\[
p = 12.5 q \text{ [kN/m}^2\text{]} \]

where ‘q’ is deck cargo loading [t/m²].

3.1.3 For weather decks forming crowns of tanks, the design pressure ‘p’ is to be taken as the greater of that given by 3.1.1 and 3.3.1.

#### 3.2 Accommodation decks

3.2.1 The design pressure ‘p’ on accommodation decks is to be taken as:

\[
p = 4.5 \text{ [kN/m}^2\text{]} \]

3.2.2 For decks forming crowns of tanks the design pressure ‘p’ is to be taken as the greater of that given by 3.2.1 and 3.3.1.

#### 3.3 Decks forming tank boundaries

3.3.1 The design pressure ‘p’ for decks forming the bottom or crown of a tank may be taken as the greater of the following:

\[
p = 6.7 h_p \text{ [kN/m}^2\text{]} \text{ or } 10 (h_s + 1) \text{ [kN/m}^2\text{]} \]

where,

- \(h_p\) = vertical distance [m], from the deck to the top of air pipe
- \(h_s\) = vertical distance [m], from the deck to the top of the tank.
Section 4

Deck Platings and Stiffeners

4.1 Deck platings

4.1.1 The thickness of the strength deck plating outside the line of hatchway openings is to be adequate to give the necessary hull section modulus and moment of inertia required by Ch.4.

4.1.2 The thickness 't' of deck platings is not to be less than:

\[ t = (t_o + 0.02L) \sqrt{k + t_c} \text{[mm]} \]

where,

- \( t_o = 5 \) for strength decks and forecastle decks
- \( t_o = 4.0 \) for other decks.

4.1.3 The strength deck plating outside the line of hatchways is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.1.4 In way of ends of bridges, poops and forecastles, the thickness of the strength deck stringer strake is to be increased by 20 per cent over four frame spaces fore and also aft of the end bulkheads.

4.2 Deck stiffeners

4.2.1 The section modulus 'Z' of deck longitudinals is not to be less than:

\[ Z = \frac{sp^2}{12\sigma} + Z_c \text{[cm}^3\text{]} \]

where,

- \( p = \) applicable design pressure [kN/m²] as given in Sec.3.
- \( \sigma = (215 - 145f_Df_z)/k, \text{ max. } 160/k \text{[N/mm}^2\text{]} \) for strength deck and decks of long superstructures/deckhouses within 0.4L amidships.
- \( = (225 - 145f_Df_z)/k, \text{ max. } 160/k \text{[N/mm}^2\text{]} \) for continuous decks below strength deck within 0.4L amidships.
- \( = 160/k \text{[N/mm}^2\text{]} \) within 0.1L from ends and for short decks.

Elsewhere, \( \sigma \) may be obtained by linear interpolation.

The longitudinals are also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.2.2 The section modulus 'Z' of transverse beams is not to be less than:

\[ Z = \frac{sp^2}{1600} + Z_c \text{[cm}^3\text{]} \]

where,

- \( p = \) applicable design pressure [kN/m²] as given in Sec.3.

Section 5

Deck Girders and Pillars

5.1 Girders

5.1.1 Deck girders and transverses are to be arranged in line with vertical members of scantlings sufficient to provide adequate support.

5.1.2 The scantlings of simple girders and transverses are to be in accordance with 5.1.3.

The scantlings of a complex girder system are to be based on a direct stress analysis.

5.1.3 The section modulus 'Z' of deck girders is not to be less than:

\[ Z = \frac{bpS^2}{m\sigma} + Z_c \text{[cm}^3\text{]} \]
where,

\[ p = \text{applicable design pressure [kN/m}^2\text{]} \text{ as given in Sec.3.} \]

\[ m = 12 \text{ for continuous longitudinal girders with end attachments in accordance with Ch.3.} \]

\[ = 10 \text{ for other girders with end attachments in accordance with Ch.3.} \]

\[ \sigma = \frac{(190 - 145f_D)}{k}, \text{max.} \frac{160}{k} \text{[N/mm}^2\text{]} \text{ for continuous longitudinal girders within 0.4L amidships.} \]

\[ = \frac{160}{k} \text{[N/mm}^2\text{]} \text{ for longitudinal girders within 0.1L from ends and for transverse girders in general.} \]

Elsewhere, \( \sigma \) may be obtained by linear interpolation.

5.1.4 The net cross sectional area 'A' of the girder web at ends is not to be less than:

\[ A = 0.07 \cdot S.b.p.k + 0.01h \cdot t_c \text{ [cm}^2\text{]} \]

where,

\[ h = \text{girder height [mm].} \]

5.1.5 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

5.2 Cantilevers

5.2.1 The scantlings of cantilever beams and supporting frames will be specially considered.

5.3 Pillars

5.3.1 The scantlings of the pillars are to be in accordance with the requirements of Ch.3, Sec.6. Axial load, if any, from pillars above is to be added to the load from deck girders.

The minimum wall thickness 't' [mm], of the tubular pillars is not to be less than:

\[ t = 4.5 + 0.015d \text{ for } d < 300 \text{ [mm]} \]

\[ = 0.03d \text{ for } d \geq 300 \text{ [mm]} \]

where,

\[ d = \text{diameter of the pillar [mm].} \]

5.3.2 Pillars are to be fitted in the same vertical line wherever possible, and arrangements are to be made to effectively distribute the load at the heads and heels. Where pillars support eccentric loads, they are to be strengthened for the additional bending moments imposed upon them. Doubling or insert plates are generally to be fitted at the head and heel of hollow pillars.

5.3.3 The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding.

5.3.4 Where the heels of hold pillars are not directly above the intersection of plate floors and girders, partial floors and intercostal girders are to be fitted as necessary to support the pillars. Lightening holes or manholes are not to be cut in the floors and girders below the heels of pillars.

5.3.5 Inside tanks, hollow pillars are not to be used and strengthening at the heads and heels of pillars is not to be obtained by means of doubling plates. Where hydrostatic pressure may give rise to tensile stresses in the pillars, their sectional area 'A' is not to be less than

\[ A = 0.07 \cdot A_L \cdot p \text{ [cm}^2\text{]} \]

where,

\[ p = \text{design pressure as given in Sec.3, causing the tensile stress in pillar} \]

\[ A_L = \text{load area of deck [m}^2\text{], being supported by the pillar.} \]
Section 6

Decks for Wheel Loading

6.1 General

6.1.1 Where it is proposed either to stow wheeled vehicles on the deck or to use wheeled vehicles for cargo handling, the requirements of this section are to be complied with in addition to those given in the preceding sections.

6.1.2 The requirements given below are based on the assumption that the considered element (Deck plating and/or stiffener) is subjected to one load area only, and that the element is continuous over several evenly spaced supports. The requirements for other loads and/or boundary conditions will be specially considered.

A "load area" is the tyre print area of individual wheels; for closely spaced wheels it may be taken as the enveloped area of the wheel group.

6.1.3 The details of wheel loadings are to be forwarded by the shipbuilder. These details are to include the proposed arrangement and dimensions of tyre prints, axle and wheel spacings, maximum axle load and tyre pressure.

6.2 Wheel loads

6.2.1 The pressure 'p' from the wheels on deck is to be taken as:

\[
p = \frac{12.5 \times 10^6 W}{n \cdot a \cdot b} \text{ [kN/m}^2\text{]} \]

- for stowed vehicles in sailing condition; and

\[
p = \frac{W}{n \cdot a \cdot b} \left( 9.81 + \frac{3}{\sqrt{W}} \right) 10^6 \text{ [kN/m}^2\text{]} \]

- for cargo handling vehicles in harbour condition

where,

W = maximum axle load, [t]. For fork lift trucks, the total weight is to be taken as the axle load.

n = number of "load areas" per axle

a = extent [mm], of the load area parallel to the stiffener (see Fig. 6.2.1)

b = extent [mm], of the load area perpendicular to the stiffener (see Fig.6.2.1)

6.3 Deck plating

6.3.1 The thickness 't' of deck plating subjected to wheel loadings is not to be less than:

\[
t = c_1 f_s \sqrt{\frac{c_b s p k.10^{-3}}{m}} + t_c \text{ [mm]} \]

where,

\[
f_s = (1.1 - 0.25 s/l) \text{ for } s \leq l, \text{ however need not be taken as greater than } 1.0
\]

a,b,s,l = deck panel dimensions [mm] (see Fig.6.2.1)

\[
c_1 = 0.137 \text{ in general for sailing conditions}
\]

= 0.127 in general for harbour conditions

= As per Table 6.3.1 for upper deck within 0.4L amidships.

Table 6.3.1 : c₁ values for upper deck plating within 0.4L amidships

<table>
<thead>
<tr>
<th>Framing system</th>
<th>Sailing conditions</th>
<th>Harbour conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>0.145</td>
<td>0.130</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.180</td>
<td>0.145</td>
</tr>
</tbody>
</table>

For upper deck plating between 0.4L amidships and 0.1L from ends, c₁ is to be varied linearly.
\[ c_2 = 1.3 - \frac{4.2}{(a/s + 1.8)^2}, \]

however, need not be taken as greater than 1.0

\[ m = \frac{38}{(b/s)^2 - 4.7(b/s) + 6.5} \quad \text{for } b \leq s \]

### 6.4 Deck stiffeners

6.4.1 The section modulus 'Z' of deck beams and longitudinals subjected to wheel loadings is not to be less than:

\[ Z = \frac{c_3 \cdot a \cdot b \cdot l \cdot p}{m \sigma} \cdot 10^{-6} + Z_c \quad [\text{cm}^3] \]

where,

\[ c_3 = (1.15 - 0.25 \cdot b/s) \quad \text{for } b \leq s, \text{ however need not be taken as greater than } 1.0 \]

\[ m = \frac{r}{(a/l)^2 - 4.7a/l + 6.5} \]

\[ r = 29 \quad \text{for continuous stiffeners supported at girders} \]

= 38 when the continuous stiffeners can be considered as rigidly supported at girders against rotation.

\[ \sigma = \frac{160}{k} \quad [\text{N/mm}^2] \quad \text{in general, for sailing conditions} \]

\[ \sigma = \frac{180}{k} \quad [\text{N/mm}^2] \quad \text{in general, for harbour conditions} \]

= As per Table 6.4.1 for deck longitudinals within 0.4L amidships, but not exceeding the above general values.

For deck longitudinals between 0.4L amidships and 0.1L from ends, \( \sigma \) is to be varied linearly.

<table>
<thead>
<tr>
<th>Condition</th>
<th>([\text{N/mm}^2])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sailing</td>
<td>((215 - 145f_{o.d.f_{z}})/k)</td>
</tr>
<tr>
<td>Harbour</td>
<td>((225 - 90f_{o.d.f_{z}})/k)</td>
</tr>
</tbody>
</table>

### 6.5 Deck girders

6.5.1 The scantlings of girders will be specially considered based on the most severe condition of moving or stowed vehicles. Also see Sec.6.1.3.

**End Of Chapter**
Chapter 9

Bulkheads

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
</tr>
<tr>
<td>2</td>
<td>Subdivision and Arrangement</td>
</tr>
<tr>
<td>3</td>
<td>Structural Arrangement and Details</td>
</tr>
<tr>
<td>4</td>
<td>Design Loads</td>
</tr>
<tr>
<td>5</td>
<td>Plating and Stiffeners</td>
</tr>
<tr>
<td>6</td>
<td>Girders</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Scope

1.1.1 The requirements of this chapter cover the arrangement and scantlings of watertight and deep tank bulkheads.

1.1.2 The requirements also cover the non-watertight bulkheads and shaft tunnels.

1.2 Statutory requirements

1.2.1 Where applicable, the number and disposition of bulkheads are to be arranged to meet the requirements for subdivision, floodability and damage stability in accordance with the requirements of the local or National Statutory Authority of the country in which the ship is registered.

1.3 Symbols

$S =$ span of girders [m]

$t_c, Z_c =$ corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1

$$f_d = \frac{Z_R}{Z_D}$$

where,

$Z_R =$ Rule midship section modulus [cm$^3$] as required by Ch.4.

$Z_D, Z =$ Actual midship section moduli in [cm$^3$] provided at deck and bottom respectively calculated as per Ch.4.

$s =$ spacing of stiffeners [mm]

$f_s =$ for side shell area above neutral axis

$l =$ span of stiffeners [m]

$f_s =$ for side shell area below neutral axis

$b =$ spacing of girders [m]
Section 2

Subdivision and Arrangement

2.1 Number of bulkheads

2.1.1 The following transverse watertight bulkheads are to be fitted in all ships:

- A collision bulkhead;
- An aftpeak bulkhead;
- A bulkhead at each end of the machinery space.

In ships with machinery aft, the aftpeak bulkhead may form the aft boundary of the machinery space.

Additional transverse watertight bulkheads are to be fitted to ensure adequate transverse strength.

2.1.2 The ordinary transverse watertight bulkheads in the holds should be spaced at reasonably uniform intervals. Where non-uniform spacing is unavoidable and the length of a hold is unusually large, the transverse strength of the ship is to be maintained by providing additional web frames, increased framing etc.

2.2 Position and height of bulkheads

2.2.1 The collision bulkhead is to be fitted at a distance of 0.04L to 0.1L from the F.P. Any recesses or steps in collision bulkheads are to fall within the limits.

2.2.2 Consideration will however be given to proposals for the collision bulkhead positioned aft of the limits given in 2.2.1, provided that the application is accompanied by calculations showing that with the ship fully loaded to maximum draught on even keel, flooding of space forward of the collision bulkhead will not result in any part of the main deck becoming submerged, nor result in any unacceptable loss of stability.

2.2.3 All ships are to have an after peak bulkhead generally enclosing the sterntube and rudder trunk in a watertight compartment. In twin screw ships where the bossing ends forward of the after peak bulkhead, the sterntubes are to be enclosed in suitable watertight spaces.

2.2.4 The watertight bulkheads are in general to extend to the uppermost continuous deck.

2.2.5 For passenger ships the number and position of the bulkheads will normally be governed by the requirements of trim and stability in damaged condition given in Pt.5, Ch.4.

2.3 Openings in watertight bulkheads and closing appliances

2.3.1 Doors, manholes, permanent access openings or ventilation ducts are not to be cut in the collision bulkhead below the uppermost continuous deck.

2.3.2 Openings may be accepted in other watertight bulkheads provided the number and the size of openings is kept to a minimum compatible with the design and proper working of the ship. Where penetrations of watertight bulkheads are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity. In way of openings, suitable reinforcements are to be provided to ensure that the strength is at least equal to that of the unpierced bulkhead.

2.4 Cofferdams

2.4.1 Cofferdams are to be provided between the following spaces to separate them from each other:

- tanks for fuel oil or lubricating oil
- tanks for edible oil
- tanks for fresh water and feed water.

2.4.2 Tanks for lubricating oil are also to be separated by cofferdams from those carrying fuel oil. However, these cofferdams need not be fitted provided that the common boundaries have full penetration welds and the head of oil is generally not in excess of that in the adjacent lubricating oil tanks.
Section 3

Structural Arrangement and Details

3.1 General

3.1.1 Oil fuel or oil carried as cargo in the deep tanks is to have a flash point of 60°C and above in closed cup test. Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the nature of the cargo.

3.1.2 The continuity of bulkhead longitudinals within a distance of 0.15D from the bottom or the strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1.

3.1.3 Carlings, girders or floors are to be fitted below the corrugated bulkheads at their supports. These supporting members are to be aligned to the face plate strips of the corrugations.

3.1.4 The weld connections are to comply with the requirements of Ch.16.

3.2 Wash bulkheads

3.2.1 A centreline wash bulkhead is to be fitted in peak spaces used as tanks, where the breadth of the tank exceeds 0.5B and also in deep tanks used for fuel oil extending from side to side.

3.2.2 The area of perforations is generally to be between 5% to 10% of the total area of bulkhead. The plating is to be suitably stiffened in way of the openings.

3.3 Supporting bulkheads

3.3.1 Bulkheads or parts thereof supporting deck structure are also to be designed as pillars. The permissible axial loads and buckling strength are to be calculated in accordance with Ch.3, Sec.6. In calculating sectional properties the width of attached plating is not to be taken in excess of 40 times the plate thickness. Also see Ch.8, Sec.5.1.1.

Section 4

Design Loads

4.1 Watertight bulkhead loads

4.1.1 The design pressure 'p', for ordinary watertight bulkheads is given by:

\[ p = 10h \] [kN/m²]

where,

\[ h = \text{the vertical distance [m] from the loadpoint to the uppermost continuous deck.} \]

4.1.2 For bulkheads bounding cargo spaces intended to carry dry bulk cargoes, the design pressure 'p' is to be taken as the higher of that given in 4.1.1 and the pressure due to bulk cargo as given below:

\[ p = 12.5 C \rho h_c \] [kN/m²]

where,

\[ C = \sin^2 \alpha \tan^2(45 - \delta/2) + \cos^2 \alpha \]

\[ \alpha = \text{angle made by the panel under consideration with the horizontal plane [deg.]} \]

\[ \delta = \text{angle of repose of cargo [deg.] not to be taken greater than the following} \]

- 20° for light bulk cargo (e.g. coal, grain)
- 25° for bulk cement cargo
- 35° for heavy bulk cargo (e.g. ore)

\[ h_c = \text{vertical distance [m], from the loadpoint to the mean horizontal plane corresponding to actual volume of cargo being considered} \]

\[ \rho = \text{density of cargo [t/m}^3\text{].} \]

For vessels designed to carry heavy bulk cargoes which are also required to carry lighter cargoes, the pressure 'p' based on maximum mass of cargo to be carried in the hold and filled up to the top of hatch coaming would also require to be considered.
Chapter 9
Part 3
Bulkheads

4.2 Tank bulkhead loads

4.2.1 The design pressure 'p' for tank bulkheads are normally to be taken as the greater of

\[ p = 12.5 h_s \text{ [kN/m}^2\text{]} \]
\[ = 6.7 h_p \text{ [kN/m}^2\text{]} \]
\[ = 10 (h_s + 1) \text{ [kN/m}^2\text{]} \]

where,

\( h_s \) = vertical distance [m] from the loadpoint to the top of the tank or hatchway.

\( h_p \) = vertical distance [m] from the loadpoint to the top of the air pipe.

For very large tanks which may be partially filled, sloshing pressures may have to be considered.

4.2.2 The pressure 'p' on girder web panels in cargo tanks or ballast tanks is not to be taken as less than 20 [kN/m²].

4.3 Wash bulkheads loads

4.3.1 The design pressure 'p' for wash bulkheads may be taken as 50% of that for boundary bulkhead in the same location.

Section 5

Plating and Stiffeners

5.1 Bulkhead plating

5.1.1 The thickness 't' of the bulkhead plating is not to be less than the minimum thickness given in 5.1.2 nor less than

\[ t = 15.8s \sqrt{p/\sigma} \times 10^{-3} + t_c \text{ [mm]} \]

where,

\( p \) = applicable design pressure as given in Sec.4.

\( \sigma \) = as per Table 5.1.1 for longitudinal bulkheads.

= 160/k for transverse tank bulkheads and collision bulkheads;

= 220/k for ordinary transverse watertight bulkheads.

= 190/k for transverse dry bulk cargo bulkheads

5.1.2 The minimum thickness requirement of the bulkhead plating is given by

\[ t = (4.0 + 0.01L) + t_c \text{ [mm]} \]

5.1.3 The plate thickness of corrugated bulkheads is not to be less than that required according to 5.1.1 and 5.1.2. The spacing 's' to be used in the calculation of the plating thickness is to be taken as the greater of 'b' or 'c' where 'b' and 'c' are indicated in Fig. 5.1.3.

For built up corrugation bulkheads, where the thickness of the flange and web are different, the thickness of the wider plating is also not to be less than:

<table>
<thead>
<tr>
<th>Region</th>
<th>Framing system</th>
<th>At neutral axis</th>
<th>At strength deck or at bottom</th>
<th>Between neutral axis and strength deck or bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4L amidships</td>
<td>Vertical</td>
<td>140/k</td>
<td>(175-130 f_s)/k max. 120/k</td>
<td>To be obtained by linear interpolation</td>
</tr>
<tr>
<td></td>
<td>Longitudinal</td>
<td>160/k</td>
<td>(185-105 f_s)/k max. 120/k</td>
<td>To be obtained by linear interpolation</td>
</tr>
<tr>
<td>Within 0.1L from ends</td>
<td>160/k</td>
<td>160/k</td>
<td>160/k</td>
<td></td>
</tr>
<tr>
<td>Elsewhere</td>
<td></td>
<td>to be obtained by linear interpolation between allowable values at regions specified above.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.1.4 The longitudinal bulkhead plating within 0.1D from bottom or strength deck is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

5.1.5 In way of stern tubes, doubling plate of same thickness as the corresponding strake is to be fitted, or the strake thickness is to be increased by at least 60 per cent.

5.2 Longitudinals

5.2.1 The section modulus of continuous longitudinal stiffeners and corrugations is not to be less than:

\[ Z = \frac{sp^2}{m\sigma} + Z_c \quad [cm^3] \]

where,

\( p = \text{applicable design pressure [kN/m2]} \) given in Sec.4.

\( m = 12 \)

\( \sigma = (215 - 145 f_s)/k, \max. 160/k \quad [N/mm^2] \) at deck/bottom level within 0.4L amidships

= 160/k at neutral axis within 0.4L amidships

= 160/k for longitudinals within 0.1L from ends.

For longitudinals between the regions specified above \( \sigma \) may be obtained by linear interpolation.

5.2.2 The thickness of the web and flange is not to be less than the minimum plating thickness requirements stipulated in 5.1.2.

5.2.3 The rule section modulus of a corrugated bulkhead element is to be obtained according to 5.2.1 taking ‘s’ as shown in Fig. 5.1.3.

5.2.4 The actual section modulus of a corrugated bulkhead element may be obtained in accordance with the following:

\[ Z_{actual} = \frac{td(b + c/3)}{2000} \quad [cm^3] \]

where, \( t,d,b \) and \( c \) [mm], are as shown in Fig. 5.1.3.

5.3 Vertical and transverse stiffeners on tank bulkheads, collision bulkheads, dry bulk cargo bulkheads and wash bulkheads

5.3.1 The section modulus of bulkhead stiffeners is not to be less than:

\[ Z = \frac{sp^2}{m\sigma} + Z_c \quad [cm^3] \]

where,

\( p = \text{applicable design pressure [kN/m2]} \) given in Sec.4.

\( m = 10 \) for transverse stiffeners and vertical stiffeners which may be considered fixed at both ends

= 7.5 for vertical stiffeners simply supported at one or both ends

= 10 for horizontal corrugation fixed at ends

= 13 for fixed upper end of vertical corrugation

= 20 for non-fixed upper end of vertical corrugation

= 10 for lower end of vertical corrugation

\( \sigma = 160/k \) for tank bulkhead and collision bulkhead

= 210/k for dry bulk cargo bulkheads.

5.3.2 The thickness of web and flange is to be as required in 5.1.2.

5.3.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.
5.3.4 Brackets are normally to be fitted at the ends of non-continuous stiffeners. Where stiffeners are snipped at the ends, the thickness of the plating supported by the stiffeners is not to be less than:

\[ t = 0.0395 \sqrt{[(l - 0.0005s) s.p.k] + tc} \ [\text{mm}] \]

5.4 Vertical and transverse stiffeners on ordinary watertight bulkheads

5.4.1 The section modulus of bulkhead stiffeners is not to be less than

\[ Z = \frac{sp1^2}{m\sigma} \]

where,

- \( p = \text{applicable design pressure given in Sec.4.} \)
- \( m = 16 \) for stiffeners fixed at both ends
- \( = 12 \) for stiffeners fixed at one end (lower end in case of vertical stiffeners) and simply supported at the other end.
- \( = 8 \) for stiffeners simply supported at both ends.
- \( \sigma = 220/k \)

5.4.2 The thickness of web and flange is to be as required in 5.1.2. For snipped ends, the thickness of bulkhead plating is to be as per 5.3.4.

5.4.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.

Section 6

Girders

6.1 General

6.1.1 Bulkhead stringers and deep transverses are to be arranged in line with other primary supporting structure to the adjoining deck, side shell and bottom so as to facilitate the formation of continuous ring structures. Otherwise equivalent scarphing arrangement is to be provided.

6.1.2 The section modulus requirement 'Z' of simple girders is not to be less than:

\[ Z = \frac{b.p.S^2 \times 10^3}{m\sigma} + Z_c \ [\text{cm}^3] \]

where,

- \( m = 12 \) for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.
- \( = 10 \) for other girders with end attachments in accordance with Ch.3, Sec.5.
- \( \sigma = (190 - 45fS), \max 160/k \ [\text{N/mm}^2], \) for continuous longitudinal girders within 0.4L amidships.
- \( = 160/k \ [\text{N/mm}^2], \) for continuous longitudinal girders within 0.1L from ends and for vertical or transverse girders on tank and collision bulkheads.
- \( = 210/k \) for vertical and transverse girders, in general.

For continuous longitudinal girders between the regions specified above, '\( \sigma \)' may be obtained by linear interpolation.

6.1.3 The depth of the girders should not be less than 2.5 times the depth of the cutout (if any) for the passage of continuous stiffeners. The net cross sectional area 'A' of the girder web at ends is not to be less than

\[ A = CkSbp + 0.01 d_w t_c \ [\text{cm}^2] \]

where,

- \( C = 0.060 \) for tank and collision bulkheads
- \( C = 0.045 \) for other watertight bulkheads
- \( d_w = \text{depth of web [mm]}. \)

However, for lower end of vertical girders value of C to be taken as 0.08 and 0.06 respectively.

6.1.4 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.
Superstructures, Deckhouses and Bulwarks

Section 1  
General

1.1 Scope

1.1.1 The scantlings of the bulwarks and of the exposed bulkheads of the superstructures and deckhouses are to comply with the requirements of this chapter. The scantlings of the decks of the superstructures and deckhouses are to be in accordance with the requirements of Ch.8, and those of the sides of the superstructures are to be in accordance with the requirements of Ch.7.

1.2 Definitions

1.2.1 For definitions of the terms 'Superstructure' and 'Deckhouse' refer to Ch.1.

1.2.2 The lowest tier is normally the tier that is directly situated on the deck to which the rule depth 'D' is measured or on superstructures which are less than 1.8 [m] in height.

1.3 Symbols

1.3.1 L and k as defined in Ch.1, Sec.2.

\[ s = \text{spacing of stiffeners [mm]} \]

\[ l = \text{span of stiffener [m]} \]

Section 2  
Scantlings

2.1 End bulkheads and exposed sides of deckhouses

2.1.1 The thickness 't' of steel plating of the fronts, sides and aft ends of deckhouses and the front and aft ends of superstructures is not to be less than:

\[ t = (0.004 \ (s + 2.5)) \sqrt{k} \quad \text{for lowest tier} \]

\[ = (0.004 \ (s + 1.5)) \sqrt{k} \quad \text{for upper tiers} \]

2.1.2 The section modulus Z of stiffeners on fronts, sides and aft ends of deck houses and the front and aft ends of superstructures is not to be less than:

\[ Z = 3.6 \ s l^2 \times 10^{-3} \cdot k \ [\text{cm}^3] \quad \text{for uppermost tier} \]

I is not to be taken less than 2.0 [m].

When a multiple tier erection is fitted, the section modulus of stiffeners on lower tiers is to be increased at the rate of 15% per tier fitted above the tier under consideration.

2.1.3 The upper end of stiffeners on all erections are to be bracketed to the deck beams or longitudinals and the lower end is to be welded to the deck below.
2.2 Protected machinery casings

2.2.1 The thickness of plating is not to be less than:

\[ t = (0.003 s + 1.5) \sqrt{k} \text{ [mm]} \]

2.2.2 The section modulus 'Z' of stiffeners is not to be less than:

\[ Z = 0.003 s l^2 \sqrt{k} \text{ [cm}^3\text{]} \]

\[ \text{where, } l \text{ is not to be taken less than 2.0 [m].} \]

2.2.3 Casings supporting one or more decks above are to be adequately strengthened.

Section 3

Structural Arrangement and Details

3.1 Structural continuity

3.1.1 Adequate transverse strength is to be provided to the deckhouses and superstructures by means of transverse bulkheads, girders and web frames.

3.1.2 The front and the after end bulkheads of large superstructures and deckhouses are to be effectively supported below by a transverse bulkhead or by a combination of partial bulkheads, girders and pillars. Similarly, the exposed sides of various tiers of erections are to be supported by bulkheads, girders or carlings below.

3.1.3 All openings cut on the sides are to be substantially framed and have well rounded corners.

3.1.4 At the ends of superstructures, which have no set-in from the ships' side, the side plating is to extend beyond the ends of the superstructure, and is to be gradually reduced in height down to the sheer strake. The extended plating is to be adequately stiffened, particularly at its upper edge.

Section 4

Bulwarks and Guard Rails

4.1 General requirements

4.1.1 Bulwarks or guard rails are to be provided on the exposed parts of the freeboard and superstructure decks and also on all upper deck spaces normally accessible to crew and passengers. The height of the bulwarks or guard rails measured above the sheathing, if any, should not be less than the following:

For all passenger ships :
- For all Zones : 900 [mm]
For all other ships :
- For Zone 1 : 900 [mm]
- For Zone 2 : 600 [mm]
- For Zone 3 : 300 [mm].

Consideration will be given to cases where this height would interfere with the normal operation of the ship.

4.1.2 Bulwarks or guard rails as required by 4.1.1 may be dispensed with in way of hatch side coamings fitted with suitable handrails.

4.1.3 Where bulwarks on the weather portion of freeboard or superstructure decks form wells, provision is to be made for rapidly freeing the decks of water.

4.2 Bulwark construction

4.2.1 Bulwarks are to be stiffened at the upper edge by a strong rail section and supported by stays from the deck, spaced not more than 2.0 [m] apart. Where bulwarks are cut in way of a gangway or other openings, stays of increased strength are to be fitted at the ends of the openings.
Bulwark stays are to be supported by, or are to be in line with, suitable underdeck stiffening, which is to be connected by double continuous fillet welds in way of the bulwark stay connection.

Bulwarks are to be adequately strengthened in way of the eyeplates for cargo gear. In way of the mooring pipes, the plating is to be increased in thickness and also adequately stiffened.

4.2.2 Bulwarks are generally not to be welded to the top of the sheerstrake within 0.6L amidships and so arranged as to ensure their freedom from main structural stresses.

4.3 Bulwark scantlings

4.3.1 The thickness of the bulwark plating is not to be less than 4.0 [mm].

4.3.2 The section modulus ‘Z’ at the bottom of the bulwark stay is not to be less than:

\[ Z = (33 + 0.44 L) h^2 s \quad [\text{cm}^3] \]

where,

\[ h = \text{height of the bulwark} \quad [\text{m}] \]

\[ s = \text{spacing of bulwark stays} \quad [\text{m}] \]

In the calculation of section modulus 'Z', only the material connected to the deck is to be included. The contribution from bulwark plating and/or stay flange may be considered depending upon the construction details.

4.4 Guard rails

4.4.1 The guard rails are to be supported by stanchions fitted not more than 3.0 [m] apart;

At least every third stanchion is to be supported by a bracket or stay.

4.4.2 Lengths of chain may be accepted in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

4.4.3 The clear opening below the lowest course of the guard rails is not to exceed 230 [mm].

End Of Chapter
Chapter 11

Openings and Closing Appliances, Ventilators, Air Pipes and Discharges

Contents

Section
1 General
2 Hatch Coamings
3 Hatch Covers
4 Miscellaneous Openings
5 Ventilators
6 Air and Sounding Pipes
7 Scuppers and Sanitary Discharges

Section 1

General

1.1 Scope

1.1.1 This Chapter applies to all ship types in general. Additional requirements pertaining to special ship types are given in Pt.5.

1.1.2 The requirements of National or local authorities should also be applied, where relevant.

1.1.3 For the purpose of this section, weathertightness of hatch covers means that closing appliances do not permit entry of water into the ship which may prejudice the safety of the vessel under the navigational conditions envisaged.

Section 2

Hatch Coamings

2.1 Coaming heights

2.1.1 The height of cargo hatchcoamings above deck is to be not less than 300 [mm] for Zones 1 and 2 and 200 [mm] for Zone 3.

In addition, the distance of coaming top above load water line is to be not less than given in Table 2.1.1.

2.2 Hatch coaming construction

2.2.1 Hatchside coamings are to extend to the lower edge of the deck beams. Side coamings not forming a part of continuous girders, are to extend two frame spaces beyond the hatch ends below the deck.

Table 2.1.1 : Height of hatch coamings [mm]

<table>
<thead>
<tr>
<th></th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>With weathertight hatch cover 1)</td>
<td>1000</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>Without weathertight hatch cover</td>
<td>1700</td>
<td>1000</td>
<td>500</td>
</tr>
</tbody>
</table>

Note 1) See 1.1.3

2.2.2 Hatch end coamings when not in line with the deck transverses are to extend below the deck, at least three longitudinal frame spaces beyond the side coaming.
2.2.3 Continuous hatchway coamings or coamings forming an effective part of the deck girder system are to be made from steel of same tensile strength as that of the deck plating.

2.2.4 If the junction of hatch coamings forms a sharp corner, the side and end coamings are to be extended in the form of tapered brackets in longitudinal and transverse directions respectively.

2.2.5 Extension brackets or rails arranged approximately in line with the cargo hatch side coamings and intended for the stowage of steel hatch covers are not to be welded to deckhouse, masthouse or to each other unless they form a part of the longitudinal strength members.

2.3 Coaming scantlings

2.3.1 The scantlings of hatch coaming plating and stiffeners are to be not less than that required for the adjacent deck.

2.3.2 Hatchway coamings 300 [mm] and above are to be stiffened in their upper edge.

Coaming stays are to be fitted at spacing of not more than 3.0 [m]. The stays are to end on stiffened plating. The coamings are to be satisfactorily stiffened against buckling.

Section 3

Hatch Covers

3.1 General

3.1.1 Hatch covers, where fitted, may be of the types a) to e) as described below.

Hatch Cover Types:

'a' : Steel plated cargo hatch covers stiffened by webs or stiffeners and secured by clamping devices. Weathertightness is to be ensured by means of gaskets. Hatch covers used for holds containing liquid cargoes are also included in this category.

'b' : Steel plated pontoon type cargo hatch covers with internal webs and stiffeners extending over the full width of the hatchway. Weathertightness is to be achieved by tarpaulins.

'c' : Wood or steel hatch covers used in conjunction with the portable beams. Weathertightness to be obtained by tarpaulins.

'd' : Access hatch covers for cargo oil tanks and adjacent spaces. The hatch covers are to be of steel and gasketed.

'e' : Access hatch covers other than 'd'. The covers are to be of steel or wood and weathertight. Escape hatches are to be operable from both sides.

3.1.2 Materials for steel hatch covers are to satisfy the requirements of hull structural steel. Where other approved materials are used, equivalent strength and stiffness are to be provided.

3.2 Design loads

3.2.1 The design weather load on the weather deck hatchcovers is to be taken as:

\[ p = H_1 - 10 h_0 \ [kN/m^2] \], minimum 3 [kN/m^2]

where,

\[ h_0 = \text{Vertical distance [m] from the maximum load waterline to the top of hatch covers.} \]

\[ H_1 = \text{as given in Table 3.2.1.} \]

<table>
<thead>
<tr>
<th>Zone</th>
<th>( H_1 )</th>
</tr>
</thead>
</table>
| 1    | 9 for \( L \leq 20 \) [m]
|      | 9 + 0.15 \((L-20)\) for \( 20 < l < 60 \) |
|      | 15 for \( L \geq 60 \) [m]          |
| 2    | 0        |
| 3    | 5        |

3.2.2 For hatch covers subjected to cargo loading the design pressure is to be taken as:

\[ p = 12.5 q \ [kN/m^2] \]

where,

\[ q = \text{specified cargo loading [t/m}^2\text{]} \text{ on the hatch cover.} \]

3.2.3 The design internal pressure on hatch covers above tanks are to be determined as per the design pressure on deck structure given in Ch.8.
3.3 Hatchcover plating

3.3.1 The thickness of steel hatch cover plating is not to be less than:

$$t = 15.8s \sqrt{\frac{p}{\sigma}} \times 10^{-2} + t_c \,[\text{mm}],$$

or

$$3 \,[\text{mm}] \text{ whichever is greater}$$

where,

$$p = \text{design pressure as per 3.2}$$

$$= 160/k \,[\text{N/mm}^2].$$

Hatch covers of G.I. sheet and other material will be specially considered.

3.3.2 The plating of hatch covers acting as compression flanges for the hatch cover stiffeners and girders is to be effectively stiffened against buckling.

In the middle part of the simply supported span the critical buckling stress $s_c$ is to be such that:

$$\sigma_c \geq 1.15 \sigma_b \,[\text{N/mm}^2]$$

where,

$$\sigma_b = \text{calculated bending stress in the compression flange corresponding to the design load as given in 3.2.}$$

$$\sigma_c = \text{the critical buckling stress as per Ch.3, Sec.6.}$$

3.4 Stiffeners and girders

3.4.1 The section modulus of the stiffeners and girders is not to be less than the following:

$$Z = 6.25s \frac{l^2}{m} \,[\text{cm}^3]$$

where,

$$l = \text{the member span between effective supports \,[m]}$$

$$s = \text{the member spacing \,[m]}$$

$$m = 8 \text{ for members simply supported at ends}$$

$$= 12 \text{ for members which can be considered as fixed at both ends.}$$

The moment of inertia of stiffeners and girders is not to be less than:

$$I = 2.1 Zl \,[\text{cm}^4]$$

For other materials the requirement will be specially considered.

3.4.2 For covers above cargo and ballast tanks, fillet welds on tank side are to be double continuous.

3.5 Hatch cover edges

3.5.1 The cover edges are to be adequately stiffened to withstand the forces imposed upon them during opening and closing of the hatches.

3.6 Wooden hatch covers

3.6.1 Wooden hatch cover planks are to have a finished thickness not less than 1/24th of the unsupported span, with a minimum of 20 [mm].

The planks of wood covers are to be connected at their underside by cross planks spaced not more than 1.5 [m].

3.6.2 The ends of all wooden hatch covers are to be protected by encircling with galvanized steel bands.

3.7 Portable hatch beams

3.7.1 The section modulus and the moment of inertia of the portable hatch beams stiffened at their upper and lower edges by continuous flat bars are to satisfy the requirements of 3.4.

3.7.2 Carriers or sockets, or other suitable arrangements are to be provided as means of the efficient fitting and securing of portable hatch beams.

3.7.3 Sliding hatch beams are to be provided with an efficient device for locking them in their correct fore and aft positions when the hatchway is closed.

3.8 Direct calculations

3.8.1 Hatchcovers of special construction and arrangement e.g. covers designed and constructed as a grillage, covers supported along more than two opposite edges and covers supporting other covers, may require submission of direct strength calculation taking into account the arrangement of stiffeners and the supporting members.

3.9 Hatch cover securing arrangement

3.9.1 The gaskets and the securing arrangements are to be designed for the expected relative movement between cover and
coaming or special devices are to be fitted to restrict such movement.

3.9.2 Securing arrangements together with suitable gasketting material are to ensure weathertightness of the covers to the satisfaction of the surveyors.

3.9.3 The gasket material is to be of satisfactory air, seawater and if necessary oil resistant quality. It is to be effectively secured along the edges of the cover in a manner as to ensure that the forces from the hatch covers or cargo stowed on top of the hatchcovers are transferred to the coaming or to the deck by direct contact without the load coaming on the gaskets. The sealing is to be achieved by relatively soft packing. The hatch coaming or steel parts on the adjacent covers in contact with the packing are to be well rounded where necessary.

A metallic contact is to be kept between the hatch cover and the hull to effect electrical earthing.

3.9.4 Where tarpaulins are fitted to make hatch covers weathertight. They are to be free from jute, and are to be waterproof and of ample strength. At least two layers of tarpaulins are to be provided and these are to be secured by battens and wedges or equivalent arrangements.

Section 4

Miscellaneous Openings

4.1 Manholes

4.1.1 Manholes on the weather decks are to be closed by substantial covers capable of closing them watertight.

4.2 Companionways, doors and accesses on weather decks

4.2.1 Companionways on exposed deck are to be equivalent in strength and weathertightness to a deckhouse in the same portion. The height of the doorway sills above deck is not to be less than 100 [mm] for Zone 3 and 150 [mm] for Zone 1 & 2 on exposed locations.

For doorways directly leading to engine room the sill height above deck is to be not less than 400 [mm].

In addition the sill heights above load waterline should not be less than the values mentioned below:

<table>
<thead>
<tr>
<th>Zone</th>
<th>[mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>1000</td>
</tr>
<tr>
<td>Zone 2</td>
<td>600</td>
</tr>
<tr>
<td>Zone 3</td>
<td>300</td>
</tr>
</tbody>
</table>

4.3 Openings on engine casing

4.3.1 Machinery space openings are to have efficient closing appliances. The openings and coamings for fiddle, funnel and machinery space ventilators in the casing in those positions are to be provided with strong covers of steel or other equivalent material permanently attached in their proper positions and capable of being secured weathertight.

4.3.2 Skylights are to be of substantial construction and secured firmly to the deck. For skylights the coaming height is not to be less than that required for the hatch coamings. Efficient means are to be provided for closing and securing the hinged scuttles, if any. The thickness of glasses in fixed or opening skylights is to be appropriate to their position and size as required for side scuttles. Glasses are to be protected against mechanical damage, and are to be fitted with deadlights or storm covers permanently attached.

4.3.3 Side scuttles in the engine casings are to be provided with fireproof glass.

4.4 Windows and side scuttles

4.4.1 Side scuttles and windows are to be made and tested according to Standards. The glass thickness of side scuttles below main deck is to be not less than 8.0 [mm].

The glass thickness of windows above deck is not to be less than:

\[
t = \frac{w}{70} \text{[mm]}, \text{ minimum 6.0 [mm]}
\]

where,

\[
w = \text{the height or the width of the window, whichever is smaller, [mm].}
\]
4.4.2 Side scuttles in the shell below main deck are to be non opening type with deadlights and the lower edge of glass is to be at least 500 [mm] above the load waterline in any condition of list or trim. Further, the scuttles are to be adequately protected against damage by direct contact.

4.4.3 Side scuttles and windows above deck may be fitted without deadlight/portable covers provided the height of lower edge of glass above waterline is not less than specified in Table 4.4.3.

<table>
<thead>
<tr>
<th>Zone</th>
<th>( h_t ) [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1700</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
</tr>
</tbody>
</table>

**Section 5**

**Ventilators**

5.1 General

5.1.1 The scantlings of exposed ventilator coamings are to be equivalent to the scantlings of deckhouses in the same position. In cargo spaces and other areas where mechanical damage is likely, the ventilator trunks are to be well protected.

5.2 Coaming heights

5.2.1 Ventilators on exposed decks are to have the lower edge of openings at a height of not less than 300 [mm] above deck.

In addition, the heights of lower edge of openings above waterline are to be not less than specified in Table 5.2.1.

<table>
<thead>
<tr>
<th>Zone</th>
<th>With closing appliances</th>
<th>Without closing appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>1000</td>
<td>1700</td>
</tr>
<tr>
<td>Zone 2</td>
<td>600</td>
<td>1000</td>
</tr>
<tr>
<td>Zone 3</td>
<td>300</td>
<td>500</td>
</tr>
</tbody>
</table>

5.3 Closing appliances

5.3.1 Ventilator openings are to be fitted with efficient weathertight closing appliances if applicable as specified in Table 5.2.1.

**Section 6**

**Air and Sounding Pipes**

6.1 General

6.1.1 Air and sounding pipes are to comply with the requirements of Pt.4, Ch.2.

6.1.2 Striking plates of suitable thickness, or their equivalent, are to be fitted under all sounding pipes.

6.1.3 Air and sounding pipes leading through cargo containment areas or other spaces where mechanical damage is likely to occur, are to be well protected.

6.2 Height of air pipes

6.2.1 The height of air pipes from the upper surface of decks exposed to the weather, to the point from where water may have access below, is not normally to be less than 300 [mm].

The heights above load waterline of air pipes with and without closing appliances are not to be less than as specified in Table 5.2.1 for ventilators.

6.2.2 Lower heights may be approved in cases where these are essential for the working of the ship, provided closing appliances are of an approved automatic type.
6.3 Closing appliances

6.3.1 Permanently attached closing appliances to prevent free entry of water are to be fitted to all sounding pipes and for air pipes where required as per 6.2.1.

6.3.2 Where the closing appliances are not of an automatic type, provision is to be made for relieving vacuum when the tanks are being pumped out.

Section 7

Scuppers and Sanitary Discharges

7.1 General

7.1.1 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

7.1.2 Scuppers draining weather decks and spaces within superstructures or deckhouses not fitted with efficient weathertight doors are to be led overboard.

7.1.3 Scuppers and discharges which drain spaces below the main deck, or spaces within intact superstructures or deckhouses on the main deck fitted with efficient weathertight doors, may be led to the bilges in the case of scuppers, or to suitable sanitary tanks in the case of sanitary discharges. Alternatively, they may be led overboard provided that the spaces drained are above the load waterline, and the pipes are fitted with efficient and accessible means of preventing water from passing inboard as required in 7.2.1.

7.1.4 Scuppers and discharge pipes should not normally pass through fuel oil or cargo oil tanks. Where scuppers and discharge pipes pass, unavoidably, through fuel oil or cargo oil tanks, and are led through the shell within the tanks, the thickness of the piping should be at least the same thickness as Rule shell plating in way, derived from the appropriate chapters.

Piping within tanks is to be tested in accordance with Pt.4, Ch.2 and Ch.3.

7.1.5 All piping is to be adequately supported.

7.2 Closing appliances

7.2.1 Where the inboard end of scuppers and discharges are below main deck, normally a screw down non-return value in an accessible location is to be fitted to prevent water from passing inboard.

Where the inboard end is above the main deck, a non-return valve is to be fitted at the shell, if the height of the inboard end above waterline is lower than the following:

Zone 1 - 1000 [mm]
Zone 2 - 600 [mm]
Zone 3 - 300 [mm].

7.3 Materials for valves, fittings and pipes

7.3.1 All shell fittings and valves required by 7.2 are to be of steel, bronze or other approved ductile material; ordinary cast iron or similar material is not acceptable.

7.3.2 All these items, if made of steel or other approved material with low corrosion resistance, are to be suitably protected against wastage.

7.3.3 The lengths of pipe attached to the shell fittings, elbow pieces or valves are to be of galvanized steel or other equivalent approved material.

End Of Chapter
Chapter 12

Rudders

Contents

Section
1 General
2 Arrangement and Details
3 Design Loads
4 Rudder Blades
5 Rudder Stock and Pintles
6 Rudder Couplings

Section 1

General

1.1 Scope
1.1.1 The requirements of this Chapter apply to arrangement and scantlings of normal streamlined or plate rudders and their supporting structure. Rudders fitted with special features e.g. special profiles, fins, flaps, steering propellers etc. to increase the lift force will be specially considered.

1.2 Material
1.2.1 All materials used in the construction of the rudder are to be tested and approved in accordance with Pt.2. ‘Materials’ of the Rules and Regulations for the Construction and Classification Steel Ships (Main Rules).
1.2.2 Material grades for plates and sections for the rudder blade are to be selected as per Pt.3, Ch.2, Sec.1.3.
1.2.3 Bearing materials for bushings are to be stainless steel, bronze, white metal, synthetic material or lignum vitae. If stainless steel is proposed to be used for liners or bushes for the rudder stocks and pintles, the chemical composition is to be submitted for approval.

Hardness of the material of the bushing is to be at least 65 Brinell lower than that of the liner or the rudder stock or pintle.

Synthetic bush materials are to be of approved type. Arrangement is to be provided for adequate supply of sea-water to these bearings.

1.3 Testing
1.3.1 Bodies of the rudders are to be tested in accordance with the requirements given in Ch.15.

Section 2

Arrangement and Details

2.1 General
2.1.1 Various types of rudder arrangement are shown in Fig. 2.1.1; other combinations of couplings and bearings may, however, be proposed.

2.1.2 Effective means are to be provided for supporting the weight of the rudder. Where the support is provided by a carrier bearing attached to the rudder head, the structure in way of the bearing is to be adequately strengthened. The plating under all rudder head bearings or rudder carriers is to be increased in thickness.
2.1.3 All rudder bearings are to be accessible for measuring wear without lifting or unshipping the rudder.

2.1.4 Satisfactory arrangement is to be provided to prevent water from entering the steering gear compartment and lubricant from being washed away from the rudder carrier. A seal or stuffing box is to be fitted above the deepest load water line for this purpose unless the top of the rudder trunk (steering gear flat) is more than 300 [mm] above the deepest waterline in way trimmed condition. When the rudder carrier is fitted below the deepest load water line, two separate seals or stuffing boxes are to be provided.

2.1.5 Suitable arrangement is to be provided to prevent the rudder from lifting and accidental unshipping.

Section 3

Design Loads

3.1 Rudder force

3.1.1 The rudder force, upon which rudder scantlings are to be based, is to be determined from the following formula:

\[ F_r = 132 \cdot K_1 \cdot K_2 \cdot K_3 \cdot A \cdot V^2 \] [N]

where,

\[ F_r = \text{rudder force} \] [N]

\[ A = \text{area of rudder blade} \] [m²]

\[ V = \text{maximum achievable ship speed (knots) in the lightest operating condition in which the rudder is fully immersed.} \]

\[ V \text{ is not to be taken as less than } 6 \text{ knots.} \]

For astern condition, the maximum astern speed is to be used, but in no case less than:

\[ V_{astern} = 0.5V \]

\[ K_1 = (\lambda + 2)/3; \text{ with } \lambda \text{ not to be taken greater than } 2. \]
\[ \lambda = \frac{b^2}{A_t}; \text{ where } b \text{ is the mean height of the rudder area [m] and } A_t, \text{ the sum of rudder blade area and area of rudder post or rudder horn, if any, within the height } b \text{ [m}^2]. \]

Mean breadth \( C \) [m] and mean height \( b \) [m] of rudder are calculated according to the coordinate system in Fig.3.1.1.

\[ \lambda = \frac{b^2}{A_t}; \]
\[ \text{where,} \]
\[ r = x_c - f \text{ [m]; but not to be taken less than } 0.1C. \]
\[ x_c = \text{the distance of the point of application of the design force } F_r \text{ from the leading edge} \]
\[ = 0.33C \text{ in ahead condition} \]
\[ = 0.66C \text{ in astern condition.} \]
\[ C = \text{Mean breadth of rudder area [m] See Fig. 3.1.1.} \]
\[ f = C \cdot \frac{A_f}{A} \text{ where } A_f \text{ is the portion of the rudder blade area situated ahead of the centre line of the rudder stock.} \]

3.2.2 In case of rudder blades with stepped contours the total rudder torque is to be obtained as follows:

\[ Q_i = \sum Q_{ri} \text{ for } i = 1,2,3,... \]

where,
\[ Q_i = F_{ri} \cdot r_i; \text{ individual torque component from each part } A_i \text{ of the total rudder area.} \]
\[ F_{ri} = F_r \cdot \frac{A_i}{A} \]
\[ r_i = x_{ci} \cdot f_i; \text{ but not to be taken less than } 0.1C_i. \]
\[ x_{ci}, f_i \text{ and } C_i \text{ are to be taken as } x_c, f \text{ and } C \text{ as in 3.2.1 for each discrete part except that for those rudder parts immediately aft of rudder horn } x_{ci} \text{ is to be taken as } 0.25C_i \text{ and } 0.55C_i \text{ in ahead and astern conditions respectively.} \]

3.3 Bending moments, shear forces and reactions

3.3.1 The bending moment (BM) and shear force (SF) distributions along the entire height of the rudder blade and rudder stock as well as the bearing reactions (R) may be obtained by direct calculation. The rudder is to be assumed as simply supported at the centres of the upper bearing and the neck bearing. In case of rudders supported by the sole piece or rudder horn the flexibility of the sole piece or rudder horn, and rudder and rudder stock is to be taken into consideration.

3.3.2 For common types of rudders, the following approximate values may be used:

- For balanced rudders with heel support :

\[ \text{BM} = \frac{F_r \cdot b}{8} \text{ [N } \cdot \text{m]} \]
at mid-height of the rudder blade;
\[ SF = \frac{F_r \cdot A_1}{A} \ [N] \]

at centre of neck bearing.

\[ SF = 0.6 \cdot F_r \ [N] \]

at top and bottom ends of the rudder blade;

\[ SF = 0.1 \cdot F_r \ [N] \]

at mid-height of the rudder blade.

\[ SF = 0.6 \cdot F_r \ [N] \]

at the heel pintle bearing;

\[ SF = 0.7 \cdot F_r \ [N] \]

at the neck bearing/ternal pintle;

\[ SF = 0.1 \cdot F_r \ [N] \]

at the upper bearing.

- For spade rudders -

\[ BM = \frac{F_r \cdot A_1 \cdot b_1}{A} \ [N - m] \]

at any cross section below and including the neck bearing.

\[ BM = \frac{b_2 + b_3}{b_3} \cdot F_r \ [N] \]

at any cross section up to the centre of the neck bearing.

\[ R = \frac{b_2 + b_3}{b_3} \cdot F_r \ [N - m] \]

at the neck bearing;

\[ R = \frac{b_2}{b_3} \cdot F_r \ [N] \]

at upper bearing;

where,

\[ A_1 = \text{rudder area below the cross section under consideration;} \]

\[ b_1 = \text{vertical distance from the centroid of } A_1 \text{ to the cross section;} \]

\[ b_2 = \text{vertical distance from the centroid of rudder area } A \text{ to the centre of the neck bearing, and} \]

\[ b_3 = \text{vertical distance between the centres of the upper and lower bearings.} \]

3.3.3 At upper bearings the bending moments are to be taken as zero and between the upper bearing and the neck bearing the bending moments may be varied linearly.

**Section 4**

**Rudder Blades**

4.1 **Construction details**

4.1.1 Care is to be taken to avoid notch effects and to maintain continuity of strength around cut-outs and openings in the side plating. The plating thickness is to be increased suitably and corners are to be well rounded and ground smooth.

4.1.2 Side plating and vertical webs transmitting the torque are to be welded to the coupling flange by full penetration welds.

4.1.3 In general, welds between plates and heavy pieces are to be made as full penetration welds. Back welding is not practicable, welding is to be performed against backing bar or equivalent.

4.1.4 Webs are to be connected to the side plating in accordance with Ch.14. Where fillet welding is not practicable, side plating is to be connected by means of slot welding to flat bars welded to the webs. Normally slots of length 75 [mm], breadth at least twice the side plating thickness and spaced 200 [mm] centre to centre will be accepted. The ends of the slots are to be well rounded. In areas subjected to large bending stresses, horizontal slots may require to be replaced by continuous weld.
4.1.5 Arrangement is to be provided to drain the rudders completely. Drain plugs are to be provided with efficient packing.

4.1.6 Internal surfaces of rudders are to be efficiently coated for corrosion resistance after completion of fabrication and testing. Where it is intended to fill the rudder with plastic foam, details of the foam material are to be submitted.

4.2 Double plated rudders

4.2.1 Thickness 't' of the rudder side, top and bottom plating is not to be less than:

\[
t = 5.5 \frac{f_a}{s} \sqrt{\left(\frac{T + \frac{F_c}{A} \cdot 10^{-4}}{s}ight) \cdot 10^{-3} + 2.5} \text{ [mm]}
\]

where,

\[
f_a = \sqrt{1.1 - 0.5\left(\frac{s}{1000l}\right)^2} \times \text{max.1.00}
\]

s = the smaller of the distances between the horizontal or the vertical web plates [mm].

l = the larger of the distances between the horizontal or the vertical web plates [mm].

The thickness 't' is however not to be less than the minimum side shell thickness as per Pt.3, Ch.7.

For nose plates the thickness is to be increased to 1.25 t.

4.2.2 The thickness of the vertical and horizontal webs is not to be less than 70 per cent of the requirement given in 4.2.1 with a minimum of 7 [mm].

4.2.3 The thickness of side plating and vertical webs forming the main piece may have to be increased locally in way of the coupling and cut-outs or openings, if any.

4.3 Single plated rudders

4.3.1 Rudder blade thickness is not to be less than:

\[
t = 1.5 \cdot y \cdot V \cdot 10^{-3} + 2.5 \text{ [mm]}
\]

where y is the spacing of horizontal arms, [mm]; and V, the speed in knots as per 3.1.1.

4.3.2 Rudder blade is to be stiffened by horizontal arms spaced not more than 1000 [mm] apart. The arms are to be efficiently attached to the main piece. The thickness of the arms is not to be less than the blade thickness. The section modulus of the arms in way of main piece is not to be less than:

\[
Z = 0.5 \cdot y \cdot x^2 V^2 \cdot 10^3 \text{ [cm}^3\text{]}
\]

where,

x is the distance from the centre line of the stock to the after end of the rudder [m].

4.3.3 The diameter of the mainpiece at top end is not to be less than that of the lower rudder stock, and it may be gradually reduced towards lower end.

Section 5

Rudder Stock and Pintles

5.1 Rudder stock

5.1.1 Diameter of the rudder stocks, when obtained by direct calculation, are normally to give an equivalent stress se not exceeding 138 [N/mm²] i.e.

\[
\sigma_e = \sqrt{\sigma^2 + 3\tau_t^2} \leq 138 \text{ [N/mm}^2\text{]}
\]

where,

\[
\sigma \text{ is the bending stress [N/mm}^2\text{],}
\tau_t \text{ is the torsional shear stress [N/mm}^2\text{].}
\]

This requirement is regardless of the liners; and both ahead and astern conditions are to be considered.

5.1.2 The diameter of the rudder stock at and above rudder carrier is given by

\[
d_u = 4.0\sqrt[3]{\left(Q_t\right)} \text{ [mm]}
\]

5.1.3 The diameter of rudder stock at any other cross section is given by
\[ d_x = d_y \cdot \sqrt{1 + \frac{4 \cdot BM^2}{3 \cdot Q_t}} \text{[mm]} \]

where BM is the bending moment at the cross section under consideration obtained as per 3.3.

5.1.4 The diameter of the rudder stock at neck bearing is to be maintained to a point as far as practicable above the top of the neck bearing and may subsequently be tapered to that required at the rudder carrier. The length of the taper is to be at least three times the reduction in diameter. Particular care is to be taken to avoid the formation of a notch at the upper end of the taper.

5.1.5 Sudden changes of section or sharp corners in way of the rudder coupling, jumping collars and shoulders for rudder carriers are to be avoided. Jumping collars are not to be welded to the rudder stock. Keyways in the rudder stock are to have rounded ends and the corners at the base of the keyway are to be adequately radiused.

5.2 Pintles and bearings

5.2.1 The diameter \( d_p \) of the pintles, measured on the inside of liners where fitted, is not to be less than:

\[ d_p = 0.35 \sqrt{R} \text{[mm]} \]

where,

\[ R = \text{Reaction force [N] at the pintle bearing, obtained as per Sec.3.3.} \]

5.2.2 Pintles are to have a conical attachment to the gudgeons and the taper on diameter is generally to range between 1:8 to 1:12. The slugging nut is to be efficiently secured. An effective sealing against sea water is to be provided at both ends of the cone.

5.2.3 The length of pintle housing in the gudgeon is not to be less than the pintle diameter \( d_p \). The thickness of the pintle housing is not to be less than 0.25 \( d_p \).

5.2.4 Where liners are fitted to pintles, they are to be shrunken or otherwise efficiently secured. If liners are to be shrunken on, the shrinkage allowance is to be indicated on the plans. Where liners are formed by stainless steel weld deposit, the pintles are to be of weldable quality steel, and details of the procedure are to be submitted. Bushing is to be effectively secured against movement.

5.2.5 Pintle clearances are normally to be as given in Table 5.2.5.

Attention is to be paid to the manufacturer’s recommendations particularly where bush material requires pre-soaking.

### Table 5.2.5: Pintle Clearances

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>For metal bearing material</td>
<td>( 0.001 d_p + 1.0 ) [mm]</td>
</tr>
<tr>
<td>For synthetic bearing material</td>
<td>To be specially determined considering the swelling and thermal expansion properties of the material, but not less than 1.5 [mm].</td>
</tr>
</tbody>
</table>

5.2.6 The bearing pressure \( P \), due to reaction \( R \) on projected bearing area is not to exceed the values given in Table 5.2.6. For the purpose of this calculation, the bearing length is not to be taken greater than 1.2 times the rudder stock or pintle diameter measured outside of liners, if fitted. Higher values than given in the table may be taken on verification by tests.

### Table 5.2.6: Bearing pressure

<table>
<thead>
<tr>
<th>Bearing Materials</th>
<th>( P ) [N/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel or bronze against lignum vitae</td>
<td>2.5</td>
</tr>
<tr>
<td>Steels against white metal, oil lubricated</td>
<td>4.5</td>
</tr>
<tr>
<td>Steel against synthetic material with hardness between 60 and 70 shore D(^{(1)})</td>
<td>5.5</td>
</tr>
<tr>
<td>Steel against stainless steel, bronze and hot pressed bronze-graphite materials</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Note: (1) Indentation hardness test at 23°C and with 50% moisture, according to a recognised standard. Synthetic bearing materials to be of approved type.
Section 6

Rudder Couplings

6.1 Horizontal bolted couplings

6.1.1 The diameter of the coupling bolts is not to be less than:

\[ d_b = 0.62 \left( \frac{d_s^3}{n \cdot e_m} \right)^{1/2} \] [mm]

where,

- \( d_s \) = Rule stock diameter [mm] in way of the coupling flange;
- \( n \) = total number of bolts;
- \( e_m \) = mean distance of the bolt axis from the centre of the bolt system [mm].

6.1.2 Coupling bolts are to be fitted bolts and a minimum of six (6) bolts are to be provided. Their nuts are to be effectively locked.

6.1.3 Mean distance \( e_m \) from the centre of the bolts to the centre of the bolt system is not to be less than 0.9 \( d_s \) [mm]. In addition, where the coupling is subjected to bending stress the mean athwartship distance from the centre of bolts to the longitudinal centreline of the coupling is not to be less than 0.6 \( d_s \) [mm].

6.1.4 The thickness of coupling flanges is not to be less than the diameter of the coupling bolts.

6.1.5 The width of material outside the bolt holes is not to be less than 0.67 \( d_b \) [mm].

6.2 Vertical flange couplings

6.2.1 The diameter of the coupling bolts is not to be less than:

\[ d_b = 0.81 \left( \frac{d_s^3}{n} \right)^{1/2} \] [mm]

where,

- \( d_s \) = Rule stock diameter [mm] in way of the coupling flange
- \( n \) = total number of bolts, not to be less than 8.

6.2.2 The first moment of area of the bolts about the centre of the coupling to be not less than:

\[ m = 0.00043 \ d_s^3 \] [cm³]

6.2.3 The thickness of the coupling flanges must be at least equal to the bolt diameter; and the width of the flange material outside the bolt holes must be greater than or equal to 0.67 \( d_b \).

End Of Chapter
Chapter 13

Anchoring and Mooring Equipment

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Introduction

1.1.1 To entitle a vessel to the letter 'L' in her character of classification, anchoring and mooring equipment is to be provided in accordance with the requirements of this Chapter.

These requirements are based on maximum current of 8 [km/hr], wind speed of 25 [m/sec], water depth of 5-7 [m] and good holding ground conditions. Where environmental conditions are more onerous, special consideration will be required.

1.1.2 Except in case of tugs, towlines are not subject of classification and the details given in the equipment table are for guidance purpose only. However, for tugs intended for towing other ships, having onboard suitable lines for the same purpose, the requirement of towline may be waived with written concurrence from the Owners.

1.1.3 Attention is drawn to any relevant requirements of the local Authorities with which the ship is to be registered.

1.2 Documentation

1.2.1 The arrangement of anchoring and mooring equipment and Equipment Number calculations are to be submitted for information.

1.2.2 Following details of the proposed equipment are to be submitted for approval:-

1) Number, weight, type and design of anchors.

2) Length, diameter, grade and type of chain cables.

3) Type and breaking load of steel and fibre ropes.

1.3 Symbols

1.3.1 L,B,T as defined in Ch.1, Sec.2.
Section 2

Structural Arrangement for Anchoring Equipment

2.1 General

2.1.1 The anchors are normally to be housed in hawse pipes and anchor pockets of adequate size, scantlings and suitable form to prevent movement of anchor and chain due to wave action.

The arrangements are to provide an easy lead of chain cable from windlass to the anchors. Upon release of the brake, the anchors are to immediately start falling by their own weight. Substantial chafing lips are to be provided at shell and deck. These are to have sufficiently large, radiused faces to minimise the probability of cable links being subjected to large bending stresses. Alternatively, roller fairleads of suitable design may be fitted.

Alternative arrangements for housing of anchors will be specially considered.

2.1.2 The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

2.1.3 The chain locker is to have adequate capacity and depth to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. The chain pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to have separate spaces. The chain lockers boundaries are to be watertight. Provisions are to be made to minimize the ingress of water to the chain locker in bad weather. Adequate arrangement for drainage of chain lockers is to be provided.

Provisions are to be made for securing the inboard ends of the chains to the structure. The strength of this attachment should be between 15 per cent to 30 per cent of the breaking strength of the chain cable. It is recommended that suitable arrangements be provided so that in an emergency the chain can be readily made to slip from an accessible position outside the chain locker.

2.1.4 The windlass and chain stoppers are to be efficiently bedded and secured to deck. The thickness of deck plating is to be increased in way of the windlass and chain stoppers and adequate stiffening underneath is to be provided.

Section 3

Equipment Specification

3.1 Equipment number

3.1.1 The equipment number, EN, on which the requirements of equipment are based is to be calculated as follows: -

\[ EN = \Delta^{2/3} + 0.1A \]

\[ \Delta \] = moulded displacement, [t], corresponding to the maximum load water line

\[ A \] = area \([\text{m}^2]\) in profile view of the hull above the maximum load waterline, including super-structures, deck houses, trunks and hatch coamings, which are within the Rule length of the vessel. Houses of breadth less than B/4 may be disregarded.

In the calculation of A, sheer and trim are to be ignored.

Parts of windscreens or bulwarks which are more than 0.8 [m] in height are to be regarded as parts of houses when determining A.

3.2 Equipment

3.2.1 The anchors, chain cables, towlines and mooring lines for all ships are to comply with Table 3.2.1, except where modified for particular ship types as per 3.2.2 to 3.2.6 below.

3.2.2 For ships without a sharp stem, a single anchor of twice the mass may be fitted in lieu of the two bower anchors required as per the table.

3.2.3 For all self-propelled ships except tugs, operating on rivers where, in view of their length, they cannot safely turn for anchoring with the bow in an upstream direction, the mass of the
stern anchor is to be twice that required as per the table.

3.2.4 For tugs intended for pushing or side tow operations, two stern anchors are to be provided and the mass of each anchor is to be based on EN calculated considering the complete barge train; but not less than 300 [kg].

3.2.5 For tugs intended for towing operations only, stern anchors need not be provided; and for tugs intended for pushing operations only, bower anchors need not be provided.

3.2.6 For non-propelled ships intended to be towed, two stern anchors of the tabular mass or one stern anchor of twice the mass are to be provided.

<table>
<thead>
<tr>
<th>EN</th>
<th>Stockless bower anchors, See Note 1 mass [kg]</th>
<th>Stockless stern anchors, See Note 2 mass [kg]</th>
<th>Towline, (Recommendation) See Note 3 Minimum breaking strength [kN]</th>
<th>Mooring lines, See Note 4 Minimum breaking strength [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 &amp; ≤ 6</td>
<td>35</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 6 &amp; ≤ 8</td>
<td>45</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 8 &amp; ≤ 10</td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>&gt; 10 &amp; ≤ 12</td>
<td>70</td>
<td>-</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>&gt; 12 &amp; ≤ 14</td>
<td>85</td>
<td>-</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>&gt; 14 &amp; ≤ 17</td>
<td>100</td>
<td>-</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>&gt; 17 &amp; ≤ 20</td>
<td>115</td>
<td>-</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>&gt; 20 &amp; ≤ 25</td>
<td>145</td>
<td>-</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>&gt; 25 &amp; ≤ 30</td>
<td>175</td>
<td>-</td>
<td>67</td>
<td>43</td>
</tr>
<tr>
<td>&gt; 30 &amp; ≤ 40</td>
<td>230</td>
<td>115</td>
<td>90</td>
<td>57</td>
</tr>
<tr>
<td>&gt; 40 &amp; ≤ 50</td>
<td>290</td>
<td>145</td>
<td>112</td>
<td>72</td>
</tr>
<tr>
<td>&gt; 50 &amp; ≤ 60</td>
<td>345</td>
<td>175</td>
<td>134</td>
<td>86</td>
</tr>
<tr>
<td>&gt; 60 &amp; ≤ 70</td>
<td>400</td>
<td>200</td>
<td>157</td>
<td>100</td>
</tr>
<tr>
<td>&gt; 70 &amp; ≤ 80</td>
<td>460</td>
<td>230</td>
<td>179</td>
<td>115</td>
</tr>
<tr>
<td>&gt; 80 &amp; ≤ 90</td>
<td>520</td>
<td>260</td>
<td>202</td>
<td>129</td>
</tr>
<tr>
<td>&gt; 90 &amp; ≤ 100</td>
<td>575</td>
<td>290</td>
<td>224</td>
<td>143</td>
</tr>
<tr>
<td>&gt; 100 &amp; ≤ 110</td>
<td>635</td>
<td>320</td>
<td>231</td>
<td>158</td>
</tr>
<tr>
<td>&gt; 110 &amp; ≤ 120</td>
<td>690</td>
<td>345</td>
<td>238</td>
<td>172</td>
</tr>
<tr>
<td>&gt; 120 &amp; ≤ 130</td>
<td>735</td>
<td>370</td>
<td>245</td>
<td>182</td>
</tr>
<tr>
<td>&gt; 130 &amp; ≤ 140</td>
<td>780</td>
<td>390</td>
<td>252</td>
<td>187</td>
</tr>
<tr>
<td>&gt; 140 &amp; ≤ 150</td>
<td>825</td>
<td>420</td>
<td>259</td>
<td>192</td>
</tr>
<tr>
<td>&gt; 150 &amp; ≤ 160</td>
<td>870</td>
<td>435</td>
<td>266</td>
<td>197</td>
</tr>
<tr>
<td>&gt; 160 &amp; ≤ 170</td>
<td>915</td>
<td>460</td>
<td>272</td>
<td>202</td>
</tr>
<tr>
<td>&gt; 170 &amp; ≤ 180</td>
<td>960</td>
<td>480</td>
<td>279</td>
<td>208</td>
</tr>
<tr>
<td>&gt; 180 &amp; ≤ 190</td>
<td>1000</td>
<td>500</td>
<td>286</td>
<td>213</td>
</tr>
<tr>
<td>&gt; 190 &amp; ≤ 200</td>
<td>1045</td>
<td>525</td>
<td>293</td>
<td>218</td>
</tr>
<tr>
<td>&gt; 200 &amp; ≤ 210</td>
<td>1090</td>
<td>550</td>
<td>300</td>
<td>223</td>
</tr>
<tr>
<td>&gt; 210 &amp; ≤ 220</td>
<td>1135</td>
<td>570</td>
<td>307</td>
<td>228</td>
</tr>
<tr>
<td>&gt; 220 &amp; ≤ 230</td>
<td>1180</td>
<td>590</td>
<td>314</td>
<td>233</td>
</tr>
<tr>
<td>&gt; 230 &amp; ≤ 240</td>
<td>1225</td>
<td>615</td>
<td>321</td>
<td>238</td>
</tr>
<tr>
<td>&gt; 240 &amp; ≤ 250</td>
<td>1270</td>
<td>635</td>
<td>328</td>
<td>244</td>
</tr>
</tbody>
</table>
### Table 3.2.1: Equipment - Anchors, anchor cables, towlines and mooring lines (Contd.)

<table>
<thead>
<tr>
<th>EN</th>
<th>Stockless bower anchors, See Note 1 mass [kg]</th>
<th>Stockless stern anchors, See Note 2 mass [kg]</th>
<th>Towline, (Recommendation) See Note 3 Minimum breaking strength [kN]</th>
<th>Mooring lines, See Note 4 Minimum breaking strength [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 250 &amp; ≤ 260</td>
<td>1315</td>
<td>660</td>
<td>335</td>
<td>249</td>
</tr>
<tr>
<td>&gt; 260 &amp; ≤ 270</td>
<td>1360</td>
<td>680</td>
<td>342</td>
<td>254</td>
</tr>
<tr>
<td>&gt; 270 &amp; ≤ 280</td>
<td>1405</td>
<td>700</td>
<td>349</td>
<td>259</td>
</tr>
<tr>
<td>&gt; 280 &amp; ≤ 290</td>
<td>1450</td>
<td>725</td>
<td>355</td>
<td>264</td>
</tr>
<tr>
<td>&gt; 290 &amp; ≤ 300</td>
<td>1495</td>
<td>750</td>
<td>362</td>
<td>269</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Normally two stockless bower anchors are required, but see 3.2.2.

2. i) For self propelled ships, see 3.2.3.
   
   ii) For tugs, see 3.2.4 and 3.2.5.
   
   iii) For non-propelled ships being towed, see 3.2.6

3. The length of the towline is to be not less than given by the following formulae, as appropriate:
   
   a) \( L + 75 \) [m] for ships for which \( 20 \leq EN \leq 160 \).
   
   b) \( L + 100 \) [m] for ships for which \( EN > 160 \).
   
   For tugs intended for towing, the breaking strength of the towline is not to be less than twice the maximum bollard pull.

4. Two mooring lines are required for ships for which \( EN \) is below 100 and three for ships having larger values. The length of each wire in the mooring lines is to be not less than \( 2.5L \), but need not be more than 100 [m].

5. The length of short or stud link chain cable for each bower anchor is to be not less than \( L + 10 \) [m] with a minimum of 40 [m] and a maximum of 60 [m]. The minimum breaking strength of the chosen diameter and grade of short or stud link chain cable or wire is to be not less than 0.343 times the mass of anchor [kg] in case of ordinary anchor and 0.458 times the mass of anchor [kg] in case of HHP anchor.

6. The length of cable for each stern anchor, on ships for which \( EN > 30 \), is to be not less than 40 [m].
Section 4

Anchors

4.1 General

4.1.1 Anchors are to be of an approved design and of a type suitable for the intended service.

4.1.2 The mass of each bower anchor as required in Sec.3 is for anchors of equal mass. The masses of individual anchors may vary by ± 7 per cent of the tabular masses, provided that the total mass of the anchors is not less than would have been required for anchors of equal mass. Where the maximum current expected in service differs considerably from 8 [km/h], the anchor weight required by Table 3.2.1 is to be suitably modified.

4.1.3 The mass of the head, including pins and fittings, of an ordinary stockless anchor is not to be less than 60 per cent of the total mass of the anchor.

4.1.4 The mass 'ex stock' of stocked bower or stream anchors is not to be less than 80 per cent of the tabular mass of ordinary stockless bower anchors. The mass of the stock is to be 25 per cent of the total mass of the anchor including the shackle etc. but excluding the stock.

4.1.5 When anchors of a design approved for the designation 'High Holding Power' are used as bower anchors, the mass of each such anchor may be 75 per cent of the tabular mass of ordinary stockless bower anchors. For approval of HHP anchors, see Pt.3, Ch.15, Cl.4.2 of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).

4.1.6 Anchor shackles are to be of a design and material suitable to the service for which the anchor is intended.

4.2 Manufacture and testing

4.2.1 Anchors and anchor shackles are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10 of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).

Section 5

Anchor Chain Cables

5.1 General

5.1.1 Chain cables may be either short link or stud link and of mild steel or special quality steel meeting the requirements of breaking strength and the length as given in Table 3.2.1. The required chain diameter is to be obtained by using tables of chain breaking strength given in Pt.2, Ch.10 of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).

5.1.2 In conjunction with HHP anchors, only Grade CC2 or ISO Grade 40 chain cable is to be used, however, for HHP anchors having a mass of 300 [kg] or less, Grade CC1 chain cable may be accepted provided the diameter of Grade CC1 cable required is increased by five per cent.

5.1.3 When desired by the Owners, steel wires may be used instead of chain cables. Steel wires are to have a breaking strength not less than that required for chain cables and their length is to be not less than 25 per cent in excess of the length required for chain cable as per Table 3.2.1.

In such cases it is recommended that a short length of chain or a swivel is fitted between the anchor and the wire rope.

5.2 Manufacture and testing

5.2.1 Chain cables, steel wire ropes and shackles are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10 of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).
Section 6

Towlines and Mooring Lines

6.1 General

6.1.1 Towlines and mooring lines may be of steel wire, natural fibre or synthetic fibre and are to be made by an approved manufacturer.

6.1.2 The number, length and breaking strength of towlines and mooring lines are to be as required by Sec.3. Also see Sec.1.1.2.

6.1.3 The lengths of individual mooring lines may be reduced by up to 10 per cent of the tabular length, provided that the total length of mooring lines is not less than would have resulted had all lines been of equal tabular length.

6.1.4 The diameter of a fibre rope is not to be less than 20 mm.

6.2 Manufacture and testing

6.2.1 Steel wire ropes are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10 of the Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).

6.3 Mooring arrangement

6.3.1 Means are to be provided to enable mooring lines to be efficiently secured on board ship by an adequate number of suitably placed bollards on either side of the ship.

6.3.2 Mooring winches should be fitted with drum brakes of sufficient strength to prevent unreeling of the mooring lines.

6.3.3 Adequate stiffening is to be provided in way of Bollards, Mooring winches etc.

Section 7

Windlass

7.1 General

7.1.1 The requirements of 7.1.2 to 7.1.5 apply equally to bow and stern anchor winches.

7.1.2 On ships equipped with anchors having a mass of over 50 kg, windlass(es) of sufficient power and suitable for the type and size of chain cable are to be fitted. Arrangements for anchor davits will be specially considered.

7.1.3 The windlasses may be hand or power operated. Hand operated windlasses are acceptable only if the effort required at the handle does not exceed 15 kgf for raising one anchor at a speed of not less than 2 m/min and making about 30 turns of the handle per minute.

7.1.4 A power operated windlass is to be capable of exerting, for a period not less than 30 minutes, a continuous duty pull of 29 d^2 [N] and to raise one anchor with chain cable at a mean speed of not less than 9 m/min, d [mm] being the diameter required for Grade CC1 chain cable.

7.1.5 Winches suitable for operation by hand as well as by external power are to be so constructed that the power drive cannot activate the hand drive.

7.2 Testing

7.2.1 After installation on board, anchoring tests are to be carried out to demonstrate satisfactory working.

End Of Chapter
Chapter 14

Welding

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
</tr>
<tr>
<td>2</td>
<td>Welding</td>
</tr>
<tr>
<td>3</td>
<td>Welded Connections</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 Scope

1.1.1 Welding in steel hull construction of all types of ships is to comply with the requirements of this Chapter.

Welding in aluminium structures will be specially considered.

1.2 Documentation

1.2.1 Connection details of the welded structural members, including type and size of welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included on the plans.

Details of proposed welding procedure is to be submitted indicating preheating temperature and any postwelding heat treatment, if employed. Extent to which automatic welding, including deep penetration welding, is to be employed should also be indicated.

Section 2

Welding

2.1 Welders and supervision

2.1.1 Welders are to be proficient in the type of work on which they are to be engaged. The records of their tests and qualifications are to be kept by the builders and made available to the Surveyors. A sufficient number of skilled supervisors are to be employed to ensure effective control at all stages of assembly and welding operations.

2.2 Welding electrodes

2.2.1 Electrodes and welding consumables approved by IRS in accordance with the requirements of Pt.2, Ch.11 and suitable for the type of joint and grade of steel, are to be used.

2.2.2 For the connection of two different grades of steel of the same tensile strength properties, electrodes suitable for the lower grade will be generally acceptable except at structural discontinuities or other points of stress concentration.

2.2.3 For the connection of steel of different tensile strengths, the electrodes are to be suitable for the tensile strength of the component, on the basis of which the weld fillet size has been determined in Sec.3.

2.3 Preparation for welding

2.3.1 The parts to be welded are to be fitted in accordance with the approved joint detail. The edge preparation is to be accurate and uniform. Means are to be provided for maintaining the parts to be welded, in correct position during the welding operations. Excessive force is not to be employed in aligning the parts before welding.
and the means employed in maintaining the alignment are to be so arranged as to allow for expansion and contraction during the welding operation. All methods employed in correcting improper alignment are to be to the satisfaction of the Surveyor.

2.3.2 All surfaces to be welded are to be clean, dry and free from rust, scale and grease. The surface and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag before the next run is applied. Before a manual sealing run is applied to the back of a weld, the original root material is to be gouged out to sound metal.

2.3.3 Tack welding is to be kept to a minimum, and where used, should be equal in quality to that of the finished welds. Any defective tack weld is to be cut out before completing the finished welds. Care is to be taken in removing the tack welds to ensure that the structure is not damaged in doing so.

2.4 Welding procedure

2.4.1 Only approved welding procedures are to be used, See 2.5.

2.4.2 Structural arrangements are to be such as to allow adequate access for satisfactory completion of all welding operations. Welded joints are to be so arranged so as to facilitate downhand welding wherever possible.

2.4.3 The sequence of welding is to be so planned that any restraint during welding operations is reduced to a minimum. The ends of the frames and stiffeners should be left unattached to the plating at the subassembly stage until connecting welds are made, in the intersecting systems of plating, framing and stiffeners, at the erection stage.

Where a butt meets a seam, the welding of the seam should be interrupted well clear of the junction and not be continued until the butt is completed. Welding of the butt should continue past the open seam and the weld be chipped out for the seam to be welded straight through.

2.4.4 Adequate precautions are to be taken to ensure that the welding site is protected from the deleterious effects of high moisture, severe wind and extreme cold.

2.5 Approval of procedures

2.5.1 Unless previously approved, welding procedures are to be established by the yard and forwarded to IRS for approval. The welding procedure specifications are to include detailed description of the base material, primer, plate thickness range, joint/groove design, welding consumable, welding position, welding techniques, welding parameters, preheating/interpass temperature and post heat treatment if any.

The welding for procedure qualification and subsequent testing, are to be witnessed by the IRS Surveyor.

2.6 Inspection of welds

2.6.1 Effective arrangements are to be provided for the inspection of finished welds to ensure that all welding has been satisfactorily completed.

2.6.2 All finished welds are to be visually inspected and are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Welds and adjacent base metal are to be free from injurious arc strikes.

2.6.3 For the examination of important structural welds, visual inspection is to be supplemented by radiography or other acceptable non-destructive crack or flaw detection methods. The extent of such examination is to be to the Surveyors’ satisfaction, but particular attention is to be given to the following locations:

a) Junction and crossings of seams and butts in strength deck, sheer strake, side and bottom shell within 0.4L amidships.

b) Butts of keel plating and rounded sheerstrake within 0.4L amidships.

c) Insert plates in way of hatch openings on the strength deck.

d) Butts of longitudinal framing and longitudinal bulkhead stiffeners within 0.4L amidships.

2.6.4 Defective sections of welds as found by visual or non-destructive examination or leakages under hydrostatic tests, are to be gouged out as necessary and carefully rewelded.
Section 3

Welded Connections

3.1 Butt welds

3.1.1 Plates of equal thickness may be manually butt welded as per Fig.3.1.1. For automatic welding procedures and special welding techniques, the welding procedure will be specially considered.

3.1.2 For joints of plates with difference in thickness of more than 4 [mm], the thicker plate is to be tapered. The taper is not to exceed 1:3. Edge preparation after the tapering is to be as indicated in Sec.3.1.1.

3.1.3 All manual butt welds are normally to be welded from both sides. Where a back ceiling run is not practicable or in certain cases when the stress level in the members is very low, welding on one side may be permitted provided the welding process is found satisfactory.

3.1.4 Where stiffening members, attached by continuous fillet welds, cross the finished butt or seam welds, these welds are to be made flush in way of the faying surface. Similarly for butt welds in webs of stiffening members, the butt weld is to be first completed and made flush with the stiffening member before the stiffener is connected to the plating by fillet weld. The ends of the flush portion are to run out smoothly without notches or any sudden change of section. Where such conditions can not be complied with, a scallop is to be arranged in the web of the stiffening member. Scallop sizes are to be of such size and in such a position, that a satisfactory weld can be made.

3.2 'T' connections

3.2.1 The throat thickness (See Fig.3.2.1) of the fillet welds is given by:

\[
throat \text{ thickness} = t_p \cdot \text{weld factor} \cdot \frac{d}{s}
\]

where,

- \( t_p \) = thickness [mm], of the thinner of the two parts being connected.
- \( d \) = distance [mm], between the successive weld fillets.
- \( s \) = length [mm], of the correctly proportioned weld fillets, clear of end craters is not to be less than 75 [mm].

The weld factors for various connections are generally to be as given in Table - 3.2.1.

Where an approved automatic deep penetration procedure is used, the weld factors may be reduced by 15 per cent.

3.2.2 The throat thickness is not to be less than 3.0 [mm] and generally not to be greater than 0.44 \( t_p \) for double continuous welds and the greater of 0.44 \( t_p \) or 4.5 [mm] for intermittent welds.

![Fig.3.1.1: Manually welded butt joints](image-url)
<table>
<thead>
<tr>
<th>Structural items</th>
<th>Weld Factors</th>
<th>d.c.</th>
<th>Int.weld</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Bottom</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre girder to keel plate or bar keel</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Side girder to bottom shell</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to floors</td>
<td>0.20</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Floors to keel plate</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to shell plating</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to centre girder</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to longitudinal bulkheads</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>stern tube covering</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bottom longitudinal to shell plating</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>Double Bottom, See Note 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre girder or duct keel to keel plate</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to inner bottom</td>
<td>0.25</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Side girder to bottom shell</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to inner bottom</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to floors</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Floors to shell plating</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to inner bottom/margin plate</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to centre girder/keel plate</td>
<td>0.20</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Margin plate to shell plating</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to inner bottom</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Inner bottom to side shell</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Tank side brackets to shell plating</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to margin plate</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bracket floor to inner bottom/bottom shell</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to centre girder</td>
<td>0.25</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to side shell/margin plate</td>
<td>0.25</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bottom frames to shell plating</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Reverse frames to inner bottom</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Longitudinals to shell plating</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to inner bottom</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Tank boundaries and bilge wells</td>
<td>0.40</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Stiffeners to floors and girders</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Structural items</td>
<td>Weld Factors</td>
<td>d.c.</td>
<td>Int.weld</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Structure in Machinery Space</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floors and girders</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to shell &amp; inner bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td>0.2</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Transverse &amp; longitudinal frames</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to shell plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to centre girder in engine, thrust</td>
<td>0.50</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>blocks &amp; boiler seatings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– in single bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– in double bottom</td>
<td>0.30</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Main engine foundation girders</td>
<td>0.5</td>
<td></td>
<td>*</td>
<td>See Note 2</td>
</tr>
<tr>
<td>to top plate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to hull structure</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Floors</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to engine girder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brackets etc.</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to engine girders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Side Structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse frames</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to side shell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– in tanks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– elsewhere</td>
<td>0.11</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Side longitudinals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to shell plating</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Web frames &amp; side stringers</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to shell plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– within 0.2 x span from ends</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– elsewhere</td>
<td>0.20</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plate and tripping bracket</td>
<td>0.15</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Web frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to side stringers</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bilge keel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to ground bars</td>
<td>0.2</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bilge keel ground bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to side shell</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td>Single cont.</td>
</tr>
<tr>
<td><strong>Deck Structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to shell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other decks</td>
<td>0.3</td>
<td></td>
<td>*</td>
<td>Generally</td>
</tr>
<tr>
<td>to shell and bulkheads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck beams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to deck plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– in tanks</td>
<td>0.13</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>– elsewhere</td>
<td>0.11</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Deck longitudinals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to decks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck girders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to deck plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– within 0.2 x span from ends</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>– elsewhere</td>
<td>0.20</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plating and tripping brackets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantilever webs</td>
<td>0.35</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to shell, decks, face plates and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>longitudinal girders at ends</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pillars</td>
<td>0.40</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to deck, inner bottom and pillar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>brackets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural items</td>
<td>Weld Factors</td>
<td>d.c.</td>
<td>Int.weld</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Construction in 0.25L from F.P.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floors &amp; girders</td>
<td>to shell</td>
<td>0.25</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to inner bottom</td>
<td>0.25</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Bottom longitudinals</td>
<td>to shell</td>
<td>0.15</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>to transverse &amp; longitudinal side framing</td>
<td>0.15</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Panting stringers</td>
<td>to shell &amp; frames</td>
<td>0.30</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>All internal structure</td>
<td>in fore peak (unless a higher factor is specified)</td>
<td>0.13</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>Aft Peak Construction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All internal structure</td>
<td>on bottom, side shell &amp; aft peak bulkhead</td>
<td>0.3</td>
<td>*</td>
<td>See 3.2.5</td>
</tr>
<tr>
<td><strong>Bulkheads and Partitions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundaries of</td>
<td>watertight, oiltight &amp; wash bulkheads and shaft tunnels</td>
<td>0.4</td>
<td>*</td>
<td>To be specially considered for chemical cargo tanks</td>
</tr>
<tr>
<td>Stiffeners</td>
<td>on tank &amp; wash bulkheads</td>
<td>0.13</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>on pillar bulkheads</td>
<td>0.13</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>on ordinary bulkheads</td>
<td>0.11</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Vertical &amp; horizontal girders in tanks &amp; wash bulkheads</td>
<td>to bulkhead plating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– within 0.2 x span from ends</td>
<td>0.40</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– elsewhere</td>
<td>0.40</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to faceplate</td>
<td>0.30</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to tripping brackets</td>
<td>0.30</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Vertical &amp; horizontal girders elsewhere</td>
<td>to bulkhead plating</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– within 0.2 x span from ends</td>
<td>0.35</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– elsewhere</td>
<td>0.20</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to faceplate &amp; tripping brackets</td>
<td>0.15</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>Primary Structures in Cargo Tanks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Webs</td>
<td>to shell, deck &amp; bulkheads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– within 0.2 x span from ends</td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– elsewhere</td>
<td>0.3</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Webs</td>
<td>to face plates</td>
<td>0.3</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Webs</td>
<td>to webs of other primary members</td>
<td>0.3</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Boundaries</td>
<td>of tripping brackets</td>
<td>0.15</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>Superstructures &amp; deckhouses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External bulkheads</td>
<td>to deck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– on 1st and 2nd tiers</td>
<td>0.40</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– elsewhere</td>
<td>0.25</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Internal bulkheads</td>
<td>boundaries</td>
<td>0.13</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Stiffeners</td>
<td>to external bulkheads</td>
<td>0.10</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Structural items</td>
<td>Weld Factors</td>
<td>d.c.</td>
<td>Int.weld</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>Hatchways and closing appliances</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hatch coaming</td>
<td></td>
<td>0.5</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to deck at corners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to deck elsewhere</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to hatch cover rest bar</td>
<td></td>
<td>0.16</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Hatch cover</td>
<td></td>
<td>0.12</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to stiffeners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudders &amp; Nozzles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main piece members</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to coupling flange</td>
<td>F.P.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to each other</td>
<td></td>
<td>0.44</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Rudder plating</td>
<td></td>
<td>0.20</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to rudder webs, elsewhere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nozzles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>generally as for rudders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous fittings &amp; equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Framing ring for manhole type covers</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to deck &amp; bulkhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Framing around ports and W.T./oiltight doors</td>
<td>to plating</td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Sea-chest boundary welds</td>
<td></td>
<td>0.5</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>exposed to sea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>elsewhere</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Ventilators, air pipes etc.</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulwark stays</td>
<td></td>
<td>0.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>to deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to bulwark plating</td>
<td></td>
<td>0.2</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Fabricated anchors</td>
<td></td>
<td>F.P.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- D.C. = double continuous
- F.P. = Full penetration weld
- Note 1: For tank boundaries see 3.2.5.
- Note 2: Preferably to be deep penetration or full penetration weld depending on the thickness of the engine girders.
- Note 3: Generally full penetration, but alternative proposals may be considered.
- Note 4: See Chapter 12, Section 4.1.
3.2.3 The leg length is not to be less than 2 times the specified throat thickness.

3.2.4 Where the connection is highly stressed, deep penetration or full penetration welding may be required. Where full penetration welding is required, the abutting plate may require to be beveled.

3.2.5 Continuous welding is to be adopted in the following locations and in any other region of high dynamic loading:

a) Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.

b) Boundaries of tanks and watertight compartments.

c) All structures in the afterpeak and the afterpeak bulkhead stiffeners.

d) All framing within holds of bulk carriers intended for carriage of coal.

e) All welding inside tanks intended for chemicals or edible liquid cargoes.

f) All lap welds in tanks.

g) Primary and secondary members to plating in way of end connections and end brackets to plating in the case of lap connection.

h) Other connections as given in Table - 3.2.1.

3.2.6 Where intermittent welding is used, the welding is to be made continuous around the ends of brackets, lugs, scallops and at other orthogonal connections with other members. In tanks for water ballast, cargo oil or fresh water, only scalloped welding is to be used.
3.2.7 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 [mm] on each side of the boundary. Alternatively, a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

3.3 Lap connections

3.3.1 Overlaps are not to be used to connect plates which may be subjected to high tensile or compressive loading. However, where they are adopted, the width of overlap is to be adequate to ensure a good weld, the surfaces are to be in close contact and the joints should be closed all round by continuous fillet weld.

3.4 Slot weld

3.4.1 For the connection of plating to internal webs, where access for welding is not practicable, the closing plating is to be attached by continuous full penetration or slot welds to flat bars fitted to the webs. Slots are to be well rounded at ends, to have a minimum length of 75 [mm] and in general, a minimum width of twice the plating thickness. The distance between the slots is not to exceed 150 [mm]. Complete filling of the slots is normally not permitted.

3.5 End connection

3.5.1 In way of the end connections of girders double continuous welding is to be used all around. The weld area is not to be less than the cross-sectional area of the member, and the throat thickness not less than that given by Table 3.2.1 for girder ends.

3.5.2 Where stiffeners have bracketed end connections, bracket arms are to be welded all around and the throat thickness is not to be less than 0.35 times the thickness of bracket.

3.5.3 Where stiffeners are continuous at girder, they are to be connected to the webs, either directly and/or by means of lugs. The weld area is to be such that the shear stress does not exceed 80/k [N/mm²]. Where the shear forces are high, a double sided connection to the web and/or a web stiffener welded on top of the continuous stiffener may be required.

End Of Chapter
Chapter 15

Hull Inspection, Workmanship and Testing

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Hull Inspection</th>
<th>Workmanship</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section 1

Hull Inspection

1.1 Approval of works

1.1.1 The builders, intending to class vessels to be built at their yard with IRS, are to demonstrate their capability to carry out the fabrication to acceptable quality standards before the commencement of the fabrication. Similar approval procedure shall apply to subcontractor's works also. Previous experience in the building and repair of relevant structures and equipment can be considered favourably in this regard.

1.2 Inspection facilities

1.2.1 Adequate facilities are to be provided to enable the Surveyor to carry out a satisfactory inspection of all components during each stage of prefabrication and construction.

Section 2

Workmanship

2.1 General

2.1.1 All workmanship is to be of good quality and in accordance with good shipbuilding practice. Any defect is to be rectified to the satisfaction of the Surveyor before being covered with paint, cement or other composition.

2.1.2 The assembly sequence and welding sequence are to be agreed prior to construction and are to be to the satisfaction of the Surveyor.

2.2 Plate edges and cut-outs

2.2.1 Openings, holes and other cut-outs in the main structural components are to be rounded off by adequately large radii. The free edges of cut-outs, hatch corners etc. are to be properly prepared and are to be free from notches. All edges should be fairied.

2.3 Cold forming

2.3.1 Flanging and bending of plates while cold forming are not to have an average bending radius less than three times the plating thickness. The minimum radius is not to be less than twice the plating thickness.

2.3.2 During joggling of plates and profiles, the depth of joggle is not to be less than four times and the bending radius not less than twice the web thickness.

2.4 Hammering, bending and straightening

2.4.1 Steel being worked on when hot, is not to be overheated, and it is to be hammered and bent in the appropriate heat condition. Steel which is burnt, is not to be used.

2.4.2 Flame heating may be employed to straighten buckled plating when the buckling is not severe.
### Section 3

#### Testing

**3.1 Definitions**

3.1.1 Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

Protective coating is a final coating protecting the structure from corrosion.

3.1.2 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. When a hydropneumatic testing is performed, the conditions should simulate, as far as practicable, the actual loading of the tank.

3.1.3 Hydropneumatic testing is a combination of hydrostatic and air testing, consisting of filling the tank with water up to its top and applying an additional air pressure. The value of the additional air pressure is to be at least as given in Sec.3.4.

3.1.4 Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.

3.1.5 Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and to other components which contribute to the watertight or weathertight integrity of the hull.

**3.2 Application**

The requirements of this Section apply to:

- tanks, including independent tanks
- watertight or weathertight structures.

The purpose of these tests is to check the tightness and/or the strength of structural elements.

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.

For the general testing requirements, See Sec.3.8 and Sec.3.9.

**3.3 Structural testing**

3.3.1 Structural testing as required in Table 3.3.1 may be carried out before or after launching.

Shop primer may be applied before carrying out the structural testing.

3.3.2 Structural testing may be carried out after the protective coating has been applied, provided that one of the following two conditions is satisfied:

a) all the welds are completed and carefully inspected visually to the satisfaction of the Surveyor, prior to the application of the protective coating,

b) leak testing is carried out prior to the application of the protective coating.

However, when leak testing is not carried out, protective coating in way of the following welds should be applied only after the structural testing has been satisfactorily completed:

- all erection welds, both manual and automatic
- all manual fillet weld connections on tank boundaries and manual penetration welds.

**3.4 Leak testing**

3.4.1 Where leak testing is carried out in accordance with Table 3.3.1, an air pressure of 7 [KN/m$^2$] is to be applied during the test.

Prior to inspection, it is recommended that the air pressure in the tank is raised to 10 [KN/m$^2$] and kept at this level for about 1 hour to reach a stabilized state, with a minimum number of personnel in the vicinity of the tank, and then lowered to the test pressure.

3.4.2 Welds are to be coated with an efficient indicating liquid.

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 to verify the test pressure. The U-tube should 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 equally reliable, may be accepted.

3.4.3 Where leak testing is carried out it should be prior to the application of a protective coating, on all fillet weld connections on tank boundaries, penetrations and erection welds on tank boundaries excepting welds made by automatic processes. Selected locations of automatic erection welds and pre-erection manual or automatic welds may require to be similarly tested at the discretion of the Surveyor, taking account of the quality control procedures operating in the shipyard. For other welds, leak testing may be carried out after the protective coating has been applied, provided that these welds were carefully inspected visually to the satisfaction of the Surveyor.

Any other recognized 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 3.3.1, a minimum pressure in the hose of at least 200 [KN/m²] is to be applied at a maximum distance of 1.5 [m]. The nozzle diameter is not to be less than 12 [mm].

3.6 Hydropneumatic testing

When hydropneumatic testing is performed, the same safety precautions as for leak testing (See Sec.3.4) are to be adopted.

3.7 Other testing methods

Other testing methods may be accepted, at the discretion of IRS, based upon equivalency considerations.

3.8 General testing requirements

General requirements for testing are given in Table 3.3.1.

3.9 Additional requirements for special type vessels/tanks

In addition to the requirements of Table 3.3.1, particular requirements for testing of certain spaces within the cargo area of following types of vessels are given in Table 3.9.1.

- edible liquid carriers
- chemical carriers

These requirements intend generally to verify the adequacy of the structural design of the tank, based on the loading conditions on which the scantlings of the tank structure were determined.
<table>
<thead>
<tr>
<th>Item number</th>
<th>Structure to be tested</th>
<th>Type of testing</th>
<th>Structural test pressure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Double bottom tanks</td>
<td>Structural testing[a]</td>
<td>The greater of the following: − head of water up to the top of overflow − head of water up to the uppermost continuous deck</td>
<td>Tank boundaries tested from at least one side</td>
</tr>
<tr>
<td>2</td>
<td>Double side tanks</td>
<td>Structural testing[a]</td>
<td>The greater of the following: − head of water up to the top of overflow − 1.0 [m] head of water above highest point of tank</td>
<td>Tank boundaries tested from at least one side</td>
</tr>
<tr>
<td>3</td>
<td>Tank bulkheads, deep tanks, Fuel oil bunkers</td>
<td>Structural testing[b]</td>
<td>The greater of the following: − head of water up to the top of overflow − 1.0 [m] head of water above highest point of tank − setting pressure of the safety relief valves, where relevant</td>
<td>Tank boundaries tested from at least one side</td>
</tr>
<tr>
<td>4</td>
<td>Fore peak and after peak used as tank</td>
<td>Structural testing</td>
<td>The greater of the following: − head of water up to the top of overflow − 1.0 [m] head of water above highest point of tank</td>
<td>Test of the after peak carried out after the stern tube has been fitted</td>
</tr>
<tr>
<td></td>
<td>Fore peak not used as tank</td>
<td>Structural testing</td>
<td>− head of water up to the uppermost continuous deck for cargo ships and bulkhead deck for passenger ships</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After peak not used as tank</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Watertight bulkheads</td>
<td>Hose testing[c]</td>
<td>Water pressure head up to the uppermost continuous deck for cargo ships and bulkhead deck for passenger ships</td>
<td>Thorough inspection of bulkhead to be carried out</td>
</tr>
<tr>
<td>6</td>
<td>Watertight doors below uppermost continuous deck or bulkhead deck</td>
<td>Structural testing[d]</td>
<td>− Water pressure head up to the uppermost continuous deck for cargo ships and bulkhead deck for passenger ships</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Double plate rudders</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Shaft tunnel clear of deep tanks</td>
<td>Hose testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Shell doors</td>
<td>Hose testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Weathertight hatchcovers and closing appliances</td>
<td>Hose testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Chain locker (if aft of collision bulkhead).</td>
<td>Structural testing</td>
<td>Head of water up to the top</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Independent tanks</td>
<td>Structural testing</td>
<td>Head of water up to the top of overflow, but not less than 0.9 [m].</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Ballast ducts</td>
<td>Structural testing</td>
<td>Ballast pump maximum pressure</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

[a] Leak or hydropneumatic testing may be accepted under the conditions specified in 3.4, provided that at least one tank for each type is structurally tested. This however does not apply to cargo space boundaries in tankers and tanks for segregated cargoes or pollutants. If the structural test reveals weakness or severe faults not detected by the leak test, all tanks are to be structurally tested.

[b] Where applicable, the highest point of tank is to be measured to the deck and excluding hatches.

[c] When hose test cannot be performed without damaging possible outfitting (machinery, cables, switchboards, insulation, etc.) already installed, it may be replaced, at the discretion of IRS by a careful visual inspection of all the crossings and welded joints; where necessary, dye penetrant test or ultrasonic leak test may be required.

[d] The test may be made before or after the door is fitted. In case test is done before, hose testing is to be carried out in place after the door is fitted.
### Table 3.9.1: Additional testing requirements for spaces within the cargo area of certain types of ships

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Types of ships</th>
<th>Structure to be tested</th>
<th>Testing requirements</th>
<th>Structural test pressure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Edible liquid carriers</td>
<td>Independent tanks</td>
<td>Structural testing</td>
<td>Head of water up to the top of overflow without being less than 0.9 [m]</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chemical carriers</td>
<td>Integral or independent tanks</td>
<td>Structural testing of cargo tanks boundaries from at least one side</td>
<td>The greater of the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>− 1.0 [m] head of water above highest point of tank</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>− setting pressure of the safety relief valves, where relevant</td>
<td></td>
</tr>
</tbody>
</table>

**End Of Chapter**
Indian Register of Shipping

Part 4

Main and Auxiliary Machinery

Contents

Chapter 1  General Requirements for the Design and Construction of Machinery
Chapter 2  Piping Design Requirements
Chapter 3  Pumping and Piping
Chapter 4  Prime Movers and Propulsion Shafting Systems
Chapter 5  Boilers and Pressure Vessels
Chapter 6  Steering Gear
Chapter 7  Control Engineering Systems
Chapter 8  Electrical Installations - Equipment and Systems
Chapter 9  Fire Protection, Detection and Extinction
Chapter 10  Spare Gear
Contents

Chapter 1

General Requirements for the Design and Construction of Machinery

Section 1

General

1.1 Scope
1.2 Machinery to be constructed under survey
1.3 Extent of survey
1.4 Departures from the rules
1.5 Plans and particulars
1.6 Availability of machinery for operation
1.7 Ambient reference conditions
1.8 Power ratings
1.9 Units
1.10 Power conditions for generator sets
1.11 Fuel
1.12 Astern power

Section 2

Machinery Room Arrangements

2.1 General

Section 3

Trials

3.1 General
3.2 Trials

Section 4

Certification of Machinery and Components based upon Quality Management Systems

4.1 General
4.2 Requirements for approval
4.3 Information required for approval
4.4 Approval and maintenance of approval
4.5 Certification of products

Chapter 2

Piping Design Requirements

Section 1

General

1.1 Scope
1.2 Classes of pipes

1.3 Design pressure
1.4 Design temperature
1.5 Design symbols
1.6 Heat treatment
Section 2

Carbon and Low Alloy Steel Pipes and Fittings

2.1 Materials
2.2 Minimum thickness of steel pipes and bends
2.3 Flange connections
2.4 Threaded sleeve joints
2.5 Non-destructive examination of welded pipes
2.6 Post-weld heat treatment

Section 3

Copper and Copper Alloys Pipes and Fittings

3.1 Materials
3.2 Minimum thickness of pipes
3.3 Heat treatment

Section 4

Cast Iron Pipes and Fittings

4.1 Spheroidal or nodular graphite cast iron
4.2 Grey cast iron

Section 5

Plastic Pipes

5.1 General
5.2 Applications
5.3 Intactness of bulkheads and decks
5.4 Design and construction

Section 6

Flexible Hoses

6.1 General
6.2 Applications

Section 7

Hydraulic Tests on Pipes and Fittings

7.1 Hydraulic tests before installation on board
7.2 Testing after assembly on board

Chapter 3

Pumping and Piping

Section 1

General

1.1 Scope
1.2 Plans
1.3 Materials
1.4 Design pressure
1.5 Design temperature
1.6 Redundancy

1.7 Valves and cocks
1.8 Shipside fittings (other than sanitary discharges and scuppers)
1.9 Piping installation

Section 2

Bilge and Ballast Piping Systems

2.1 General
2.2 Drainage of cargo holds
2.3 Drainage from fore and aft peaks

2.4 Drainage from tanks, cofferdams and void spaces

2.5 Drainage from spaces above fore and after peaks and above machinery spaces

2.6 Drainage from machinery spaces

2.7 Sizes of bilge suctions

2.8 Bilge pumps and ejectors

2.9 Pump types

2.10 Bilge piping arrangements and fittings

2.11 Additional requirements for passenger ships

2.12 Ballast system

Section 3

Air and Sounding Piping Systems

3.1 General

3.2 Air pipes

3.3 Sounding arrangements

Section 4

Fuel Oil Systems

4.1 General

4.2 Oil fuel tanks

4.3 Oil fuel piping

4.4 Arrangement of valves, cocks, pumps and fittings

4.5 Filling arrangements

4.6 Oil fuel burning arrangements

Section 5

Engine Cooling Water Systems

5.1 General

5.2 Cooling water main supply

5.3 Cooling water standby supply

5.4 Relief valves on cooling water pumps

5.5 Sea inlets for cooling water pumps

Section 6

Lubricating Oil Piping Systems

6.1 General

6.2 Pumps

6.3 Control of pumps and alarms

6.4 Filters

6.5 Valves and cocks on lubricating oil tanks

Section 7

Engine Exhaust Gas Piping Systems

7.1 General

Section 8

Pumping and Piping Systems for Vessels not Fitted with Propelling Machinery

8.1 Scope

8.2 Vessels without auxiliary power

8.3 Vessels with auxiliary power
Chapter 4

Prime Movers and Propulsion Shafting Systems

Section 1

General

1.1 General
1.2 Materials
1.3 Primemovers and reduction gearing
1.4 Turning Gear

Section 2

Main Propulsion Shafting

2.1 Scope
2.2 Plans and particulars
2.3 Materials for shafting
2.4 Intermediate and thrust shafts
2.5 Tailshafts and tube shafts
2.6 Hollow shafts
2.7 Integral couplings
2.8 Demountable couplings
2.9 Coupling bolts
2.10 Tailshaft liners
2.11 Keys and keyways
2.12 Stern tube and bearings

Section 3

Propellers

3.1 Scope
3.2 Plans and particulars
3.3 Materials
3.4 Design
3.4.1 Minimum blade thickness
3.4.2 Keyless propellers
3.4.3 Controllable pitch propellers
3.5 Fitting of propellers

Section 4

Vibrations and Alignment

4.1 Scope
4.2 Basic system requirements
4.3 Resilient mountings
4.4 Torsional vibration
4.5 Axial vibrations
4.6 Lateral vibrations
4.7 Shaft alignment

Chapter 5

Boilers and Pressure Vessels

Section 1

General

1.1 Scope
1.2 Design pressure
1.3 Metal temperature
1.4 Plans and particulars
1.5 Classification of pressure vessels
1.6 Materials
Chapter 6

Steering Gears

Section 1
General

Section 2
Design Criteria

2.1 General
2.2 Fully powered steering gear

2.3 Manual drive
2.4 Rudder position

2.5 Rudder propellers and Voith Schneider equipment
2.6 Tillers, quadrants and connecting rods
2.7 Locking or brake gear and springs
2.8 Rudder stops

Chapter 7

Control Engineering Systems

Section 1
General Requirements

Section 2
Essential Features for Control and Alarm Systems

2.1 General
2.2 Control station(s) for machinery
2.3 Alarm system
2.4 Control systems

2.5 Fire detection alarms systems

Section 3
Control and Supervision of Machinery

3.1 General
3.2 Oil engines for propulsion purposes
3.3 Boilers
3.4 Auxiliary engines
3.5 Remote control for propulsion machinery
3.6 Controllable pitch propellers and transverse thrust units
3.7 Steering gear
3.8 Main propulsion shafting
Chapter 8

Electrical Installations - Equipment and Systems

Section 1

General Requirements

1.1 General
1.2 Plans
1.3 Additions or alterations
1.4 Application
1.5 Ambient reference conditions
1.6 Location and Construction
1.7 Earthing
1.8 Creepage and Clearance
1.9 Electrical equipment for use in explosive gas atmospheres

Section 2

System Design

2.1 Design
2.1.1 Supply and distribution systems
2.1.2 Earth indication
2.1.3 Number and rating of generating sets
2.1.4 Emergency Source of Power in Passenger Ships
2.1.5 Essential services
2.1.6 Diversity factor
2.1.7 Lighting circuits
2.1.8 Motor circuits
2.1.9 Motor control
2.1.10 Remote stops for ventilation fans and pumps
2.1.11 Steering gear
2.1.12 Fire detection, alarm and extinguishing systems on passenger ships
2.1.13 Navigation Lights
2.1.14 Size of batteries and charging facilities
2.1.15 Heating and cooking equipment
2.1.16 Temporary external supply/shore connection
2.2 Protection
2.2.1 General
2.2.2 Protection against overload
2.2.3 Protection against short-circuit
2.2.4 Combined circuit-breakers and fuses
2.2.5 Protection of circuits
2.2.6 Protection of generators
2.2.7 Protection of feeder circuits
2.2.8 Protection of power transformers
2.2.9 Protection of lighting circuits
2.2.10 Protection of meters, pilot lamps, capacitors and control circuits
2.2.11 Protection of batteries
2.2.12 Protection of communication circuits

Section 3

Cables

3.1 General
3.2 Insulating Materials
3.3 Sheaths and protective coverings
3.4 Voltage rating
3.5 Current rating
3.6 Correction factors for current rating
3.7 Testing

3.8 Connections between entrained ships

3.9 Installation of cables

3.10 Mechanical protection of cables

3.11 Earthing of metal coverings

3.12 Penetration of bulkheads and decks by cables

3.13 Installation of cables in pipes and conduits

3.14 Cables for alternating current

3.15 Cable ends

3.16 Joints and branch circuits in cable systems

**Section 4**

**Switchboards**

4.1 General

4.2 Instruments

4.3 Instrument transformers

4.4 Switchgear

4.5 Fuses

4.6 Testing

**Section 5**

**Control Gear**

5.1 General

5.2 Testing

**Section 6**

**Rotating Machines Construction and Testing**

6.1 General

6.2 Rating

6.3 Temperature rise

6.4 Direct current service generators

6.5 Alternating current service generators

6.6 Inspection and testing

**Section 7**

**Transformers - Construction and Testing**

7.1 General

7.2 Installation

7.3 Construction

7.4 Regulation

7.5 Short circuit

7.6 Tests

**Section 8**

**Miscellaneous Equipment**

8.1 Accumulator Batteries

8.1.1 Construction

8.1.2 Location

8.1.3 Installation

8.1.4 Ventilation

8.2 Luminaries

8.2.1 General

8.3 Accessories - Construction and testing

8.3.1 Enclosures

8.3.2 Inspection and draw boxes

8.3.3 Socket outlets and plugs

8.4 Heating and cooking equipment

8.4.1 General

8.5 Lightning conductors

**Section 9**

**Trials**

9.1 General

9.2 Insulation resistance measurement
Chapter 9

Fire Protection, Detection and Extinction

Section 1

General

1.1 Scope
1.2 Plans and Information
1.3 Definitions
1.4 Ship Types

Section 2

Fire Protection

2.1 General
2.2 Paints and similar coatings
2.3 Ventilation
2.4 Means of escape
2.5 Additional requirements for passenger ships
2.6 Un-propelled vessels

Section 3

Fire Detection

3.1 Cargo ships
3.2 Passenger ships

Section 4

Fire Extinction

4.1 All ships
4.1.1 Fire pumps
4.1.2 Fire main
4.1.3 Hydrants
4.1.4 Fire hoses and nozzles
4.1.5 Portable fire extinguishers
4.1.6 Non-portable fire extinguishers
4.1.7 Fixed fire extinguishing systems
4.2 Additional requirements for Roll-on/Roll-off ships
4.3 Additional requirements for ferries
4.4 Additional requirements for oil and chemical tankers
4.5 Additional requirements for liquefied gas carriers
4.6 Additional requirements for passenger ships
4.6.1 Fire pumps
4.6.2 Portable fire extinguishers
4.6.3 Non-portable fire extinguishers
4.6.4 Fireman’s outfit

Chapter 10

Spare Gear

Section 1

General

1.1 General
1.2 Table of spare parts
Chapter 1

General Requirements for the Design and Construction of Machinery

Contents

Section
1 General
2 Machinery Room Arrangements
3 Trials
4 Certification of Machinery and Components based upon Quality management Systems

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter and those given in Ch.2 to 10 apply to the construction and installation of main propulsion and auxiliary machinery systems, together with their associated equipment, boilers, pressure vessels and pumping and piping arrangements fitted in vessels intended to be classed with IRS.

1.2 Machinery to be constructed under survey

1.2.1 In ships intended to be built under Special Survey, all important units of equipment are to be surveyed at the manufacturer's works. The workmanship is to be to the Surveyor's satisfaction and the Surveyor is to be satisfied that the components are suitable for the intended purpose and duty. Examples of such units are:

- Main propulsion engines, including their associated gearing, flexible couplings, scavenge blowers and superchargers;
- Boilers supplying steam for propulsion or for services essential for the safety or the operation of the ship at sea, including superheaters, economisers, desuperheaters, steam receivers. All other boilers having working pressures exceeding 3.5 bar, and having heating surfaces greater than 4.65 [m²];
- Auxiliary engines of 110 [kW] (150 shp) and over which are the source of power for services essential for safety or for the operation of the ship.
- Steering machinery;
- Athwartship thrust units, their prime movers and control mechanisms;
- All pumps necessary for the safety of vessel, e.g. bilge, ballast, fire pumps, etc.;
- Air compressors, air receivers and other pressure vessels necessary for the operation of main propulsion and essential machinery.
- Alarm and control equipment as detailed in Ch.7; and
- Electrical equipment and electrical propelling machinery as detailed in Ch.8.

1.3 Extent of survey

1.3.1 The Surveyors are to examine and test the materials and workmanship from the commencement of work until the final test of the machinery under full power working conditions. Any defects, etc., are to be indicated as early as possible. On completion, the Surveyors will submit a report and, if this is found to be satisfactory by IRS, a certificate of class will be granted and an appropriate notation assigned in accordance with Pt.1.
1.4 Departures from the rules

1.4.1 Where it is proposed to depart from the requirements of the Rules, IRS will be prepared to give due consideration to the circumstances of any special case.

1.5 Plans and particulars

1.5.1 Before the work is commenced, plans in triplicate of all machinery items, as detailed in the Ch.2 to 9 giving the requirements for individual systems, are to be submitted for approval. The particulars of the machinery, including power ratings and design calculations, where applicable, necessary to verify the design, are also to be submitted. Any subsequent modifications are subject to approval before being put in to operation.

1.5.2 The strength requirements for rotating parts of the machinery, as specified in Ch.4 to 8, are based upon strength consideration only and their application does not relieve the manufacturer from the responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range.

1.6 Availability of machinery for operation

1.6.1 The design and arrangement is to be such that the machinery can be started and controlled on board ship without external aid, so that operating conditions can be maintained under all circumstances.

1.7 Ambient reference conditions

1.7.1 The rating of the main and auxiliary machinery is to be suitable for the temperature conditions associated with the geographical limits of the restricted service.

1.7.2 Machinery installations are to be designed such as to ensure proper operations under the conditions as under:

- Permanent list of 10°
- Permanent trim of 5°

1.8 Power ratings

1.8.1 In the following Chapters, where the dimensions of any particular component are determined from shaft power, P in [kW] (H, in shp), and revolutions per minute, R, the values to be used are to be derived from the following:

For main propelling machinery, the maximum shaft power and corresponding revolutions per minute giving the maximum torque for which the machinery is to be classed; and

For auxiliary machinery, the maximum continuous shaft power and corresponding revolutions per minute which will be used in service.

1.9 Units

1.9.1 Units and formulae included in the Rules are shown in SI units followed by metric units in brackets, where appropriate.

1.9.2 Where the metric version of shaft power, i.e. (shp), appears in the Rules, 1 shp is equivalent to 75 [kgf metre/sec] or 0.735 [kW].

1.9.3 Pressure gauges may be calibrated in bar, where,

1 bar = 0.1 [N/mm²] = 1.02 [kgf/cm²]

1.10 Power conditions for generator sets

1.10.1 Auxiliary engines coupled to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output and, if developing for a short period (15 minutes) an overload power of not less than 10 per cent.

1.10.2 Engine builders are to satisfy the Surveyors by tests on individual engines that the above requirements, as applicable, can be complied with, due account being taken of the deference between the temperature under test conditions and those specified in 1.7.1. Alternatively, where it is not practicable to test the engine/generator set as a unit, type tests (e.g. against a brake) representing a particular size and range of engines may be accepted. With oil engines any fuel stop fitted is to be set to permit the short period overload power of not less than 10 per cent above full rated output being developed.

1.11 Fuel

1.11.1 The flash point (closed cup test) of oil fuel is to be not less than 55°C, unless specially approved. 1.11.2 Fuels with flash points lower than 55°C, but not less than 43°C, unless specially approved, may be used in ships intended for service restricted to certain geographical limits, where it can be ensured that the temperature of the machinery spaces will
always be 10°C below the flash point of the fuel. In such cases, safety precautions and the arrangements for storage and pumping will be specially considered.

1.12 Astern power

1.12.1 Sufficient astern power is to be provided to maintain control of the ship in all normal circumstances.

Section 2

Machinery Room Arrangements

2.1 General

2.1.1 The machinery is to be so designed, installed and protected that risks of fire, explosions, accidental pollution, leakages and accidents thereof, and accidents to personnel working in machinery spaces will be minimised.

2.1.2 The design and arrangement of machinery foundations, shaft connections, piping and ducting is to take into account the effects of thermal expansion, vibrations, mis-alignment and hull interaction to ensure operation within safe limits. Bolts and nuts exposed to dynamic forces and vibrations are to be properly secured.

2.2 Accessibility

2.2.1 Accessibility, for attendance and maintenance purposes, is to be provided for machinery plants.

2.3 Fire protection

2.3.1 All surfaces of machinery where the surface temperature may exceed 220°C and where impingement of flammable liquids may occur are to be effectively shielded to prevent ignition. Where insulation covering these surfaces is oil absorbing or may permit penetration of oil, the insulation is to be encased in steel or equivalent.

2.3.2 Flammable or oil absorbing materials are not to be used in floors, gratings, etc. in boiler and engine rooms, shaft tunnels or in compartments where settling tanks are installed.

2.4 Ventilation

2.4.1 All spaces, including engine and cargo pump spaces, where flammable or toxic gases or vapours may accumulate, are to be provided with adequate ventilation under all conditions.

2.5 Communications

2.5.1 At least one independent means of communication is to be provided between the bridge and engine room control station.

Section 3

Trials

3.1 General

3.1.1 Tests of components and trials of machinery, as detailed in the Chapters giving the requirements for individual systems are to be carried out to the satisfaction of the Surveyors.

3.2 Trials

3.2.1 For all types of installations, the trials are to be of sufficient duration, and carried out under normal maneuvering conditions, to prove the machinery under power. The trials are also to demonstrate that any vibration which may occur within the operating speed range is acceptable.

3.2.2 The trials are to include demonstrations of the following:

- The adequacy of the starting arrangements to provide the required number of starts of the main engines;

- The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal maneuvering conditions, and so bring the ship to rest from maximum ahead rated speeds.
3.2.3 Where controllable pitch propellers are fitted, the free route astern trial is to be carried out with the propeller blades set in full pitch astern position. Where emergency manual pitch setting facilities are provided, their operation is to be demonstrated to the satisfaction of the Surveyors.

3.2.4 All trials are to be to Surveyor's satisfaction.

Section 4

Certification of Machinery and Components based upon Quality Management Systems

4.1 General

4.1.1 This certification scheme is applicable to works where the employment of quality control procedures is well established. IRS will have to be satisfied that the practices employed will ensure that the quality of finished products is to the standards which would be demanded when using traditional survey procedures.

4.1.2 IRS will consider proposed designs for compliance with the Rules, or other appropriate requirements, and the extent to which the manufacturing processes and control procedures ensure conformity of the product to the design. A comprehensive survey will be made by the Surveyors of the actual operation of the quality control programme and of the adequacy and competence of the staff to implement it.

4.1.3 Where IRS considers that the requirements of 4.1.2 can be satisfactorily complied with, the manufacturers will, in general, be approved and authorised to inspect and certify their products.

4.1.4 The procedures and practices of manufacturer which have been granted approval will be kept under continuous review.

4.1.5 Approval by another organization will not normally be acceptable as sufficient evidence that a manufacturer's arrangements comply with IRS requirements.

4.2 Requirements for approval

4.2.1 The manufacturer is required to have adequate equipment and facilities for those operations appropriate to the level of design, development and manufacture being undertaken.

4.2.2 The manufacturer shall demonstrate that the firm has experience consistent with technology and complexity of the product for which approval is sought and that firm's products have been of a consistently high standard.

4.2.3 The manufacturer should have implemented quality management systems generally in accordance with the ISO 9000 series of standards.

4.2.4 The manufacturer shall establish and maintain procedures and controls to ensure that IRS requirements for certification of materials and components at sub-contractor's works are complied with to the satisfaction of IRS.

4.3 Information required for approval

4.3.1 Manufacturers applying for approval under this scheme are to submit the following information:

- Description of the products for which certification is required including, where applicable, model or type number;
- Applicable plans and details of materials used;
- An outline description of all important manufacturing plant and equipment;
- A summary of equipment used for measuring and testing during manufacturing and completion;
- The quality manual;
- The system used for identification and traceability;
- Number and qualification of personnel engaged in quality control and quality assurance; and
- A list of suppliers of materials and components and proposed arrangements to...
ensure compliance with IRS requirements for certification.

4.4 Approval and maintenance of approval

4.4.1 After receipt and appraisal of the information required by 4.3, an assessment of the Works would be carried out by the Surveyors to ensure compliance with the quality manual.

4.4.2 If the initial assessment of the Works confirms that the implementation of the quality management systems is satisfactory, IRS will issue to the manufacturer a Quality Assurance Approval Certificate which will include details of the products for which approval has been given.

4.4.3 An extension of approval in respect of product type may be given at the discretion of IRS without any additional assessment.

4.4.4 The certificate will be valid for 3 years subject to surveillance assessments being carried out every 6 months.

4.4.5 When significant faults or deficiencies are found during surveillance assessments or surveillance assessments are not carried out, the certificate of approval may be withdrawn/suspended at the discretion of IRS.

4.5 Certification of products

4.5.1 After issue of the Quality Assurance Approval Certificate, the manufacturer would be authorized to issue certificate for products on behalf of IRS subject to the certificates being countersigned by IRS Surveyors. Arrangements for this will be specially advised by IRS.
Chapter 2

Piping Design Requirements

Contents

Section

1 General
2 Carbon and Low Alloy Steel Pipes and Fittings
3 Copper and Copper Alloy Pipes and Fittings
4 Cast Iron Pipes and Fittings
5 Plastic Pipes
6 Flexible Hoses
7 Hydraulic Tests on Pipes and Fittings

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter apply to the design and construction of piping systems, including pipe fittings forming parts of such systems but excluding steam piping systems and systems where the temperature exceeds 300°C.

1.1.2 For steam piping systems and systems having temperatures greater than 300°C, the Rules and Regulations for the Construction & Classification of Steel Ships will be applicable.

1.2 Classes of pipes

1.2.1 For the purpose of testing, type of joints to be adopted, heat treatment and welding procedure, piping systems are divided into three classes, as given in Table 1.2.1.

1.2.2 For Class I piping, the Rules and Regulations for the Construction & Classification of Steel Ships will be applicable.

1.2.3 In addition to the pressure piping systems in Table 1.2.1, Class III pipes may be used for open ended piping, e.g. overflows, vents, boiler waste steam pipes, open ended drains etc.

1.3 Design pressure

1.3.1 The design pressure, \( P \), is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve.

1.3.2 The design pressure of feed piping and other piping on the discharge from pumps is to be taken as the pump pressure at full rated speed against a shut valve. Where a safety valve or other protective device is fitted to restrict the pressure to a lower value than the shut valve load, the design pressure is to be the highest set pressure of the protective device.

Table 1.2.1 : Classes of piping systems

<table>
<thead>
<tr>
<th>Piping system</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel oil</td>
<td>( P &gt; 16 ) or ( T &gt; 150 )</td>
<td>( P \leq 16 ) and ( T \leq 150 )</td>
<td>( P \leq 7 ) and ( T \leq 60 )</td>
</tr>
<tr>
<td>Other media</td>
<td>( P &gt; 49 ) or ( T &gt; 300 )</td>
<td>( P \leq 40 ) and ( T \leq 300 )</td>
<td>( P \leq 16 ) and ( T \leq 200 )</td>
</tr>
</tbody>
</table>
1.4 Design temperature

1.4.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C.

1.5 Design symbols

1.5.1 The symbols used in this Chapter are defined as follows:

- \( a \) = percentage negative manufacturing tolerance on thickness;
- \( b \) = bending allowance [mm];
- \( c \) = corrosion allowance [mm];
- \( D \) = outside diameter of pipe [mm] (see 1.5.2);
- \( d \) = inside diameter of pipe [mm] (see 1.5.3);
- \( e \) = weld efficiency factor (see 1.5.4);
- \( P \) = design pressure, in [N/mm²];
- \( Pt \) = hydraulic test pressure, in [N/mm²];
- \( R \) = radius of curvature of a pipe bend at the centreline of the pipe [mm];
- \( T \) = design temperature, in °C;
- \( t \) = the minimum thickness of a straight pipe [mm] including corrosion allowance and negative tolerance, where applicable;
- \( t_b \) = the minimum thickness of a straight pipe to be used for a pipe bend [mm] including bending allowance, corrosion allowance and negative tolerance, where applicable;
- \( \sigma \) = maximum permissible design stress, in [N/mm²].

1.5.2 The outside diameter, \( D \), is subject to manufacturing tolerance, but these are not to be used in the evaluation of formulae.

1.5.3 The inside diameter, \( d \), is not to be confused with nominal size, which is an accepted designation associated with outside diameters of standard rolling sizes.

1.5.4 The weld efficiency factor, \( e \), is to be taken as 1.0 for seamless and electric resistance and induction welded steel pipes. Where other methods of pipe manufacture are proposed, the value of \( e \) will be specially considered.

1.6 Heat treatment

1.6.1 Method of heat treatment and means of temperature control and recording are to be to the satisfaction of Surveyors.

Section 2

Carbon and Low Alloy Steel Pipes and Fittings

2.1 Materials

2.1.1 Materials for Class I and Class II piping systems, also for ship-side valves and fittings and valves on the collision bulkhead, are to be manufactured and tested in accordance with the appropriate requirements of Ch.8, Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships.

2.1.2 Materials for Class III piping systems may be manufactured and tested in accordance with the requirements of acceptable national/international specifications. Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 0.4 [N/mm²]. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

2.2 Minimum thickness of steel pipes and bends

2.2.1 The maximum permissible design stress, \( \sigma \), is to be taken as the lowest of the following values:

\[
\sigma = \frac{E_t}{1.6} \text{ or } \sigma = \frac{R_{20}}{2.7} \text{ or } \sigma = \frac{S_R}{1.6}
\]

where,

- \( E_t \) = specified minimum lower yield or 0.2 per cent proof stress at the design temperature,
- \( R_{20} \) = specified minimum tensile strength at ambient temperature,
- \( S_R \) = average stress to produce rupture in 100,000 hours at the design temperature.
2.2.2 The minimum thickness, \( t \), of straight steel pipes is to be determined by the following formula:

\[
t = \left( \frac{PD}{2\sigma e + P} + b + c \right) \frac{100}{100 - a} \text{ [mm]}
\]

where,

- \( P, D, e, b \) and \( a \) are defined in Sec.1, Cl.1.5.1;
- \( \sigma \) is defined in 2.2.1 and also obtained from Tables 2.2.1.
- \( c \) is obtained from Table 2.2.2.

\[c\text{ obtained from Table 2.2.2.}\]

2.2.3 The minimum thickness, \( t_b \), of a straight steel pipe to be used for a pipe bend is to be determined by the following formula, except where it can be demonstrated that the use of a thickness less than \( t_b \) would not reduce the thickness below \( t \) at any point after bending:

\[
t_b = \left( \frac{PD}{2\sigma e + P} + b + c \right) \frac{100}{100 - a} \text{ [mm]}
\]

where,

- \( P, D, R, e, b \) and \( a \) are defined in Sec.1, Cl.1.5.1;
- \( \sigma \) and \( c \) are defined in tables 2.2.1 and 2.2.2 respectively;

\[b = \frac{D}{2.5R} \left( \frac{PD}{2\sigma e + P} \right) \text{ [mm]}\]

In general, \( R \) is to be not less than 3D.

2.2.4 The minimum thickness calculated in accordance with 2.2.2 and 2.2.3 is not to be less than that given in Table 2.2.4. Where the pipes are efficiently protected against corrosion, the thickness may be reduced by not more than 1.0 [mm]. For threaded pipes, where permitted, the thickness is to be measured at the bottom of the threads.
2.3 Flange connections

2.3.1 Flanges with their pressure-temperature ratings in accordance with recognized national/international standards will normally be accepted.

2.3.2 Flanges may be cut from plates or may be forged or cast. The material is to be suitable for the design temperature. Flanges may be attached to the branches by screwing and expanding or by welding. Alternative methods of flange attachment may be accepted provided details are submitted for consideration.

2.3.3 Examples of accepted flanged connections and their uses are given in Fig. 2.3.1 and Table 2.3.1 respectively.

![Fig. 2.3.1]

Table 2.3.1 : Type of flange connections

<table>
<thead>
<tr>
<th>Class of piping</th>
<th>Lub. and fuel oil</th>
<th>Other media</th>
<th>Typical flange application</th>
<th>t°C</th>
<th>Typical flange application</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>A - B - C</td>
<td>&gt; 250 ≤ 250</td>
<td>A - B - C</td>
<td></td>
<td>A - B - C - D - E</td>
</tr>
<tr>
<td>III</td>
<td>A - B - C - E</td>
<td></td>
<td>A - B - C - D - E</td>
<td></td>
<td>A - B - C - D - E</td>
</tr>
</tbody>
</table>
2.3.4 Where flanges are secured by screwing, as indicated in Fig.2.3.1, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed position of pipe over the thread is not to be appreciably less than the outside diameters of the unscrewed pipe. After the flange has been screwed hard home, the pipe is to be expanded into the flange. The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

2.4 Threaded sleeve joints

2.4.1 Threaded sleeve joints, in accordance with national or other established standards, may be used with carbon steel pipes within the limits given in Table 2.4.1 and for services other than pipe systems conveying combustible fluids.

<table>
<thead>
<tr>
<th>Nominal bore [mm]</th>
<th>Maximum pressure [N/mm²]</th>
<th>Maximum temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 25</td>
<td>1.2</td>
<td>260</td>
</tr>
<tr>
<td>&gt; 25 ≤ 40</td>
<td>1.0</td>
<td>260</td>
</tr>
<tr>
<td>&gt; 40 ≤ 80</td>
<td>0.85</td>
<td>260</td>
</tr>
<tr>
<td>&gt; 80 ≤ 100</td>
<td>0.7</td>
<td>260</td>
</tr>
</tbody>
</table>

2.5 Non-destructive examination of welded pipes

2.5.1 In addition to visual examination of pipe welds by the Surveyors, non-destructive examination of butt and fillet welds is to be carried out in accordance with 2.5.2 to 2.5.4 to the satisfaction of the Surveyors.

2.5.2 Selected butt welds of pipes of outside diameter of 101.6 [mm] and over in Class II piping systems are to be radiographed at Surveyor's discretion. Use of ultrasonic examination in lieu of radiography will be specially considered.

2.5.3 Selected fillet welds in pipes of 101.6 [mm] outside diameter and over in Class II piping systems are to be examined by magnetic particle or liquid penetrant flaw testing at Surveyor's discretion.

2.5.4 Defects in welds are to be rectified and re-examined by the appropriate test method, all to the satisfaction of the Surveyors.

2.6 Post-weld heat treatment

2.6.1 Carbon and carbon-manganese steel pipes and fabricated branch pieces, manufactured from material having a carbon content not exceeding 0.25 per cent and having a thickness exceeding 30 [mm], are to be given a stress relieving heat treatment on completion of welding. All pipes and branches having a carbon content in excess of 0.25 per cent are to be given a stress relieving heat treatment. Where oxy-acetylene welding has been employed, however, all the pipes and branch pieces are to be normalised on completion of welding.

Section 3

Copper and Copper Alloys Pipes and Fittings

3.1 Materials

3.1.1 Materials for Class II piping systems and shipside valves and fittings and valves on the collision bulkhead are to be manufactured and tested in accordance with the requirements of Ch.8, Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships.

3.1.2 Materials for Class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national/international specifications. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

3.1.3 Pipes are to be seamless and branches are to be provided by cast or stamped fittings, pipe pressings or other approved fabrications.

3.1.4 Brazing and welding materials are to be suitable for the operating temperature and for the medium being carried. All brazing and welding are to be carried out to the satisfaction of the Surveyors.
3.1.5 In general, the maximum permissible service temperature of copper and copper alloy pipes, valves and fittings is not to exceed 200°C for copper and aluminium brass, and 300°C for copper nickel. Cast bronze valves and fittings complying with the requirements of Ch.8, Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships may be accepted up to 260°C.

3.2 Minimum thickness of pipes

3.2.1 The minimum thickness, \( t \), of straight copper and copper alloy pipes is to be determined by the following formula:

\[
t = \left( \frac{PD}{2 \sigma + P} + c \right) \frac{100}{100 - a} \text{ [mm]}
\]

where \( P, D \) and \( a \) are as defined in Sec.1, Cl.1.5.1;

\( \sigma \) = maximum permissible design stress, in [N/mm²], from Table 3.2.1; intermediate values of stresses may be obtained by linear interpolation;

\( c \) = corrosion allowance;

\( = 0.8 \text{ [mm]} \) for copper, aluminium brass and copper-nickel alloys where the nickel content is less than 10 per cent;

\( = 0.5 \text{ [mm]} \) for copper-nickel alloys where the nickel content is 10 per cent or greater;

\( = 0 \) where the media are non-corrosive relative to the pipe material.

<table>
<thead>
<tr>
<th>Pipe material</th>
<th>Condition of supply</th>
<th>Specified min. tensile strength [N/mm²]</th>
<th>Permissible stress [N/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Copper</td>
<td>Annealed</td>
<td>220</td>
<td>41.2</td>
</tr>
<tr>
<td>Aluminium brass</td>
<td>Annealed</td>
<td>320</td>
<td>78.5</td>
</tr>
<tr>
<td>90/10 copper nickel iron</td>
<td>Annealed</td>
<td>270</td>
<td>68.6</td>
</tr>
<tr>
<td>70/30 copper nickel</td>
<td>Annealed</td>
<td>360</td>
<td>81.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Maximum design temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Copper</td>
<td>Annealed</td>
<td>220</td>
<td>18.6</td>
</tr>
<tr>
<td>Aluminium brass</td>
<td>Annealed</td>
<td>320</td>
<td>24.5</td>
</tr>
<tr>
<td>90/10 copper nickel iron</td>
<td>Annealed</td>
<td>270</td>
<td>58.8</td>
</tr>
<tr>
<td>70/30 copper nickel</td>
<td>Annealed</td>
<td>360</td>
<td>69.6</td>
</tr>
</tbody>
</table>

3.2.2 The minimum thickness, \( t_b \), of a straight seamless copper or copper alloy pipe to be used for a pipe bend is to be determined by the formula below, except where it can be demonstrated that the use of a thickness less than \( t_b \) would not reduce the thickness below \( 't' \) at any point after bending:

\[
t_b = \left( \frac{PD}{2 \sigma + P} + b + c \right) \frac{100}{100 - a} \text{ [mm]}
\]

where \( P, D, b \) and \( c \) are defined in Sec.1, Cl.1.5.1, and \( e \) and \( c \) are defined in 3.2.1

\[
b = \frac{D}{2.5R} \left( \frac{PD}{2 \sigma + P} \right) \text{ [mm]}
\]

In general, \( R \) is to be not less than 3D.
Table 3.2.2 : Limiting design conditions for threaded sleeve joints

<table>
<thead>
<tr>
<th>Standard pipe sizes (outside diameter) [mm]</th>
<th>Minimum overriding nominal thickness [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copper</td>
</tr>
<tr>
<td>8 to 10</td>
<td>1.0</td>
</tr>
<tr>
<td>12 to 20</td>
<td>1.2</td>
</tr>
<tr>
<td>25 to 44.5</td>
<td>1.5</td>
</tr>
<tr>
<td>50 to 76.1</td>
<td>2.0</td>
</tr>
<tr>
<td>88.9 to 108</td>
<td>2.5</td>
</tr>
<tr>
<td>133 to 159</td>
<td>3.0</td>
</tr>
<tr>
<td>193.7 to 267</td>
<td>3.5</td>
</tr>
<tr>
<td>273 to 457.2</td>
<td>4.0</td>
</tr>
<tr>
<td>508</td>
<td>4.5</td>
</tr>
</tbody>
</table>

3.2.3 Where the minimum thickness calculated by 3.2.1 or 3.2.2 is less than shown in Table 3.2.2, the minimum nominal thickness for the appropriate standard pipe size shown in the Table is to be used. No allowance is required for negative tolerance or reduction in thickness due to bending on this nominal thickness. For threaded pipes, where permitted, the minimum thickness is to be measured at the bottom of the thread.

3.3 Heat treatment

3.3.1 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to being tested by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

Section 4

Cast Iron Pipes and Fittings

4.1 Spheroidal or nodular graphite cast iron

4.1.1 Spheroidal or nodular graphite iron castings for pipes, valves and fittings in Class II and III piping systems are to be made in a grade having a specified minimum elongation not less than 12 per cent on gauge length of $5.65 \sqrt{S_o}$, where $S_o$ is the actual cross-sectional area of the test piece.

4.1.2 Castings for Class II and III systems, also for ship-side valves and fittings and valves on collision bulkhead, are to be manufactured and tested in accordance with the requirements of acceptable national specifications. A manufacturer's test certificate will be accepted and is to be provided for each consignment of material.

4.1.3 Where the elongation is less than the minimum required by 4.1.1, the material is, in general, to be subject to the same limitations as grey cast iron.

4.2 Grey cast iron

4.2.1 Grey cast iron pipes, valves and fittings will, in general, be accepted in Class III piping systems except as stated in 4.2.2.

4.2.2 Grey cast iron is not to be used for the following:

a) Pipes for steam systems and fire extinguishing systems;
b) Pipes, valves and fittings for boiler blow down systems and other piping systems subject to shock or vibration;
c) Ship-side valves and fittings;
d) Valves fitted on collision bulkhead;
e) Clean ballast lines through cargo oil tanks to forward ballast tanks;
f) Bilge lines in tanks;
g) Outlet valves of fuel tanks with static head.

4.2.3 Grey iron castings for piping systems are to comply with acceptable national/international specifications.
5.1 General

5.1.1 Proposals to use plastics material in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions of temperature and pressure, and the intended service. Any proposed service for plastics pipe not mentioned in these Rules is to be submitted for special consideration.

5.1.2 The specification of the plastics material, including mechanical and thermal properties and chemical resistance data, is to be submitted for consideration.

5.1.3 These requirements are applicable to thermo-plastic pipes but, where appropriate, may also be applied to pipes manufactured in fibre-reinforced thermosetting resins.

5.1.4 Plastics pipes are not to be used where they will be subjected to temperatures above 60°C or below 0°C. Special consideration will be given to particular materials in appropriate applications at higher temperatures.

5.2 Applications

5.2.1 Plastics pipes of approved type may be used for the following services:

a) Air and sounding pipes to tanks used exclusively for carrying water ballast or fresh water, with the exception of the portion above deck;

b) Sounding pipes to cargo holds;

c) Water ballast and fresh water pipes situated inside tanks used exclusively for carrying water ballast or fresh water; and

d) Scupper pipes draining inboard provided they are not led within the boundaries of refrigerated chambers. The first two items (a and b) are not applicable to passenger ships.

5.2.2 Plastics pipes may be used for domestic and similar services for which there are no Rule requirements, such as for the following:

a) Domestic cold sea and fresh water systems;

b) Sanitary systems;

c) Sanitary and domestic waste pipes wholly situated above the freeboard deck; and

d) Water pipes associated with air conditioning plants.

Notwithstanding the foregoing, plastics pipes are not to be used in sea water systems where leakage or failure of the pipes could give rise to the danger of flooding.

5.2.3 Since plastics materials are generally heat sensitive and very susceptible to fire damage, plastics pipes will not be acceptable for service essential to safety, such as the following:

a) Fire extinguishing pipes;

b) Bilge pipes in cargo holds;

c) Bilge and ballast pipes in the machinery space;

d) Main and auxiliary water circulating pipes;

e) Feed and condensate pipes; and

f) Pipes carrying oil or other flammable liquids.

5.3 Intactness of bulkheads and decks

5.3.1 Where plastics pipes are arranged to pass through watertight or fire-resisting bulkheads or decks, provision is to be made for maintaining the integrity of the bulkhead or deck in the event of pipe failure. Details of the arrangements are to be submitted for approval.
5.4 Design and construction

5.4.1 Pipes and fittings are to be of robust construction and are to comply with the requirements of such national/international standards as may be consistent with their intended use. Particulars of scantlings and joints are to be submitted for consideration.

5.4.2 All pipes are to be adequately but freely supported. Suitable provision for expansion and contraction is to be made in each range of pipes to allow for large movements between plastics pipe and steel structure, the coefficient of thermal expansion for plastics being eight or more times that of steel.

5.4.3 All fittings and branches are to be suitable for the intended service and are to have joints of cemented, flanged or other approved types.

5.4.4 The strength of the pipes and fittings and the acceptability of any jointing system employed is to be check tested at the Surveyor's discretion. The strength of pipes, fittings, joints between pipes and joints between pipes and fittings, as appropriate, is to be determined by hydraulic pressure tests to destruction of sample assemblies. The pressure is to be so applied that failure of the test sample assembly occurs in not less than 5 minutes. Deformation of the pipes and fittings during tests is acceptable.

Section 6

Flexible Hoses

6.1 General

6.1.1 Short joining lengths of flexible hoses of approved type may be used, where necessary to accommodate relative movement between various items of machinery connected to permanent piping systems.

6.1.2 For the purpose of approval for the applications in 6.2, details of the materials and construction of the hoses, and the method of attaching the end fittings, are to be submitted for consideration.

6.1.3 In general, the use of hose clips as a means of securing the ends of hoses is to be restricted to the engine cooling water system, where the hose consists of a short, straight length joining two metal pipes, between two fixed points on the engine.

6.1.4 Prototype pressure tests are to be carried out on each new type of hose, complete with end fittings, and in no case is the bursting pressure to be less than five times the maximum working pressure in service.

6.1.5 Attention is to be given to any statutory requirements of the National Authority of the country in which the ship is to be registered. Such requirements may include a fire test for hoses that are intended to be used in systems conveying flammable fluids or sea water.

6.2 Applications

6.2.1 Synthetic rubber hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea water cooling systems. In the case of sea water systems, where failure of the hoses could give rise to the danger of flooding, the hoses are to be suitably enclosed.

6.2.2 Synthetic rubber hoses, with single or double closely woven integral wire braid reinforcement, or convoluted metal pipes with wire braid protection, may be used in bilge, ballast, compressed air, fresh water, sea water, fuel oil and lubricating oil systems. Where synthetic rubber hoses are used for fuel oil supply to burners, the hoses are to have external wire braid protection in addition to the integral wire braid.
Section 7

Hydraulic Tests on Pipes and Fittings

7.1 Hydraulic tests before installation on board

7.1.1 All Class II pipes and their associated fittings are to be tested by hydraulic pressure to the Surveyor’s satisfaction. Further, all steam, feed, compressed air and fuel oil pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 0.35 \( N/mm^2 \). The test is to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

7.1.2 The test pressure is to be 1.5 times the design pressure.

7.1.3 All valve bodies are to be tested by hydraulic pressure to 1.5 times the nominal pressure rating at ambient temperature. However, the test pressure need not be more than 7 \( N/mm^2 \) above the design pressure specified for the design temperature.

7.2 Testing after assembly on board

7.2.1 Heating coils in tanks and fuel oil piping are to be tested by hydraulic pressure, after installation on board, to 1.5 times the design pressure but in no case to less than 0.35 \( N/mm^2 \).

7.2.2 Where bilge pipes are accepted in way of double bottom tanks or deep tanks, the pipes after fitting are to be tested by hydraulic pressure to the same pressure as the tanks through which they pass.

End Of Chapter
Chapter 3

Pumping and Piping

Contents

Section 1 General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to all ships except where otherwise stated.

1.1.2 Piping systems layouts, for which no requirements are given herein, will be specially considered.

1.2 Plans

1.2.1 The following plans in diagrammatic form are to be submitted for consideration before proceeding with the work.

a) General arrangement of pumps and piping systems;

b) Fuel oil filling, transfer and service piping systems;

c) Bilge and ballast piping systems;

d) Lubricating-oil piping systems;

e) Liquid cargo pumping systems;

f) Hydraulic power piping systems for essential services;

g) Compressed air piping systems;

h) Steering gear piping systems;

i) Sea water and fresh water service piping systems;

j) Air and sounding piping systems;

k) Steam and feed water piping systems;

l) Sanitary piping systems;

m) Fire main and fire extinguishing piping systems.

1.2.2 The plans are to include the information like, wall thickness, maximum working pressure temperature and material of all pipes and type, size and material of the valves and fittings.

1.3 Materials

1.3.1 The materials to be used in piping systems are to be suitable for the service intended. In general, except where otherwise stated, pipes, valves and fittings are to be made of steel, cast iron, copper, copper alloy or other approved material.

1.3.2 Cast iron is not to be used for:

a) Shipside and collision bulkhead fittings;

b) Outlet valves of fuel tanks with static head;
c) Bilge and ballast lines passing through double bottom tanks, pipe tunnel and cargo oil tanks;

d) Any piping which can be subjected to shock such as water hammer.

1.3.3 Materials sensitive to heat such as aluminium, lead or plastics, are not to be used in systems essential to the safe operation of the ship.

1.4 Design pressure

1.4.1 The design pressure is considered to be, the most severe condition of co-incident pressure and temperature expected in normal operation. For this purpose the maximum difference in pressure between inside and outside of the part is to be considered.

1.5 Design temperature

1.5.1 Unless otherwise specified the temperature used in design is to be not less than the mean metal temperature (through the thickness) expected under operating conditions for the part considered.

1.5.2 When sudden cyclic changes in temperature are apt to occur in normal operation with only minor pressure fluctuations, the design is to be governed by the highest probable operating temperature and corresponding pressure.

1.6 Redundancy

1.6.1 Redundancy is the ability of a system or a component thereof to maintain or restore its function when one failure has occurred. This can be achieved for instance by installation of more units or alternative means for performing the function.

1.7 Valves and cocks

1.7.1 All the valves and cocks are to be so designed and constructed so that the valve covers or glands will not slacken up when the valves are operated.

1.7.2 All the valves are to be designed to close with right hand (clockwise when facing the end of the stem) motion of the wheel of the valve.

1.7.3 All the valves and cocks are to be fitted in places where they are easily accessible at all times and are to be fitted with legible nameplates indicating their function in the system and their installation is to be such that it can be readily observed that they are open or closed.

1.7.4 All the valves and cocks fitted with remote control are to be provided with local manual control independent of the remote operating mechanism. The operation of the local control is not to render the remote control system inoperable.

1.7.5 The valves, cocks and other fittings which are attached directly to plating, which is required to be of watertight construction, are to be secured to the plating by means of studs screwed into the plating and not by bolts passing through clearance holes. Alternatively the studs may be welded to the plating.

1.8 Shipside fittings (other than sanitary discharges and scuppers)

1.8.1 All sea inlet and overboard discharge valves are to be fitted in either of the following ways:

   a) directly on the shell plating;

   b) to the plating of fabricated steel water boxes of rigid construction integral with the ship's plating;

   c) to short, rigid distance pieces welded to the shell plating.

1.8.2 All valves and cocks fitted directly to the shell plating are to have spigots extending through the plating. These spigot on valves may however be omitted, if valves are fitted on pads which themselves form spigots in way of plating.

1.8.3 Valves and cocks are to be attached to the shell plating by bolts tapped into the plating and fitted with countersunk heads, or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the pad plating.

1.8.4 Ship side valves and fittings, if made of steel or material with low corrosion resistance, are to be suitably protected against wastage.

1.8.5 Gratings are to be fitted at all openings in ship's side for inlet of seawater. The net area through the gratings is to be at least twice the area of the valves connected to the opening.

1.8.6 The scantlings of valves and valve stools fitted with steam, or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.
1.9 Piping installation

1.9.1 Heavy pipes and valves are to be so supported that their weight is not taken up by connected pumps and fittings.

1.9.2 Support of the pipes is to be such that detrimental vibrations do not arise in the system.

1.9.3 Where pipes are carried through watertight bulkheads or tank tops, means are to be made to ensure the integrity of the watertightness of the compartment.

1.9.4 As far as possible, installation of pipes for water, oil, or steam, is to be avoided near electric switchboards. If this is impracticable, all the joints in pipe line and valves are to be at a safe distance from the switchboards and shielded to prevent damage to switchboard.

1.9.5 Provision is to be made to take care of expansion or contraction stresses in pipes due to temperature stresses or working of the hull.

1.9.6 Expansion pieces of approved type, made of oil resistant re-inforced rubber or other approved material may be used in circulating water systems in machinery spaces.

1.9.7 All piping systems, where a pressure greater than the designed pressure could be developed, are to be protected by suitable relief valves.

1.9.8 All pipes, situated in cargo spaces, fish holds or other spaces, where they can be damaged mechanically, are to be suitably protected.

1.9.9 All pipes which pass through chambers intended for the carriage or storage of refrigerated cargo are to be well insulated. In case the temperature of the chamber is below 0°C the pipes are to be insulated from the ship's structure also, except at positions where the temperature of the ship's structure is always above 0°C and is controlled by outside temperature.

Air refreshing pipes leading to and from refrigerated chambers need not be insulated from the ship's structure.

2.1 General

2.1.1 All ships are to be provided with necessary pumps, suction and discharge piping and means of drainage so arranged that any compartment can be pumped out effectively, when the ship is on an even keel and is either upright or has a list of not more than 5 degrees, through at least one suction, except from machinery spaces where at least two suctions are required, one of which is to be a branch bilge suction and the other is to be a direct bilge suction. Wing suctions will, generally, be necessary for this purpose, except for short narrow compartments, where a single suction may be sufficient.

2.1.2 All passenger ships are to be provided with an efficient bilge pumping plant capable of pumping from and draining any watertight compartment under all practicable conditions after a casualty whether the ship is upright or listed.

2.1.3 Attention is drawn to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

2.2 Drainage of cargo holds

2.2.1 In ships having only one hold, and this over 30 [m] in length, bilge suctions are to be provided in the fore and after sections of the hold.

2.2.2 In ships having a flat bottom with breadth exceeding 5 [m], bilge suctions are to be fitted at the wings.

2.2.3 Where close ceilings or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby the water in the hold may find its way to the suction pipes.

2.2.4 In ships fitted with double bottoms, suitably located bilge wells are to be provided.

2.3 Drainage from fore and aft peaks

2.3.1 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in case of small tanks (generally not exceeding 2 [m^3]) used for the carriage of domestic fresh water where hand pumps may be used.
2.3.2 The peaks may be drained by hand pumps provided the peaks are not used as tanks and they are not connected to bilge main. The suction lift is to be well within the capacity of the hand pumps and is not to exceed 7.3 [m].

The after peak may be drained by means of a self closing cock situated in a well lighted and accessible position, and draining into engine room or tunnel.

2.3.3 The collision bulkhead is not to be pierced below the bulkhead deck by more than one pipe for dealing with the contents inside the fore peak tank except as permitted in 2.3.4. The pipe is to be provided with a screw down valve capable of being operated from above the bulkhead deck and the chest of the valve is to be secured to the collision bulkhead inside the tank except as permitted by 2.3.5. An indicator is to be provided to indicate whether the valve is open or shut.

2.3.4 In ships, other than passenger vessels, where the forepeak is divided into two compartments, the collision bulkhead may be pierced by two pipes, i.e. one for each compartment and fitted as in 2.3.3.

2.3.5 In ships other than passenger ships, the valve required by 2.3.3 may be fitted on the after side of the collision bulkhead, provided the valve is readily accessible at all time and is not subject to mechanical damage.

2.4 Drainage from tanks, cofferdams and void spaces

2.4.1 All the tanks except self-draining tanks, whether for water ballast, oil fuel, liquid cargoes, etc. are to be provided with suction pipes led to suitable power pumps. The pumping plant is to be so arranged that any water or liquid within any compartment of the ship can be pumped out through at least one suction, when the ship is on an even keel and is either upright or has a list of not more than 5 degrees.

2.4.2 Where the length of the ballast tank exceeds 30 [m], an additional suction is to be provided at the forward end of the tank. Where the width of the tank is unusually large, suctions near the centreline in addition to wing suctions may be required.

2.4.3 Suction pipes from the cofferdams and void spaces are to be led to the main bilge line.

2.4.4 In ships where deep tanks may be used for either water ballast or dry cargo, provision is to be made for blanking the water ballast suction and filling when the tank is being used for carrying cargo and for blanking the bilge line when the tank is being used for carriage of water ballast.

2.5 Drainage from spaces above fore and after peaks and above machinery spaces

2.5.1 Provision is to be made for the drainage of chain locker and watertight compartments above the fore peak tank by hand or power pump suctions.

2.5.2 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power bilge suctions.

2.5.3 If the compartments referred to in 2.5.2 are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers of not less than 38 [mm] bore, discharging into the tunnel (or machinery spaces in case of ships with machinery aft) and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not applicable to passenger ships unless they are specially approved in relation to subdivision considerations.

2.5.4 Accommodation spaces which overhang machinery spaces may also be drained as in 2.5.3.

2.6 Drainage from machinery spaces

2.6.1 The bilge drainage arrangements for machinery spaces are to be in accordance with the requirements of 2.1.

2.6.2 In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for the bilge suctions to be fitted in the forward wings as well as in the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

2.6.3 Where the machinery space is divided into watertight compartments, the drainage system for all compartments except for main engine room is to be same as for cargo holds except that one direct bilge suction from each watertight compartment would also be required.

2.7 Sizes of bilge suctions

2.7.1 The internal diameter of the bilge pipes is not to be less than that found by the following formula to the nearest 5 [mm] commercial size available:
a) \( d_m = 1.5 \sqrt{L(B + D)} + 25 \text{ [mm]} \)

b) \( d_m = 2.0 \sqrt{C(B + D)} + 25 \text{ [mm]} \)

where,

\( d_m = \text{internal diameter of bilge main [mm]} \);
\( d_b = \text{internal diameter of branch bilge [mm]} \);
\( L = \text{Rule length of ship [m]} \);
\( B = \text{Moulded breadth of ship [m]} \);
\( C = \text{Length of the compartment [m]} \);
\( D = \text{Moulded depth to bulkhead deck [m]} \).

2.7.2 In any case, bilge main suction line and branch bilge suction line diameters are not to be less than 40 [mm] and the diameter of the main bilge line is not be less than that of the branch bilge line.

2.7.3 The internal diameter of the direct bilge suction is not to have less than the main bilge line when connected to a power pump and not less than branch bilge suction when connected to a hand pump.

2.7.4 In oil tankers and similar ships, where the engine room pumps do not deal with bilge drainage outside the machinery spaces, the rule diameter of the bilge main may be reduced provided the proposed cross-sectional area of the bilge main is not less than twice that required for the branch bilge suction in machinery spaces.

2.7.5 The area of each branch pipe connecting the bilge main to a distribution chest is to be not less than the sum of the areas required by the rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

2.8 Bilge pumps and ejectors

2.8.1 In ships with main propulsion engines up to 220 [kW] (300 shp), at least one power bilge is to be provided which may be driven by the main engines. In addition hand pump suction are to be fitted. In ships where the main propulsion engines power exceeds 220 [kW] (300 shp), at least two power bilge pumps are to be provided and at least one of which is to be independently driven. See also 2.11 for requirements regarding passenger ships.

2.8.2 The capacity of the bilge pump may be found by the following formula:

\[ Q = 5.75 \times 10^{-3} \times d^2 \text{ [m}^3/\text{hour]} \]

where,

\( Q = \text{capacity of pump [m}^3/\text{hour]} \);
\( d = \text{rule diameter of bilge main [mm]} \).

2.8.3 In ships, other than passenger ships, where one bilge pump is of slightly less than rule capacity, the deficiency may be made good by an excess capacity of the other pump. In general this deficiency is to be limited to 30 percent.

2.8.4 An ejector in conjunction with a sea water pump may be accepted as a substitute for independent power bilge pump. This however, is not acceptable on passenger ships.

2.9 Pump types

2.9.1 The bilge pumps required by the rules are to be of self-priming type, unless an approved priming system is provided for these ships.

2.9.2 General service pumps and ballast pumps may be accepted as independent power bilge pumps provided:

a) Their capacity is adequate and in accordance with 2.8.2;

b) These pumps, together with the pipelines to which they are connected, are fitted with necessary devices to ensure that there is no risk of entry of water or oil fuel in the holds or machinery spaces.

2.10 Bilge piping arrangements and fittings

2.10.1 Bilge pipes are not, as far as possible, to pass through double bottom tanks. If unavoidable, such bilge pipes are to be of heavy gauge, with welded joints or heavy flanged joints and are to be tested after fitting to the same pressure as the tanks through which they pass.

2.10.2 The parts of bilge pipes passing through deep tanks, intended to carry water ballast, fresh water, liquid cargo or fuel oil are normally to be contained in a pipe tunnel, but where this is not done, the pipes are to be of heavy gauge with welded or heavy flange joints. The open ends of such pipes are to be fitted with non-return valves. The pipes are to be tested, after fitting, to a pressure of not less than the maximum head to which the tanks may be subjected.
2.10.3 Expansion bends, not glands, are to be fitted to pipes passing through double bottom tanks or deep tanks.

2.10.4 The intactness of the machinery spaces, bulkheads and of tunnel plating is not to be impaired by fitting of scuppers discharging into machinery spaces or tunnel from adjacent compartments which are situated below the bulkhead deck. These scuppers may, however, be led into a strongly built scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

a) The scupper tank air pipe is to be led above the bulkhead deck and provision is to be made for ascertaining the level of the water in the tank;

b) Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

2.10.5 No drain valve or cock is to be fitted to the collision bulkhead. Drain valves or cocks are not to be fitted to other watertight bulkheads if alternative means of drainage are practicable. These arrangements are not permissible in passenger ships.

2.10.6 Where drain valves or cocks are fitted to bulkheads other than collision bulkhead, as permitted by 2.10.5, the drain valves or cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut.

2.10.7 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to bilge, ballast or oil line.

2.10.8 The arrangement of pumps, valves and piping is to be such that any pump could be opened up for overhaul and repairs without affecting the operation of the other pumps.

2.10.9 The arrangement of valves, pumps, cocks and their pipe connections is to be such as to prevent the possibility of placing one watertight compartment in communication with another, or of cargo spaces, machinery spaces or other dry spaces coming in communication with the sea or the tanks. For this purpose the bilge suction, pipe of any pump also having sea suction is to be fitted with a non-return valve which cannot permit communication between the bilges and the sea or the compartments in use as tanks.

2.10.10 Screw-down non-return valves are to be provided in the following fittings:

a) Bilge distribution chest valves;

b) Direct bilge suction and bilge pump connection to main line;

c) Bilge suction hose connections on the pumps or on the main line;

d) Emergency bilge suctions.

2.10.11 Bilge suction pipes from machinery spaces and shaft tunnel, except emergency bilge suction, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges. The open ends of the tail pipes are not to be fitted with strum boxes. The mud boxes are to be provided with covers which can be easily opened and closed for cleaning purposes.

2.10.12 Strum boxes are to be fitted to the open ends of bilge suction pipes from the cargo holds. The diameter of holes from these strum boxes is not to be more than 10 [mm] and the total area of the holes is not to be less than twice the area of the pipes.

2.10.13 Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

2.10.14 Adequate distance is to be provided between the open ends of suction pipes and bilge well bottom to permit adequate and easy flow of water and to facilitate cleaning.

2.10.15 All the valves, cocks and mud boxes are to be located in easily accessible positions above or at the same level as the floor plates. Where this is unavoidable, they may be fitted immediately below the floor plates provided the floor plates are capable of being opened and closed easily and suitable name plates are fitted indicating the fittings below.

2.10.16 Where relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform. The arrangement is to be such that
any discharge from the relief valves will also be readily visible.

2.10.17 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

2.11 Additional requirements for passenger ships

2.11.1 Where practicable, the power bilge pumps are to be placed in watertight compartments so arranged or situated that these compartments will not readily be flooded by the same damage. If the engines and boilers are in two or more watertight compartments, the pumps available for bilge service are to be distributed throughout these compartments as far as is possible.

2.11.2 In passenger ships the arrangements are to be such that at least one power pump is available for use in all ordinary circumstances in which a ship may be flooded at sea. This requirement will be satisfied if:

a) One of the required pumps is an emergency pump of reliable submersible type having a source of power situated above the bulkhead deck; OR

b) The pumps and their sources of power are so disposed throughout the length of the ship that under any condition of flooding which the ship is required by statutory requirements to withstand, at least one pump in undamaged compartment will be available.

2.11.3 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose where the pipe is at any part situated nearer the side of the ship than one-fifth the breadth of the ship (measured at right angles to the centreline at the level of the deepest subdivision loadline), or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

2.11.4 All the distribution boxes, cocks and valves in connection with the bilge pumping arrangements are to be in positions which are accessible at all times under ordinary circumstances. They are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment, in addition damage to a pump or its pipe connecting to the bilge main outboard of a line drawn at one-fifth of the breadth of the ship is not to put the bilge system out of action. If there is only one system of pipes common to all the pumps, the necessary cocks or valves for controlling the bilge suctions must be capable of being operated from above the bulkhead deck. Where in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions, in that case only the cocks and valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

2.11.5 All valves and cocks mentioned in 2.11.4 which can be operated from above the bulkhead deck shall have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

2.12 Ballast system

2.12.1 Provision is to be made for ballasting and deballasting all the ballast tanks by pipe lines which are entirely separate and distinct from pipe lines used for bilging.

2.12.2 Where the length of the ballast tanks exceeds 30 [m], an additional suction is to be provided at the forward end of the tanks. Where the width of the tank is unusually large, suction near the centreline in addition to wing suctions may be required.
Section 3

Air and Sounding Piping Systems

3.1 General

3.1.1 Reference to oil in this Section is to be taken to mean oil which has a flash point of 60°C or above (closed cup test).

3.1.2 The portions of vent, overflow and sounding pipes fitted above the weather deck are to be of steel.

3.1.3 Name plates are to be affixed to the upper ends of all vent and sounding pipes.

3.2 Air pipes

3.2.1 Vent pipes are to be fitted to all tanks, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements.

3.2.2 The vent pipes are to be fitted at the opposite end of the tank to which the filling pipes are placed and/or at the highest part of the tank and are to be of the self draining type. Where the tank top is of unusual or irregular profile, special consideration will be given to the number and positions of the vent pipes.

3.2.3 Tanks provided with anodes for cathodic protection are to be provided with vent pipes at forward and aft ends.

3.2.4 Vent pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea and sea chests are to be run up from the sea and sea chests are to be led above the bulkhead deck.

3.2.5 Vent pipes to oil fuel and cargo oil tanks, cofferdams, all tanks which can be pumped up, shaft tunnels and pipe tunnels are to be led above the bulkhead deck and to open air.

3.2.6 Vent pipes from lubricating oil storage tanks may terminate in the machinery spaces, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

3.2.7 The open ends of vent pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled.

3.2.8 For details regarding height and closing devices for vent pipes see Pt.3, Ch.11.

3.2.9 The open ends of vent pipes to oil fuel, cargo oil and ballast tanks fitted with anodes for cathodic protection, are to be fitted with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning. The clear area through the wire gauze is to be at least equal to the area of the vent pipe.

3.2.10 In the case of all tanks which can be pumped up either by ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the vent pipes to each tank, or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

3.3 Sounding arrangements

3.3.1 All tanks, cofferdams and pipe tunnels are to be provided with sounding pipes or other approved means for ascertaining the level of liquid in the tanks. Bilges of compartments which are not at all times readily accessible are to be provided with sounding pipes. The soundings are to be taken as near the suction pipes as practicable.

3.3.2 Where gauge glasses are used for indicating the level of liquid in tanks containing lubricating oil, oil fuel or other flammable liquid, the glasses are to be of heat resisting quality, adequately supported, protected from mechanical damage and fitted with self-closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

3.3.3 Except as permitted by 3.3.4 sounding pipes are to be led to positions above the bulkhead deck which are at all times accessible and in the case of oil fuel tanks, cargo oil tanks and lubricating oil tanks, the sounding pipes are to be led to safe positions on the open deck.

3.3.4 Short sounding pipes may be fitted to double bottom tanks and cofferdams in shaft tunnels and machinery spaces provided the pipes are readily accessible. Short sounding pipes to oil fuel tanks, cargo oil tanks and lubricating oil tanks are not to be placed in the vicinity of boilers, preheaters, heated surfaces, electric generators or motors with commutator or collector rings or electric appliances which are not totally enclosed. The short sounding pipes are to be arranged in such a way that overflow
or oil spray will not reach any of machinery components mentioned above. The short sounding pipes are to be fitted with self-closing cocks having cylindrical plugs with weight loaded levers permanently attached and with pedals for opening or other approved arrangements. Short sounding pipes to tanks not intended for oil are to be fitted with screw caps attached by chain to the pipe or with shut off cocks.

3.3.5 In passenger ships, short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in the machinery space and are in all cases to be fitted with self closing cocks as described in 3.3.4.

3.3.6 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes. Where slotted pipes having closed ends are employed, the closing plugs are to be of substantial construction.

3.3.7 The upper ends of all sounding pipes are to be provided with efficient closing devices. The sounding pipes are to be arranged to be as straight as practicable, and if curved, the curvature is to be large enough to permit easy passage of sounding rod/chain.

Section 4

Fuel Oil Systems

4.1 General

4.1.1 Oil fuel for machinery and boilers is normally to have a flash point not lower than 60°C (closed cup test). For emergency generator engines, the oil fuel is to have a flash point not lower than 43°C (closed cup test).

4.1.2 Fuels with flash point lower than 60°C may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 10°C below the flash point of the fuel. In such cases safety precautions and the arrangements for storage and pumping will be specially considered. However, the flash point of the fuel is not to be less than 43°C unless specially approved.

4.2 Oil fuel tanks

4.2.1 Oil fuel tanks are to be separated from fresh water and lubricating oil tanks by means of cofferdams.

4.2.2 Oil fuel tanks are not to be located directly above the highly heated surfaces.

4.3 Oil fuel piping

4.3.1 Oil fuel pressure pipes are to be led, where practicable, remote from heated surfaces and electrical appliances, but where this is impracticable the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

4.3.2 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast iron or steel, having flanged joints suitable for a working pressure of not less than 0.69 [N/mm²]. The flanges are to be machined and the jointing material is to be impervious to oil. Where the pipes are 25 [mm] bore or less, they may be seamless copper or copper alloy, except those which pass through storage tanks.

4.3.3 Pipes in connection with compartments storing fresh water are to be separate and distinct from any pipes which may be used for oil or oily water and are not to be led through tanks which contain oil, nor are oil pipes to be led through fresh water tanks.

4.3.4 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing such cargoes.

4.3.5 In passenger ships, provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage tank.

4.4 Arrangement of valves, cocks, pumps and fittings

4.4.1 The oil fuel and pumping piping arrangements are to be distinct from other pumping systems as far as practicable and the means provided for preventing dangerous interconnection in service are to be thoroughly effective.
4.4.2 All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the machinery spaces are to be above the working platform.

4.4.3 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or a cock.

4.4.4 For oil fuel tanks which are situated above the double bottom tanks, the inlet and outlet, pipes which are connected to the tank at a point lower than the outlet of the overflow pipe or below the top of the tanks without an overflow pipe, are to be fitted with shut off valves located on the tank itself.

4.4.5 In the machinery spaces valves, mentioned in 4.4.4, are to be capable of being closed locally and from positions outside these spaces which will always be accessible in the event of fire occurring in these spaces. Instructions for closing the valves are to be indicated at the valves and at the remote control positions.

4.4.6 Settling tanks are to be provided with means for draining water from the bottom of the tanks. If the settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains.

Open drains for removing water from oil tanks are to be fitted with valves or cocks of self-closing type and suitable provision is to be made for collecting the oily discharge.

4.4.7 Where a power driven pump is necessary for transferring oil fuel, a stand by pump is to be provided and connected ready for use, or, alternatively, emergency connections may be made to another suitable power driven pump.

4.4.8 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in close circuit, i.e. arranged to discharge back to the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

4.4.9 Valves or cocks are to be interposed between the pumps on the suction and discharge pipes in order that any pump may be shut off for opening up and overhaul.

4.4.10 Drip trays are to be fitted under all oil fuel appliances which are required to be opened up frequently for cleaning or adjustment.

4.5 Filling arrangements

4.5.1 The bunkering of the ship is to be carried out through a permanently fitted pipeline, provided with the required fittings and ensuring fuel delivery to all storage tanks. The open end of the fitting pipe is to be led to the tank bottom.

In passenger ships fuel bunkering stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

4.5.2 Provision is to be made against over-pressure in the filling pipes, and any relief valve fitted for this purpose is to be discharge in to an overflow tank or other safe position.

4.6 Oil fuel burning arrangements

4.6.1 Filters are to be fitted in the supply lines to the main and auxiliary machinery. For non-redundant units for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the unit.

For auxiliary engines one single oil fuel filter for each engine may be accepted.

4.6.2 Where an oil fuel booster pump is fitted, which is essential to the operation of the main engine(s), a standby pump is to be provided. The standby pump is to be connected ready for immediate use but where two or more main engines are fitted, each with its own pump, a complete spare pump may be accepted provided that it readily accessible and can be easily installed.

4.6.3 Where pumps are provided for fuel valve cooling, the arrangements are to be as in 4.6.2.

4.7 Remote stop of oil fuel pumps and fans

4.7.1 Emergency stop of power supply to the following pumps and fans is to be arranged from a central place outside the engine and boiler room:

- oil fuel transfer pump;
- oil fuel booster pump;
- nozzle cooling pumps when oil fuel is used as coolant;
- oil fuel purifiers;
- pumps for oil-burning installations;
- fans for ventilation of engine rooms.
Section 5

Engine Cooling Water Systems

5.1 General

5.1.1 Centrifugal cooling water pumps are to be installed as low as possible in the ship.

d) Where each auxiliary is fitted with a cooling water pump, standby means of cooling need not be provided for auxiliaries. Where, however, a group of auxiliaries is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system. This pump is to be connected ready for immediate use and maybe a suitable general service pump.

5.2 Cooling water main supply

5.2.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to lubricating oil and fresh water coolers, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

5.3 Cooling water standby supply

5.3.1 Provision is also to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity.

5.3.2 The following arrangements are acceptable, depending on the purpose for which the cooling water is intended:

a) Where only one main engine, with power exceeding 370 [kW] (500 shp), is fitted, the standby pump is to be connected ready for immediate use;

b) Where more than one main engine is fitted, each with its own pump, a complete spare pump of each type may be accepted;

c) Where fresh water cooling is employed for main/auxiliary engines, a standby means of cooling need not be fitted if there are suitable emergency connections from a salt water system;

d) When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, condenser doors, water boxes, etc. are to be protected by an approved device against inadvertent over pressure.

5.4 Relief valves on cooling water pumps

5.4.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system.

5.5 Sea inlets for cooling water pumps

5.5.1 Sea-water cooling systems for main and auxiliary machinery are to be connected to at least two cooling water inlets, preferably on opposite sides of the ship.

5.5.2 Where sea water is used for the direct cooling of main engines and auxiliaries, the sea water suction pipes are to be provided with strainers which can be cleaned without interrupting the cooling water supply.

Section 6

Lubricating Oil Piping Systems

6.1 General

6.1.1 Lubricating oil systems are to be entirely separated from other systems. This requirement, however, does not apply to hydraulic governing and maneuvering systems for main and auxiliary engines.

6.1.2 Lubricating oil tanks are to be separated from other tanks containing water, fuel oil or cargo oil by means of cofferdams.

6.2 Pumps

6.2.1 Where lubricating oil for the main engine(s) is circulated under pressure, a
standby lubricating oil pump is to be provided where one main engine is fitted and the output of the engine exceeds 370 [kW] (500 shp).

6.2.2 Satisfactory lubrication of the engines is to be ensured while starting and maneuvering.

6.2.3 Similar provisions to those of 6.2.1 and 6.2.2 are to be made where separate lubricating oil systems are employed for piston cooling, reduction gearing, oil operated couplings and controllable pitch propellers, unless approved alternative arrangements are provided. Where the oil glands for stern tubes are provided with oil circulating pump, and the continuous running of this pump is necessary during normal operation, then a standby pump for this purpose is to be provided.

6.2.4 Independently driven rotary type pumps are to be fitted with non-return valves on the discharge side of the pumps.

6.2.4 A relief valve in close circuit is to be fitted on the pump discharge if the pump is capable of developing a pressure exceeding the design pressure of the system, the relief valve is to effectively limit the pump discharge pressure to the design pressure of the system.

6.3 Control of pumps and alarms

6.3.1 The power supply, to all independently driven lubricating oil pumps is to be capable of being stopped from a position outside the space which will always be accessible in the event of fire occurring in the compartment in which they are situated, as well as from the compartment itself.

6.3.2 All main and auxiliary engines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines and turbines are of more than 75 [kW] (100 shp), audible and visual alarms are to be fitted to given warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

6.4 Filters

6.4.1 In systems, where lubricating oil is circulated under pressure, provision is to be made for efficient filtration of the oil. For non-redundant units, for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the units.

6.5 Valves and cocks on lubricating oil tanks

6.5.1 Outlet valves and cocks on lubricating oil service tanks, other than double bottom tanks, situated in machinery spaces are to be capable of being closed locally and from positions outside the space which will always be accessible in the event of fire occurring in these spaces. Remote controls need only be fitted to outlet valves and cocks which are open in normal service and are not required for other outlets such as those on storage tanks.

Section 7

Engine Exhaust Gas Piping Systems

7.1 General

7.1.1 Where the surface temperature of the exhaust pipes and silencer may exceed 220°C, they are to be water cooled or efficiently lagged.

7.1.2 Where lagging covering the exhaust piping including flanges, is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or equivalent. In locations where the Surveyor is satisfied that oil impingement could not occur, the lagging need not be encased.

7.1.3 Exhaust pipes which are led overboard near the waterline are to be protected against the possibility of water finding its way inboard.

Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

7.1.4 Exhaust pipes of two or more engines are not to be connected together, but are to be led separately to the atmosphere unless arranged to prevent the return of gases to an idle engine.

7.1.5 In two-stroke engines fitted with exhaust gas turbo-chargers which operate on the impulse systems, provision is to be made to prevent broken piston rings entering the turbine casing and causing damage to blades and nozzle rings.
Section 8

Pumping and Piping Systems for Vessels not Fitted with Propelling Machinery

8.1 Scope

8.1.1 Following requirements are applicable to vessels not fitted with propelling machinery.

8.2 Vessels without auxiliary power

8.2.1 Hand pumps are to be fitted in number and position, as may be required for the efficient drainage of the vessel.

8.2.2 In general, one hand pump is to be provided for each compartment. Alternatively, two pumps connected to a bilge main, having at least one branch to each compartment are to be provided through non-return valves.

8.2.3 The hand pumps are to be capable of being worked from the upper deck or from positions above the load waterline which are at all times readily accessible. The suction lift is not to exceed 7.3 [m] and is to be well within the capacity of the pump.

8.2.4 The pump capacity is to be based upon the diameter of the suction pipe required for the compartment and as determined in Sec.2.

8.3 Vessels with auxiliary power

8.3.1 In vessels in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

8.3.2 The pumping arrangements are to be as required for self propelled vessels, so far as these requirements are applicable.

End Of Chapter
Chapter 4

Prime Movers and Propulsion Shafting Systems

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
</tr>
<tr>
<td>2</td>
<td>Main Propulsion Shafting</td>
</tr>
<tr>
<td>3</td>
<td>Propellers</td>
</tr>
<tr>
<td>4</td>
<td>Vibrations and Alignment</td>
</tr>
</tbody>
</table>

Section 1

General

1.1 General

1.1.1 The requirements of this Chapter are applicable to all ships but may be modified for ships intended for special services.

1.1.2 Prime movers of electric generators of less than 50 [kW] capacity, supplying power for lighting loads only, when the ship is in harbour, need not be built under survey.

1.1.3 Attention is drawn to any relevant statutory requirements of the country in which the ship is to be registered.

1.1.4 Power transmission systems not specified in this Chapter will be specially considered.

1.2 Materials

1.2.1 Materials intended for the main parts of the prime movers and power transmission systems are to be manufactured and tested in accordance with the requirements of Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships.

1.3 Primemovers and reduction gearing

1.3.1 Primemovers and reduction gearings are to be designed, manufactured and tested in accordance with the requirements of Rules and Regulations For the Construction & Classification of Steel Ships.

1.4 Turning Gear

1.4.1 Arrangements are to be provided to turn the primemover of main propulsion systems and auxiliary drives.

Section 2

Main Propulsion Shafting

2.1 Scope

2.1.1 The requirements of this Section relate, in particular, to formulae for determining the diameters of shafting for main propulsion installations, but requirements for couplings, coupling bolts, keys, keyways, sternbushes and associated components are also included. The diameter of shafting as calculated may require to be modified as a result of alignment considerations and vibration characteristics (See Sec.8) or the inclusion of stress raisers, other than those contained in this section.

2.2 Plans and particulars

2.2.1 The following plans, in triplicate, together with the necessary particulars of the machinery, including the maximum power and revolutions
per minute, are to be submitted for approval before the work is commenced:

- Final gear shaft;
- Thrust shaft;
- Intermediate shafting;
- Tube shaft, where applicable;
- Tail shaft;
- Stern bush.

2.2.2 The specified minimum tensile strength of each shaft is to be stated.

2.2.3 A shafting arrangement plan indicating the relative position of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, 'A' brackets and propeller, as applicable, is to be submitted for information.

2.3 Materials for shafting

2.3.1 The materials are to comply with the relevant requirements of Ch.5, Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships. The specified minimum tensile strength of forings is to be selected within the following general limits:

a) Carbon and carbon-manganese steel - 400-600 [N/mm²]

b) Alloy steels - Not exceeding 800 [N/mm²]

2.3.2 Ultrasonic tests are required on shaft forings where the diameter is 250 [mm] or greater.

2.4 Intermediate and thrust shafts

2.4.1 The diameter, d, of the shaft is to be not less than determined by the following formula:

\[ d = 103.5 \times a \times \sqrt[3]{\frac{410P}{(U+160)R}} \]  [mm]

where,

a = 0.95 for turbine installations, electric propulsion installations and oil engine installations with slip type couplings;

= 1.0 for other oil engine installations;

k = 1.0 for shafts with integral coupling flanges complying with 2.7 or shrink fit couplings;

= 1.10 for shafts with keyways, where the fillet radii in the transverse section of the bottom of the keyway are not to be less than 0.0125 d; after a length of 0.2 d from the end of the keyway, the shaft diameter may be reduced to the diameter calculated with k = 1.0;

= 1.10 for shafts with transverse or radial holes, where the diameter of the hole is not greater than 0.3 d;

= 1.20 for shafts with longitudinal slots having a length of not more than 1.4 d and a width of not more than 0.2 d, where d is calculated with k = 1.0;

U = Specified minimum tensile strength of the material [N/mm²]

P = maximum shaft power [kW];

R = Revolutions per minute corresponding to maximum shaft power giving maximum torque.

2.4.2 For shafts with design features other than stated in 2.4.1, the value of k will be specially considered.

2.5 Tailshafts and tube shafts

2.5.1 The diameter, \( d_p \), of the tailshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the tailshaft flange, is to be not less than determined by the following formula:

\[ d_p = 103.5 \times k_a \times \sqrt[3]{\frac{410P}{(U+160)R}} \]  [mm]

where,

k = 1.22 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange, and where the shaft is fitted with continuous liner or is oil lubricated and provided with an approved type of oil sealing gland;

= 1.26 for a shaft carrying a keyed propeller, and where the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland;

= 1.25 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange and is fitted with water lubricated bearings with non-continuous shaft liners;
= 1.29 for a shaft carrying a keyed propeller and is fitted with water lubricated bearings with non-continuous shaft liners;

\[ U = \text{Specified minimum tensile strength of the shaft [N/mm}^2\text{], but is not to be taken greater than 600 [N/mm}^2\text{]} \]

P, a and R are defined in 2.4.1.

2.5.2 The diameter, \( d_p \), of the tailshaft determined in accordance with the formula in 2.5.1 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or 2.5 \( d_p \) whichever is the greater.

2.5.3 The diameter of the portion of the tailshaft and tubeshaft forward of the length required by 2.5.2 to the forward end of the forward stern tube seal is to be determined in accordance with the formula in 2.5.1 except that:

\[ k = 1.15, \text{ when } k = 1.22 \text{ or } 1.26 \text{ as required by 2.5.1} \]

\[ k = 1.18, \text{ when } k = 1.25 \text{ or } 1.29 \text{ as required by 2.5.1} \]

The change of diameter from that required by 2.5.1 to that required by this clause should be gradual.

2.5.4 The taper of the shaft cone is normally not to be steeper than 1:12 on diameter in case of keyed shafts and 1:15 on diameter in case of keyless shafts.

2.5.5 Tailshafts which run in stern tubes and tube shafts may have the diameter forward of the length required by 2.5.2 to the forward end of the forward stern tube seal to be determined in accordance with the formula in 2.5.1 except that:

\[ k = 1.15, \text{ when } k = 1.22 \text{ or } 1.26 \text{ as required by 2.5.1} \]

\[ k = 1.18, \text{ when } k = 1.25 \text{ or } 1.29 \text{ as required by 2.5.1} \]

The change of diameter from that required by 2.5.1 to that required by this clause should be gradual.

2.6 Hollow shafts

2.6.1 For hollow shafts where the bore exceeds 40 per cent of the outside diameter the minimum shaft diameter is not to be less than that given by the following equation:

\[ d_o = d \left[ \frac{1}{3 \left[ 1 - \left( \frac{d}{d_o} \right)^4 \right]} \right] \text{ [mm]} \]

where,

\( d_o = \text{outside diameter [mm]} \),

\( d = \text{Rule size diameter of shaft [mm], calculated in accordance with 2.4 or 2.5} \)

\( d_i = \text{diameter of central hole [mm]} \).

2.6.2 Where the diameter of central hole does not exceed 0.4 times the outside diameter, no increase over Rule size need be provided.

2.7 Integral couplings

2.7.1 The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts calculated as in para 2.9, where \( U_b = U \) or 0.2 times the rule diameter of the shaft under consideration, whichever is greater.

2.7.2 The fillet radius at the base of the coupling flange is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

2.7.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

2.8 Demountable couplings

2.8.1 Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft.

2.8.2 Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed pre-loading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted torque and pre-load stress is not to exceed 70 per cent of the yield strength.

2.8.3 Provision is to be made to resist astern pull.

2.9 Coupling bolts

2.9.1 The diameter of the coupling bolts of the fitted type at the joining faces of the coupling is to be not less than that given by the following formula:
\[ d_b = \sqrt{\frac{0.427 d^3 (U + 155)}{N D U_B}} \] [mm]

where,

- \( d_b \) = diameter of the fitted coupling bolts [mm];
- \( d \) = required diameter [mm] for the shaft in accordance with 2.4 or 2.5 as appropriate calculated by taking the value of \( k \) as 1.0;
- \( U \) = specified minimum tensile strength of the shaft material in [N/mm²];
- \( U_B \) = specified minimum tensile strength of the bolt material in [N/mm²];

and also \( U \leq U_B \leq 1.7U \);

- \( N \) = Number of bolts in the coupling;
- \( D \) = Pitch circle diameter of bolt holes [mm].

2.9.2 The diameter of the non-fitted bolts will be specially considered upon the submittal of detailed pre-loading and stress calculations and fitting instructions.

2.10 Tailshaft liners

2.10.1 The thickness, \( t \), of bronze or gunmetal liners fitted on tail shafts, in way of bearings, is not to be less than given by following formula:

\[ t = \frac{168 + d_p}{28} \] [mm]

where,

- \( t \) = thickness of liner [mm];
- \( d_p \) = diameter of tail shaft under the liner [mm].

2.10.2 The thickness of the continuous liner between the bearings is not to be less than 0.75t.

2.10.3 Continuous liners are preferably to be cast in one length. If made of several lengths, the joining of the separate pieces is to be made by welding through the whole thickness of liner before shrinking. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0.5 per cent. The composition of the electrode or filler rods is to be substantially lead free.

2.10.4 The liners are to withstand a hydraulic pressure of 0.2 [N/mm²] after rough machining.

2.10.5 The liners are to be carefully shrunk or forced upon the shaft by hydraulic pressure, and they are not to be secured by pins.

2.10.6 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

2.10.7 If the liner does not fit the shaft tightly between the bearing portions in the stern tube, the space between the shaft and the liner is to be filled with a plastic insoluble non-corrosive compound.

2.11 Keys and keyways

2.11.1 Round ended or sled-runner ended keys are to be used, and the key ways in the propeller boss and cone of the tail shaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0.0125 of the diameter of the tail shaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

2.11.2 Two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter and the edges of the holes are to be slightly beveled.

2.11.3 The distance between the top of the cone and the forward end of the keyway is to be not less than 0.2 of the diameter of the tailshaft at the top of the cone.

2.11.4 The effective sectional area of the key in shear, is to be not less than \( \frac{d^3}{2.6 d_1} \) [mm²]

where,

- \( d \) = diameter [mm], required for the intermediate shaft determined in accordance with 2.4, based on material having a specified minimum tensile strength of 400 [N/mm²];
- \( d_1 \) = diameter of shaft at mid-length of the key [mm].

2.12 Stern tube and bearings

2.12.1 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:
a) For water lubricated bearings which are lined with lignum vitae, rubber composition or staves of approved plastic material; the length is to be not less than 4 times the rule diameter required for the tailshaft under the liner;

b) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland; the length of the bearing is to be approximately twice the rule diameter required for the tailshaft and is to be such that the nominal bearing pressure will not exceed 0.8 [N/mm²]. The length of the bearing is to be not less than 1.5 times its rule diameter;

c) For bearings of cast iron, bronze which are oil lubricated and fitted with an approved oil sealing gland; the length of the bearing is, in general, to be not less than 4 times the rule diameter required for tailshaft;

d) For bearings which are grease lubricated; the length of bearing is to be not less than 4 times the rule diameter required for the tailshaft;

e) For water lubricated bearings lined with two or more circumferentially spaced sectors of an approved plastics material, in which it can be shown that the sectors operate on hydrodynamic principles, the length of the bearing is to be such that the nominal bearing pressure will not exceed 0.55 [N/mm²]. The length of the bearing is not to be less than twice actual diameter of shaft.

2.12.2 Forced water lubrication is to be provided for all bearings lined with rubber or plastics and for those bearings lined with lignum vitae where the shaft diameter is 380 [mm] or over. The supply water may come from a circulating pump or other pressure source. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by wear down, particularly for bearings of the plastic type.

2.12.3 The shut off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

2.12.4 Where a tank supplying lubricating oil to the sterntube is fitted, it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

2.12.5 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means of ascertaining the temperature of the oil in the sternbush are also to be provided.

2.12.6 The oil sealing glands used for sterntube bearings, which are oil lubricated, are to be of approved type.

Section 3

Propellers

3.1 Scope

3.1.1 The requirements of this Section cover the construction, materials and inspection of propellers.

3.2 Plans and particulars

3.2.1 A plan, in triplicate, of the propeller is to be submitted for approval, together with the following particulars:

a) Maximum shaft power, P, in [kW];

b) Revolutions per minute of the propeller at maximum power, R;

c) Propeller diameter, D [m];

d) Pitch at 25 per cent radius (for solid propellers only), P₀.25 [m];

e) Pitch at 35 per cent radius (for controllable pitch propellers only), P₀.35 [m];

f) Pitch at 70 per cent radius, P₀.7 [m];

g) Length of blade section of the expanded cylindrical section at 25 per cent radius (for solid propeller only), L₀.25, [mm];

h) Length of blade section of expanded cylindrical section at 35 per cent radius (for controllable pitch propellers only) L₀.35, in [mm];
3.3 Materials

3.3.1 Castings for propellers and propeller blades are to comply with the requirement of Ch.8, Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships. The specified minimum tensile strength is to be not less than stated in Table 3.4.1.

3.3.2 When it is proposed to use materials which are not included in Table 3.4.1, details of the chemical composition, mechanical properties and density are to be submitted for approval.

3.4 Design

3.4.1 Minimum blade thickness

3.4.1.1 Where the propeller blades are of conventional design, the thickness, \( t \), of the propeller blades at 25 per cent radius for solid propellers, at 35 per cent for controllable pitch propellers, neglecting any increase due to fillets, is to be not less than:

\[
\begin{align*}
  t_{0.25} &= 1003 \left( \frac{AP}{C_n C R N} + 0.024 B K C_s \right) [\text{mm}] \\
  t_{0.25} &= 805 \left( \frac{AP}{C_n C R N} + 0.015 B K C_s \right) [\text{mm}]
\end{align*}
\]

where,

\( t_{0.25} \) = minimum blade thickness required at 25 per cent radius;

\( t_{0.35} \) = minimum blade thickness required at 35 per cent radius;

\( C_n \) = Section modulus coefficient at 25 per cent radius or 35 per cent radius as applicable;

\( C_s \) = Section area coefficient at 25 per cent radius or 35 per cent radius as applicable;

\( A = 1.0 + \frac{6.0 D}{P_{0.7}} + \frac{4.3 P_{0.25}}{D} \)

\( B = \left( \frac{4300 w a}{N} \right) \left( \frac{R}{100} \right)^2 \left( \frac{D}{20} \right)^3 \)

\( C = \left( 1 + \frac{1.5 P_{0.25}}{D} \right) \left( L_{0.25} f - B \right) \)

a) For fixed pitch propellers

\[
A = 1.0 + \frac{6.0 D}{P_{0.7}} + \frac{3.0 P_{0.35}}{D} \]

b) For controllable pitch propellers

\[
A = 1.0 + \frac{6.0 D}{P_{0.7}} + \frac{3.0 P_{0.35}}{D} \]
3.4.1.2 Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

3.4.1.3 Fillets at the root of the blades are not to be considered in the determination of blade thickness.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Specified min. UTS [N/mm²]</th>
<th>f</th>
<th>w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese bronze Grade Cu 1</td>
<td>440</td>
<td>22.6</td>
<td>8.3</td>
</tr>
<tr>
<td>Ni-Manganese bronze Grade Cu 2</td>
<td>440</td>
<td>22.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Ni-Aluminium bronze Grade Cu 3</td>
<td>590</td>
<td>25.7</td>
<td>7.5</td>
</tr>
<tr>
<td>Mn-Aluminium bronze Grade Cu 4</td>
<td>630</td>
<td>25.6</td>
<td>7.5</td>
</tr>
<tr>
<td>Cast iron</td>
<td>250</td>
<td>11.77</td>
<td>7.2</td>
</tr>
<tr>
<td>Carbon and low alloy steels</td>
<td>400</td>
<td>14.0</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Note: The value of f may be increased by 10 percent for twin screw and outboard propellers of triple screw ships.

3.4.2 Keyless propellers

3.4.2.1 Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for approval.

3.4.3 Controllable pitch propellers

3.4.3.1 In the case of controllable pitch propellers, means are to be provided to lock the blades in ahead position in case of the failure of the pitch operating mechanism.

3.4.3.2 A propeller pitch indicator is to be fitted at each station from which it is possible to control the pitch of the propeller.

3.5 Fitting of propellers

3.5.1 The propeller boss is to be a good fit on the tailshaft cone. The forward edge of the bore of the propeller boss is to be rounded to about 6 [mm] radius.

3.5.2 The exposed part of the tailshaft is to be protected from the action of water by filling all spaces between propeller hub, cap and shaft with a suitable filling material. The propeller assembly is to be sealed at the forward end with a well-fitted soft rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub and the ring is to be sufficiently sized to squeeze in to the clearance space when the propeller is driven up on the shaft; and, where necessary, a filler piece is to be fitted in the propeller - hub keyway to provide a flat unbroken seating for the ring. The recess formed at the small end of the taper by the over hanging propeller hub is to be packed with red lead putty or rust-preventing compound before the propeller nut is put on.

3.5.3 Effective means are to be provided to prevent the slackening of the propeller nut.

Section 4

Vibrations and Alignment

4.1 Scope

4.1.1 The requirements of this Section are applicable to main propulsion systems with power exceeding 200 [kW] and auxiliary machinery systems for essential services with powers exceeding 200 [kW].

4.1.2 Unless otherwise advised, it is the responsibility of the Shipbuilder as the main contractor to ensure, in co-operation with the Engine builders, that the information required by this Section is prepared and submitted.

4.2 Basic system requirements

4.2.1 The systems are to be free from excessive torsional, axial and lateral vibration, and are to be aligned in accordance with tolerances agreed with the respective manufacturers.
4.2.2 Where changes are subsequently made to a dynamic system which has been approved, revised calculations are to be submitted for consideration.

4.3 Resilient mountings

4.3.1 Where the machinery is installed on resilient mountings, linear vibration (steady state and transient) is not to exceed the limiting values agreed with the manufacturers of the machinery nor those of the resilient mountings.

4.3.2 Misalignment arising from such vibration is not to impose excessive loading on machinery components within the system.

4.4 Torsional vibration

4.4.1 Torsional vibration calculations, including an analysis of the vibratory torques and stresses for the dynamic systems formed by the oil engines, turbines, motors, generators, flexible couplings, gearing, shafting and propeller, where applicable, including all branches, are to be submitted for approval together with the associated plans.

4.4.2 Particulars of the division of power developed throughout the speed range for turbines, or from all intended combinations of operation in oil engine installations having more than one engine and/or with power take-off systems are to be submitted.

4.4.3 Any special speed requirements for prolonged periods in service are to be indicated, e.g., range of trawling revolutions per minute, range of operation revolutions per minute with a controllable pitch propeller, idling speed, etc.

4.4.4 The calculations and/or measurements carried out on oil engine installations containing transmission items sensitive to vibratory torque, e.g. gearing, flexible couplings, or generator rotors and their drives, are to take into account the effects of engine malfunction commonly experienced in service, such as cylinder(s) not firing.

4.4.5 Restricted speed ranges will be imposed in regions of speed where stresses are considered to be excessive for continuous running. Similar restrictions will be imposed, or other protective measures required to be taken, where vibratory torques are considered to be excessive for particular machinery items.

4.4.6 Where calculations indicate the possibility of excessive torsional vibration within the range of working speeds, torsional vibration measurements, using the appropriate recognized techniques, may be required to be taken from the machinery installation for the purpose of determining the need for restricted speed ranges.

4.5 Axial vibrations

4.5.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to axial vibrations are satisfactory throughout the speed range, so far as practicable. Where appropriate, amplitudes may be reduced by the use of suitable vibration dampers or phasing of propeller and engine, etc.

4.5.2 Unless previous experience of similar installation shows it to be unnecessary, calculations of the shafting system are to be carried out. These calculations are to include the effect of the thrust block seating and the surrounding hull structure taking part in the vibration. The result of these calculations or the evidence of previous experience is to be submitted for consideration.

4.5.3 Where calculations indicate the possibility of excessive axial vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting systems for the purpose of determining the need for restricted speed ranges.

4.6 Lateral vibrations

4.6.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to lateral vibrations are satisfactory throughout the speed range.

4.6.2 Unless previous experience of similar installations shows it to be unnecessary, calculations of lateral, or bending, vibration characteristics of the shafting system are to be carried out. These calculations, taking account of dynamic bearing stiffnesses, are to cover the frequencies giving rise to all critical speeds which may result in significant amplitudes within the speed range, and are to indicate relative deflections and bending moments throughout the shafting system.

4.6.3 The results of these calculations, or the evidence of previous experience, is to be submitted for consideration.

4.6.4 Where calculations indicate the possibility of excessive lateral vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting system.
for the purpose of determining the need for restricted speed ranges.

4.7 Shaft alignment

4.7.1 For main propulsion installations, the shafting is to be aligned to give acceptable bearing reactions, and bending moments at all conditions of ship loading and operation. The Shipbuilder is to position the bearings and construct the bearing seatings to minimize the effects of movements under all operating conditions.

4.7.2 For geared installations, where two or more pinions are driving the final reduction wheel, calculations are to be submitted to verify that shaft alignment is such that proper bearing reactions are maintained under all operating conditions.

4.7.3 Shaft alignment is to be verified by measurement.

End Of Chapter
Chapter 5

Boilers and Pressure Vessels

Contents

Section 1 General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to pressure vessels of seamless and fusion welded construction, and their mountings and fittings, for the following uses:

a) Fired boilers;
b) Exhaust gas heated boilers;
c) Economizers, superheaters, reheaters and steam receivers for, and associated with (a) and (b);
d) Steam heated steam generators;
e) Other pressure vessels, not included in (a) to (d).

1.1.2 Consideration will be given to arrangements or details of boilers, pressure vessels and equipment which can be shown to comply with other recognized standards, provided they are not less effective.

1.2 Design pressure

1.2.1 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of any safety valve.

1.2.2 The calculations made to determine the scantlings of the pressure parts are to be based on the design pressure, adjusted where necessary to take account of pressure variations corresponding to the most severe operational conditions.

1.2.3 It is desirable that there should be a margin between the normal pressure at which the boiler or pressure vessel operates and the lowest pressure at which any safety valve is set to lift, to prevent unnecessary lifting of the safety valve.

1.3 Metal temperature

1.3.1 The metal temperature, T, used to evaluate the allowable stress is to be taken as the actual metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when plans of the pressure parts are submitted for consideration.

1.3.2 For boilers, the design metal temperature is not to be taken less than the following values, unless justified by an exact calculation of the temperature drop and is in no case to be taken less than 250°C:

a) For steam heated steam generators, secondary drums of double evaporation boilers, steam receivers and pressure parts of fired pressure vessels not heated by hot gases and adequately protected by insulation, the metal temperature, T is to be taken as the maximum temperature of the internal fluid;
b) For pressure parts heated by hot gases, T is to be taken as not less than 25°C in excess of the maximum temperature of the internal fluid;
c) For combustion chambers of the type used in horizontal wet-back boilers, T is to be taken as not less than 50°C in excess of the maximum temperature of the internal fluid;
d) For furnaces, fire boxes, rear-tube plates of dry-back boilers and pressure parts subject to similar rates of heat transfer, T is to be taken as not less than 90°C in excess of the maximum temperature of the internal fluid;
e) For boiler, superheater, reheater and economizer tubes, the design temperature is to be taken as under:

- For boiler tubes the design temperature is to be taken as not less than saturated steam temperature plus 25°C for tubes mainly subject to convection heat, or plus 50°C for tubes mainly subject to radiant heat;

- For superheater and reheater tubes, the design temperature is to be taken as not less than steam temperature expected in the part being considered, plus 35°C for tubes mainly subject to convection heat. For tubes mainly subject to radiant heat the design temperature is to be taken as not less than the steam temperature expected in the part being considered, plus 50°C, but the actual metal temperature expected is to be stated when submitting plans;

- The design temperature for economizer tubes is to be taken as not less than 35°C in excess of the maximum temperature of the internal fluid.

1.3.3 In general, any part of boiler drums or headers not protected by tubes, and exposed to radiation from the fire or to the impact of hot gases, is to be protected by a shield of good refractory material or by other approved means.

1.3.4 Drums and headers of thickness greater than 30 [mm] are not to be exposed to combustion gases having an anticipated temperature in excess of 650°C unless they are efficiently cooled by closely arranged tubes.

1.4 Plans and particulars

1.4.1 The following plans, in triplicate, for boiler and pressure vessels are to be submitted for approval, in so far as applicable:

a) General arrangement, including arrangement of valves and fittings;

b) Sectional assembly;

c) Seating arrangements;

d) Steam, water drum and header details;

e) Water wall details;

f) Steam and superheater tubing, including the tube support arrangements;

g) Economizer details;

h) Casing arrangement;

i) Reheat section;

j) Fuel oil burning arrangement;

k) Forced draft system;

l) Boiler mountings including steam stop valves, safety valves and their relieving capacities, feed water connections, blow-off arrangements, watergauges, test cocks, etc.

1.4.2 The plans are to include the following particulars, in so far as applicable:

a) Scantlings;

b) Materials;

c) Weld details;

d) Design pressures and temperatures;

e) Heating surface areas of boilers and superheaters;

f) Estimated pressure drop through superheater;

g) Estimated evaporation rate;

h) Proposed setting pressure of safety valves on steam drum and superheater;

i) Pressure vessel class;

j) Details of heat treatment and testing of welds;

k) Calculations of thicknesses, when required;

l) Test pressures.

1.5 Classification of pressure vessels

1.5.1 For Rule purposes, boilers and pressure vessels are graded as shown in Table 1.5.1.

1.5.2 Pressure vessels which are constructed in accordance with the requirements of Class 2 or Class 3 will, if manufactured in accordance with the requirements of a superior class, be approved with the scantlings appropriate to that class.
Table 1.5.1: Grading of pressure vessels

<table>
<thead>
<tr>
<th>Class</th>
<th>Boilers</th>
<th>Steam-heated steam generators</th>
<th>Other pressure vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>(p &gt; 3.5)</td>
<td>(D_i &gt; \left(\frac{15}{p} - 1\right)1000)</td>
<td>(P &gt; 50) or (t &gt; 38)</td>
</tr>
<tr>
<td>Class 2</td>
<td>(p \leq 3.5)</td>
<td>(D_i &lt; \left(\frac{15}{p} - 1\right)1000)</td>
<td>(P \leq 50) or (D_i &gt; \left(\frac{20}{p} - 1\right)1000) and (16 &lt; t \leq 38) or material temperature (&gt; 150^\circ C)</td>
</tr>
<tr>
<td>Class 3</td>
<td></td>
<td></td>
<td>(D_i \leq \left(\frac{20}{p} - 1\right)1000) and (t \leq 16) and material temperature (\leq 150^\circ C)</td>
</tr>
</tbody>
</table>

Notes:

- \(P =\) design pressure, in bar
- \(D_i =\) internal diameter [mm]
- \(t =\) shell thickness [mm]

1.5.3 In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be required that certain pressure vessels be manufactured in accordance with the requirements of a superior class.

1.6 Materials

1.6.1 Materials used in the construction of boilers and pressure vessels are to be manufactured in accordance with the requirements of Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships.

1.6.2 The specified minimum tensile strength of carbon and carbon manganese steel plates, pipes, forgings and castings is to be within the following general limits:

a) For seamless and Class 1 and Class 2 fusion welded pressure vessels - 340 - 520 \([N/mm^2]\);
b) For boiler furnaces, combustion chambers and flanged plates - 400 - 520 \([N/mm^2]\).

1.6.3 The specified minimum tensile strength of low alloy steel plates, pipes, forgings and castings is to be within the general limits of 400 - 500 \([N/mm^2]\), and pressure vessels made in these steels are to be either seamless or Class 1 fusion welded.

1.6.4 The specified minimum tensile strength of boiler and superheater tubes is to be within the following general limits:

a) Carbon and carbon-manganese steels - 320 - 460 \([N/mm^2]\);
b) Low alloy steels - 400 - 500 \([N/mm^2]\).

1.6.5 Where it is proposed to use materials other than those specified in Pt.2, Inspection and Testing of Materials, of Rules & Regulations for the Construction and Classification of Steel Ships, details of the chemical compositions, heat treatment and mechanical properties are to be submitted for approval. In such cases the values of the mechanical properties used for deriving the allowable stress are to be subject to agreement by IRS.

1.6.6 Where a fusion welded pressure vessel is to be made of alloy steel and approval of the scantlings is required on the basis of the high temperature properties of the material, particulars of the welding consumables to be used, including typical mechanical properties and chemical composition of the deposited weld metal, are to be submitted for approval.

1.7 Pressure parts of irregular shape

1.7.1 Where pressure parts are of such irregular shape that it is impracticable to design their scantlings by the application of formulae given in this Chapter, the suitability of their construction is to be determined by hydraulic proof test of a prototype or by an agreed alternative method.
1.8 Adverse working conditions

1.8.1 Where working conditions are adverse, special consideration may be required to be given to increasing the scantlings derived from the formulae, e.g. by increasing the corrosion or other allowance at present shown in the formulae, or by adopting a design pressure higher than defined in 1.2, to offset the possible reduction of life in service caused by the adverse conditions. In this connection, where necessary, account should also be taken of any excess of loading resulting from:

a) impact loads, including rapidly fluctuating pressures;

b) weight of the vessel and normal contents under operating and test conditions;

c) superimposed loads such as other pressure vessels, operating equipment, insulation, corrosion-resistant or erosion-resistant linings and piping;

d) reactions of supporting lugs, rings, saddles or other types of supports;

or

e) the effect of temperature gradients on maximum stress.

1.9 Design

1.9.1 The boilers and pressure vessels are to be designed in accordance with the requirements of Ch.5, Pt.4, Main and Auxiliary Machinery, of Rules & Regulations for the Construction and Classification of Steel Ships.

1.10 Manufacture

1.10.1 The manufacture of boilers and pressure vessels is to be carried out in accordance with the requirements of Ch.10, Pt.4, Main and Auxiliary Machinery, of Rules & Regulations for the Construction and Classification of Steel Ships.

End Of Chapter
Chapter 6

Steering Gears

Contents

Section
1 General
2 Design Criteria

Section 1

General

1.1 General

1.1.1 All ships are to be provided with reliable steering systems which would allow the vessel to be steered safely having regard to the use and principal dimensions of the ship. This requirement does not apply to ships intended to be pushed only. Proposals to fit a hand tiller only will receive special consideration.

1.1.2 For ships not fitted with rudders but equipped with steering propellers/nozzles or Voith-Schneider propellers, see 2.5. For ships fitted with rudders, a steering gear is to be provided.

1.1.3 The steering gear is to be secured to the seating by fitted bolts, and suitable chocking arrangements are to be provided. The seating is to be of substantial construction.

1.1.4 The steering gear is to be so designed that the rudder cannot change position when not intended to do so.

1.1.5 Steering gears may be manually operated (steering chains and rods or hand/hydraulic) or fully powered (electric or electric/hydraulic). However, when the rule diameter of the rudderstock exceeds 150 [mm] in way of tiller, a fully powered steering gear is to be provided.

1.1.6 Manually operated gears or power assisted gears are only acceptable when the operation does not require an effort exceeding 16 [kgf] under normal conditions.

1.1.7 If a fully powered steering gear is fitted an independent secondary means of steering is to be provided.

1.1.8 Requirements for chemical tankers, gas carriers and similar vessels will be specially considered by IRS.

Section 2

Design Criteria

2.1 General

2.1.1 The entire steering gear is to be designed, constructed and installed to allow for a permanent transverse list of up to 15 and for ambient temperatures commensurate with the area in which he ship is to operate.

2.1.2 The parts comprising the steering gear are to be so dimensioned that they can withstand all the maximum stresses to which they will be subjected in normal operating conditions. The steering gear is to be sufficiently strong so that in the event of rudder touching the bottom or bank, the maximum damage would be limited to deformation or fracturing of the rudder stock.

2.1.3 The steering gear is to be so designed that a rudder angle of not less than 35 on either side can be obtained.
2.1.4 Where the steering gear is manually operated, on an average one complete turn of the hand wheel is to correspond to at least 3 of rudder angle.

2.1.5 Where the steering gear is fully powered, it is to be capable of turning the rudder at an average rate of 4 per second through the entire rudder arc when the rudder is fully immersed and with the ship at full speed.

2.1.6 Where fully powered steering gear is provided with a second, manually operated gear, the latter is to permit the ship to proceed to a mooring at reduced speed.

2.2 Fully powered steering gear

2.2.1 Fully powered steering gears may be of the direct electric or electric/hydraulic type.

2.2.2 Powered steering gears are to be fitted with means to limit the torque exerted by the drive.

2.2.3 In case of failure of the main drive and the secondary drive not engaging automatically, it is to be possible to engage the secondary drive by hand at the steering position within 5 seconds, with the rudder in any position.

2.2.4 At the steering station, automatic indication is to be provided as to which drive is in operation.

2.2.5 If the independent secondary drive is manual the power drive is not to actuate the hand wheel. A device is to be fitted to prevent inadvertent turning of the hand wheel when the manual drive is engaged automatically.

2.2.6 Where the main steering gear is power hydraulically operated whilst the secondary steering is a manually operated hydraulic system, the piping of both systems is to be completely separate, and the main installation is to operate without using the steering wheel pump of the secondary installation.

2.2.7 Where both the main and secondary drive are power hydraulic, the respective pumps must be driven independently.

2.2.8 Where the secondary pump is driven by an engine which does not operate continuously whilst the ship is in motion, means are to be provided to operate the steering gear instantly whilst the emergency engine is gaining the required speed.

2.2.9 The two installations are to have separate pipes, valves, controls, etc. Where the independent functioning of the two installations is ensured, they may have common components.

2.3 Manual drive

2.3.1 Where the sole steering installation is a manually operated system, an independent secondary steering system is not required, provided that in the case of a hydraulic system, the dimensioning, construction and layout of the piping precludes deterioration through mechanical action or fire, and the construction of the steering wheel pump ensures faultless operation.

2.4 Rudder position

2.4.1 If the position of the rudder(s) is not clearly perceivable from the steering station, a reliable rudder angle indicator is to be provided at the steering station.

2.4.2 Any rudder angle indicator fitted, is to function for both the main and secondary steering gear.

2.5 Rudder propellers and Voith Schneider equipment

2.5.1 Where a steering propeller/nozzle or Voith Schneider propeller is fitted, two independent control systems are to be provided between the steering station and the propulsion installation.

2.5.2 Where two or more independent steering propulsion installations are fitted, a secondary independent control system is not required provided the ship remains sufficiently maneuverable in the event of one of the installations failing.

2.6 Tillers, quadrants and connecting rods

2.6.1 For the requirements regarding rudder, rudder stock, See Pt.3, Ch.12.

2.6.2 All components transmitting mechanical forces to the rudder stock are to have a strength of at least equivalent to the rudder stock in way of the tiller. The combined resultant stress, \( \sigma_e \), caused by the transmission of rudder torque, \( Q_r \), in tillers, vanes and other power transmitting components is not to exceed 138 \([N/mm^2]\), i.e.

\[
\sigma_e = \sqrt{\sigma^2 + 3 \tau^2} \leq 138 \ [N/mm^2]
\]

where,

\( \sigma_e \) = The combined equivalent stress, \([N/mm^2]\)
\( \sigma = \) The bending stress, \([\text{N/mm}^2]\)
\( \tau = \) The torsional shear stress, \([\text{N/mm}^2]\)

\( Q_r = \) The rudder torque \([\text{N-m}]\) calculated as per Pt.3, Ch.12, Sec.3.2;

2.6.3 The section modulus 'Z' \([\text{cm}^3]\) and the sectional area 'A' \([\text{cm}^2]\) of the tiller arms is not to be less than the following:

\[
Z = 0.012 Q_r \left( 1 - \frac{x}{R} \right) \quad \text{[cm}^3]\]

\[
A = 2.0 \frac{Q_r}{R} x 10^{-4} \quad \text{[cm}^2]\]

where,

\( R = \) The distance \([\text{m}]\) from the point of application of the effort on the tiller to the centre of rudder stock; and

\( x = \) The distance \([\text{m}]\) from the section under consideration to the centre of the rudder stock.

2.6.4 The boss may be fitted on the rudder stock by shrinking with/without key or may be of the split type. The ratio between the mean of outer and inner diameters of the boss is to be not less than 1.75 and the height of the boss is not to be less than the inner diameter of the boss.

2.6.5 Co-efficient of friction for shrink fitting is not to be taken greater than 0.17 for dry fitting and 0.15 for oil injection fitting.

2.6.6 In case of split type boss, the total number of joining bolts is to be at least 4. The distance of the centre of the bolts from the centre of the rudder stock is generally to be 1.15\( du \) and the thickness of the coupling flange is to be at least 1.1 times the required bolt diameter. The thickness of shim to be fitted between two halves before machining is to be 0.0015\( du \). The diameter of the coupling bolt, \( d_b \) is to be not less than:

\[
d_b = 0.60 \frac{d_u}{\sqrt{n}} \quad \text{[mm]}\]

where,

\( d_u = \) The rudder stock diameter in way of the tiller calculated in accordance with Pt.3, Ch.12, Sec.3;

\( n = \) Total number of joining bolts.

2.6.7 The shear area of the key, \( A_s \), is not to be less than:

\[
A_s = \frac{0.18 Q_r}{d_m} \quad \text{[cm}^2]\]

where,

\( d_m = \) diameter of the conical part of the rudderstock at midway of key, \([\text{mm}]\)

The keyway is to extend over the full depth of the tiller and have rounded edges. The abutting surface area of the key, \( A_b \), (discounted rounded edges) between the key and the rudder stock or the key and the tiller boss is not to be less than:

\[
A_b \geq 0.5 A_s
\]

2.6.8 Where higher tensile bolts are used on bolted tillers and quadrants, the yield and ultimate tensile stresses of the bolt material are to be stated on the plans submitted for approval, together with full details of the methods to be adopted to obtain the required setting-up stress. Where patent nuts or systems are used, the manufacturer's instructions for assembly should be adhered to.

2.6.9 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

2.6.10 Steel-wire rope, chain and other mechanical systems, when these are used for rudder stock diameters of 120 \([\text{mm}]\) and less but excluding allowance for strengthening in ice, will be specially considered. In general the breaking strength of rods/chains etc. is not to be less than:

\[
\text{Breaking strength} \geq 6 \frac{Q_r}{R} \quad \text{[N]}
\]

Where \( R \) is defined in 2.6.3.

2.7 Locking or brake gear and springs

2.7.1 An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary. In the case of hydraulic steering gears which are fitted with isolating valves on the body of the gear and duplicate power units, an additional mechanical brake need not be fitted.
2.7.2 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

2.7.3 The steering gear, unless hydraulically powered, is to be protected by means of springs or buffers from damage by impact on the rudder.

2.8 Rudder stops

2.8.1 Suitable stopping arrangements are to be provided for the rudder. Cut-outs on the steering engine are to be arranged to operate at a smaller angle of helm than those for the rudder.

End Of Chapter
Chapter 7

Control Engineering Systems

Contents

Section
1 General Requirements
2 Essential Features for Control and Alarm Systems
3 Control and Supervision of Machinery

Section 1

General Requirements

1.1 General

1.1.1 This Chapter applies to all ships and is in addition to other relevant Chapters of the Rules.

1.1.2 Attention should also be given to any relevant requirements of National, International or Local Authorities which would apply to the ships in service.

1.1.3 This Chapter states requirements for systems of automatic or remote control which may be used for controlling the machinery contained in 1.2.2. The design and installation of other control equipment is to be such that there is no risk of danger due to failure.

1.1.4 The details of control systems will vary with the type of machinery being controlled and special consideration will be given to each case.

1.2 Plans

1.2.1 Where control systems are applied to essential machinery or equipment as listed in 1.2.2, plans are to be submitted in triplicate. They are to include or to be accompanied by:

- Details of operating medium, i.e. pneumatic, hydraulic or electric, including standby sources of power.
- Description and/or block diagram showing method of operation.
- Line diagrams of control circuits.
- Lists of points monitored.
- List of control points.
- Test facilities provided.
- Test schedules.

1.2.2 Control systems. Plans are required for the following:

- Ballast systems.
- Bilge systems.
- Cargo pumping systems for tankers.
- Controllable pitch propellers.
- Electrical generating plant.
- Fire detection systems.
- Main propelling machinery including essential auxiliaries.
- Steam raising plant.
- Transverse thrust units.
- Steering gear plant.

1.2.3 Alarm systems. Details of the overall alarm system linking engine room, wheelhouse and, where applicable, accommodation spaces are to be submitted.

1.2.4 Control Station. Location and details of control station are to be submitted, e.g. control panels.
1.2.5 **Standard system.** Where it is intended to employ a system which has been previously approved, plans may not be required to be submitted.

1.3 **Alarm and control equipment**

1.3.1 Major units of equipment associated with control, alarm and safety systems as defined in 1.2 are to be surveyed at the manufacturers' works and the inspection and testing is to be to the Surveyor's satisfaction.

1.3.2 Equipment used in control, alarm and safety systems should whenever practicable, be selected from the List of Type Approved Control and Electrical Equipment published by IRS. A copy of IRS Test Requirements for the Type Approval of Control and Electrical Equipment will be furnished on application.

1.3.3 Assessment of performance parameters, such as accuracy, repeatability and the like, are to be in accordance with an acceptable National or International Standard.

1.4 **Alterations or additions**

1.4.1 When an alteration or addition to the approved system(s) is proposed, plans are to be submitted for approval. The alterations or additions are to be carried out under survey, and the inspection, testing and installation is to be to the Surveyor's satisfaction.

---

**Section 2**

**Essential Features for Control and Alarm Systems**

2.1 **General**

2.1.1 Where it is proposed to install control and alarm systems to the equipment defined in 1.2.2 the applicable features contained in 2.2 to 2.5 are to be incorporated in the system design.

2.2 **Control station(s) for machinery**

2.2.1 A system of alarm displays and controls are to be provided which readily ensure identification of faults in the machinery and satisfactory supervision of related equipment.

2.3 **Alarm system**

2.3.1 Where an alarm system, which will provide warning of faults in the machinery and control systems is installed, the requirements of 2.3.1 to 2.3.10 are to be satisfied.

2.3.2 Machinery and control system faults are to be indicated at the relevant control station to advise duty personnel of a fault condition.

2.3.3 Individual alarm channels may be displayed as group alarms at the main control station (if fitted) or alternatively at subsidiary control stations.

2.3.4 All alarms are to be both audible and visual. If arrangements are made to silence audible alarms they are not to extinguish visual alarms.

2.3.5 If an alarm has been acknowledged and a second fault occurs before the first was rectified then audible and visual alarms are again to operate.

2.3.6 Failure of the power supply to the alarm system is to be indicated.

2.3.7 The alarm system should be designed with self-monitoring properties. As far as practical, any fault in the alarm system should cause it to fail to the alarm condition.

2.3.8 The alarm system is to be designed as far as practical to function independently of control systems, such that a failure or malfunction in these systems will not prevent the alarm from operating.

2.3.9 Disconnection or manual overriding of any part of the alarm system should be clearly indicated.

2.3.10 The alarm system is to be capable of being tested.

2.4 **Control systems**

2.4.1 Control systems for machinery operations are to be stable throughout their operating range.

2.4.2 Failure of the power supply to a control system for propulsion machinery and associated systems is to operate an audible and visual alarm.

2.4.3 When remote or automatic controls are provided, sufficient instrumentation is to be fitted
at the relevant control stations to ensure effective control and indicate that the system is functioning correctly.

2.4.4 Where valves are operated by remote or automatic control, the system of control should include the following safety features:

(a) Failure of actuator power should not permit a closed valve to open inadvertently.

(b) Positive indication is to be provided at the remote control station for the service to show the actual valve position or alternatively that the valve is fully open or closed. Valve position indicating systems are to be of an approved type.

(c) Equipment located in places which may be flooded should be capable of operating when submerged.

(d) A secondary means of operating the valves, which may be local manual control is to be provided.

2.5 Fire detection alarms systems

2.5.1 Where an automatic fire detection system is to be fitted in a machinery space the requirements of 2.5.2 to 2.5.9 are to be satisfied.

2.5.2 A fire detector indicator panel is to be located in such a position that a fire in the machinery spaces will not render it inoperative.

2.5.3 The audible fire alarm is to have a characteristic tone which distinguishes it from any other alarm system. The audible fire alarm is to be audible on all parts of the bridge and in the accommodation areas.

2.5.4 The alarm system should, so far as practicable, be designed with self-monitoring properties.

2.5.5 Failure of power supply to the alarm system is to be indicated.

2.5.6 Detector heads of an approved type are to be located in the machinery spaces so that all potential fire outbreak points are guarded.

2.5.7 The fire detection system is to be capable of being tested.

2.5.8 It is to be demonstrated to the Surveyor’s satisfaction that detector heads are so located that air currents will not render the system ineffective.

2.5.9 A drawing showing the location of the fire detector heads and the fire indicator panel, is to be submitted.

Section 3

Control and Supervision of Machinery

3.1 General

3.1.1 When machinery, as defined in 1.2.2, is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators then it is to be provided with the arrangements specified in 3.2 to 3.7. Alternative arrangements which provide equivalent safeguards will be considered.

3.2 Oil engines for propulsion purposes

3.2.1 The following systems are to be provided with alarms:

<table>
<thead>
<tr>
<th>System</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricating oil pressure for the engine</td>
<td>Low</td>
</tr>
<tr>
<td>including gearing</td>
<td></td>
</tr>
<tr>
<td>Lubricating oil pressure for the engine</td>
<td>Failure, see 3.2.2</td>
</tr>
<tr>
<td>including gearing</td>
<td></td>
</tr>
<tr>
<td>Cooling system(s) temperature</td>
<td>High</td>
</tr>
<tr>
<td>Cooling system(s) temperature</td>
<td>Excessively high, see 3.2.3</td>
</tr>
</tbody>
</table>
3.2.2 In the case of the lubricating oil system, in addition to the alarm indication as required by 3.2.1, at complete loss of lubricating oil the engine is to be stopped automatically or alternatively a second and separate alarm is to be provided giving audible and visible warning in the wheelhouse and in the engine room. The circuit and sensor employed for this automatic stop or alarm are to be additional to the alarm circuit and sensor required by 3.2.1.

3.2.3 In the case of cooling system(s), in addition to the alarm indication as required by 3.2.1, a shutdown system for excessively high temperatures may be fitted, which is to be independent of the alarm system.

3.2.4 Prolonged running in a restricted speed range is to be prevented automatically; alternatively, indication of restricted speed ranges is to be provided at each control station.

3.3 Boilers

3.3.1 A system of water level detection is to be fitted which will operate alarms and shut off automatically the oil supply to the burners when the water level falls to a predetermined low level.

3.3.2 The oil fuel is to be shut off automatically from the burners, and alarms are to operate on flame failure and failure of combustion air supply detected by either low pressure at the fan outlet or stopping of the fan motor.

3.3.3 Where the burner flame(s) is/are extinguished and reignited automatically in response to steam demand then after total flame failure re-ignition shall not take place until the furnace has been purged of explosive gases.

3.4 Auxiliary engines

3.4.1 The following systems for auxiliary engines of more than 37 kW (50 shp) are to be provided with alarms:

<table>
<thead>
<tr>
<th>System</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricating oil pressure</td>
<td>Low *</td>
</tr>
<tr>
<td>Cooling system temperature</td>
<td>High *</td>
</tr>
</tbody>
</table>

* These alarms may be combined with an automatic shutdown system, if fitted

3.5 Remote control for propulsion machinery

3.5.1 The following systems are to be provided with alarms:

<table>
<thead>
<tr>
<th>System</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating medium for hydraulic or pneumatic coupling in propulsion system</td>
<td>Low pressure</td>
</tr>
<tr>
<td>Operating medium for hydraulic or pneumatic remote control system for main engine</td>
<td>Low pressure</td>
</tr>
<tr>
<td>Electrical supply to remote control system for main engine</td>
<td>Loss of supply</td>
</tr>
</tbody>
</table>

3.6 Controllable pitch propellers and transverse thrust units

3.6.1 Preferred alarms and safeguards are indicated in 3.6.2 to 3.6.4.

3.6.2 In the case of main propulsion systems, means are to be provided to prevent the engines and shafting being subjected to excessive torque due to changes in propeller pitch, alternatively an engine overload indicator may be fitted at each station for which it is possible to control the pitch of the propeller.

3.6.3 Where transverse thrust units are remotely controlled, means are to be provided at the remote control station to stop the propulsion unit.

3.6.4 The following systems are to be provided with alarms:

<table>
<thead>
<tr>
<th>System</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic system pressure</td>
<td>Low</td>
</tr>
<tr>
<td>Power supply to the control system between the remote control station and hydraulic actuator</td>
<td>Loss of supply</td>
</tr>
</tbody>
</table>

3.7 Steering gear

3.7.1 For power operated steering gear, safeguards and alarms are to be provided as indicated in 3.7.2 and 3.7.5.

3.7.2 Provision should be made at the bridge to ensure that the steering gear may be rapidly and effectively transferred to an alternative power and control system, which may be manual.

3.7.3 Where the alternative steering gear system is also power operated this system should be independent of the main power system.

3.7.4 The control system for the alternative steering gear system required by 3.7.2 is to be
independent of the main steering gear control system.

3.7.5 The following systems are to be provided with alarms:

<table>
<thead>
<tr>
<th>System</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering gear power system(s)</td>
<td>Failure</td>
</tr>
<tr>
<td>Steering gear control system(s)</td>
<td>Failure</td>
</tr>
<tr>
<td>Steering gear hydraulic oil tank level</td>
<td>Low</td>
</tr>
</tbody>
</table>

3.8 Main propulsion shafting

3.8.1 Where a tank supplying lubricating oil to the sternbush is fitted, it is to be located above the load waterline and is to be provided with a low level alarm.

End Of Chapter
Chapter 8

Electrical Installations - Equipment and Systems

Contents

Section
1 General Requirements
2 System Design
3 Cables
4 Switchboards
5 Control Gear
6 Rotating Machines - Construction and Testing
7 Transformers - Construction and Testing
8 Miscellaneous Equipment
9 Trials

Section 1

General Information

1.1 General

1.1.1 The requirements of this Chapter apply to self-propelled and non self-propelled ships for service on inland waterways unless otherwise stated. Attention should also be given to any relevant applicable requirements of National or Local Authorities.

1.1.2 In passenger ships, services essential for safety are to be maintained under emergency conditions and the safety of ship and personnel from electrical hazards is to be assured.

1.1.3 Electrical installations are to be constructed and installed in accordance with the relevant sections of this Chapter and are to be inspected and tested by the Surveyors. Compliance with the requirements of an acceptable National or International Standard may be accepted as meeting the requirements of this Chapter, subject to inspection and testing by the Surveyors.

1.1.4 IRS will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules. Consideration will also be given to the electrical arrangements of small ships and ships to be assigned class notation for a specified limited service.

1.2 Plans

1.2.1 The plans and particulars in 1.2.2 to 1.2.4 are to be submitted in triplicate for approval.

1.2.2 Electrical Equipment: The arrangement plan and circuit diagram of the switchboard(s). Diagrams of the wiring system including cable sizes, type of insulation, normal working current in the circuits and the capacity, type and make of protective devices. Calculations of short circuit currents at main busbars and the secondary side of transformers are to be submitted.

1.2.3 Oil tankers, and similar vessels: A general arrangement of the ship showing hazardous zones or spaces and the location of electrical equipment in such zones or spaces. A schedule of safe type electrical equipment located in hazardous zones or spaces giving details of the type of equipment fitted, the Certifying Authority, the certificate number and copies of the certificate.

1.2.4 Centralised, remote or automatic controls: See Ch.7.
### 1.3 Additions or alterations

1.3.1 Additions or alterations, (temporary or permanent) to the approved load of an existing installation are not to be made until it has been ascertained that the current carrying capacity and the condition of the existing accessories, conductors and switchgear are adequate for the proposed modification.

1.3.2 Plans for the proposed modifications are to be submitted for approval and the alterations or additions are to be carried out under the inspection, and to the satisfaction of the Surveyors.

### 1.4 Application

1.4.1 Except where a specific statement is made to the contrary, all requirements of this Chapter are applicable to both alternating current and direct current installations.

1.4.2 Direct current equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent.

1.4.3 Alternating current equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent at rated frequency, and under frequency fluctuations of ± 5 per cent at rated voltage.

1.4.4 Contactors and similar electromagnetic equipment are not to drop out at or above 85 per cent rated voltage.

1.4.5 For D.C. installations supplied by batteries, consideration is to be given to the supply voltage variations between the battery's full charged and minimum charged voltages. For installations with float charging, the maximum charging voltage is also to be considered.

### 1.5 Ambient reference conditions

1.5.1 The rating of electrical equipment is to be suitable for the temperature conditions associated with the geographical limits of the intended service. See also Ch.1.

### 1.6 Location and construction

1.6.1 Electrical equipment is to be placed in accessible and adequately lighted spaces clear of flammable material and heat sources. The spaces should be well ventilated, and the equipment should not be exposed to risk of mechanical injury or damage from water, excessive moisture, steam, oil or any other dangerous fluid. Where necessarily exposed to such hazards, the equipment is to be suitably constructed or enclosed.

1.6.2 Live parts are to be efficiently shielded from any accidental contact.

1.6.3 All electrical apparatus and equipment is to be constructed and installed so as to avoid injury or electrical shock when handled or touched in the course of normal operation.

1.6.4 All nuts and bolts/screws used to connect or secure current-carrying parts and working parts are to be effectively locked, to prevent them from working loose during operation.

### 1.7 Earthing

1.7.1 All non-current-carrying exposed metal parts of electrical machines or equipment are to be effectively earthed.

1.7.2 All accessible non-current-carrying metal parts of portable electrical apparatus rated in excess of 55 volts are to be earthed through a suitable conductor unless equivalent safety provisions are made such as by double insulation or by an isolating transformer.

1.7.3 In general earthing connections are to be equal to the cross section of the current-carrying conductor up to 16 [mm²]. Above this figure they are to be equal to at least half the cross section of the current carrying conductor with a minimum of 16 [mm²]. Earthing connections which are not made of copper are to have a conductance not less than that specified for a copper earthing connection. These are to be securely installed and protected where necessary against mechanical damage and electrolytic corrosion. These are to be made in an accessible location and secured at both ends by corrosion resistant screws or clamps with cross section corresponding to the earth conductor. Such screws or clamps are not to be used for other purposes. Suitable washers and conductor terminals are to be used so that a reliable contact is ensured.

1.7.4 The metallic sheaths of cables other than the measuring circuits are to be earthed at their two ends.

### 1.8 Creepage and clearance

1.8.1 Distance between live parts and between live parts and earthed metal, whether across surfaces or in air, are to be adequate for the working voltages considering the nature of the insulating material and the transient over voltages developed by switch and fault conditions.
1.9 Electrical equipment for use in explosive gas atmospheres

1.9.1 Where the Rules require electrical equipment to be of a "safe type", such equipment is to be certified for the gases/vapours involved. The equipment should conform to IEC publication 79, "Electrical Apparatus for Explosive Gas Atmospheres", or an equivalent national standard.

1.9.2 Copies of type test certificate by a competent independent Testing Authority are to be made available.

1.9.3 When "safe type" equipment is permitted in hazardous zones or spaces all switches and protective devices are to interrupt all lines or phases and, where practicable, are to be located in a non-hazardous zone or space unless specifically permitted otherwise. Appropriate labels of non-flammable material are to be permanently affixed to such equipment, switches and protective devices for identification purposes.

Section 2

System Design

2.1 Design

2.1.1 Supply and distribution systems

2.1.1.1 The following systems of generation and distribution are acceptable for parallel systems at constant voltage:

a) d.c. two-wire insulated,
b) a.c. single-phase two-wire insulated,
c) a.c. three-phase, three-wire insulated,
d) a.c. three-phase, four-wire with neutral earthed but without hull return.

2.1.1.2 Systems of generation and distribution, other than those specified above, will, upon application, be given special consideration.

2.1.2 Earth indication

2.1.2.1 Every insulated distribution system is to be provided with lamps or other means to indicate the state of insulation from earth. Where lamp indicators are used, the lamps are to be of the metal filament type and their power is not to exceed 30 watts.

2.1.3 Number and rating of generating sets

2.1.3.1 The number and rating of service generating sets are to be adequate to ensure the operation of services essential for the propulsion and safety of the ship.

2.1.3.2 On oil tankers and similar vessels, where electrical power is required for essential equipment, the generating plant and converting plant is to be of such capacity that this essential equipment can be operated satisfactorily even with one generating set or converting set out of action.

2.1.4 Emergency source of power in passenger ships

2.1.4.1 All passenger ships are to be provided with an emergency source of electrical power. On ships having a rule length of 25 [m] or more, the emergency source is to be situated outside the engine room and the space is to be constructed of watertight and fire resisting bulkheads and decks.

2.1.4.2 Where emergency generating sets are fitted they are to be capable of being started readily when cold.

2.1.4.3 If hand starting is demonstrated to be practicable, alternative means of starting are not required. Where hand starting is not practicable, other means are to be provided and, in general, should provide for at least 12 starts in a period of thirty minutes without recourse to sources within the machinery space.

2.1.4.4 The emergency source of power is to be either:

a) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point of not less than 43°C or

b) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop.
2.1.4.5 An indicator is to be mounted in the machinery space, or in the wheelhouse, to indicate when any accumulator battery fitted in accordance with 2.1.4.4 is being discharged.

2.1.4.6 The emergency switchboard is to be installed as near as is practicable to the emergency source of power.

2.1.4.7 The emergency switchboard may be supplied from the main switchboard during normal operation.

2.1.4.8 The power available is to be sufficient to supply all services necessary for the safety of passengers and crew in an emergency, due regard being paid to such services as may have to be operated simultaneously. Special consideration is to be given to emergency lighting in all alleyways, stairways and exits, in the machinery spaces and in the control stations where radio, main navigating or central fire recording equipment or the emergency generator is located, to fire detection and alarm systems, to the emergency fire pump if electrically driven, automatic sprinkler systems if fitted, and to navigation lights. The power is to be adequate for a period of at least 3 hours.

2.1.5 Essential services

2.1.5.1 Where essential services are duplicated, they are to be served by individual circuits separated throughout their length as widely as is practicable and without the use of common feeders, protective devices or control circuits.

2.1.6 Diversity factor

2.1.6.1 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways (feeders) are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

2.1.6.2 The diversity factor may be applied when calculating cable size and when calculating the rating of switchgear and fusegear.

2.1.6.3 The diversity factors are not applicable to supply cables to distribution switchboards for lighting and heating.

2.1.7 Lighting circuits

2.1.7.1 Lighting circuits are to be supplied by final sub-circuits, which are separate from those for heating and power. This provision need not be applied to cabin fans and small wardrobe heaters.

2.1.7.2 A final sub-circuit of rating exceeding 15 amperes is not to supply more than one point.

2.1.7.3 A final sub-circuit of rating 15 amperes or less is not to supply more than the following number of lighting points:

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Number of Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 - 55 V</td>
<td>10</td>
</tr>
<tr>
<td>110 - 127 V</td>
<td>14</td>
</tr>
<tr>
<td>220 - 250 V</td>
<td>18</td>
</tr>
</tbody>
</table>

This provision is not applicable to final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped. In such cases, the number of points is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10 amperes.

2.1.7.4 Lighting of unattended spaces, such as cargo spaces is to be controlled by multi-pole linked switches located outside such spaces. Provision is to be made for the complete isolation of these circuits and locking in the "OFF" position of the means of control.

2.1.7.5 Emergency lighting is to be fitted in accordance with 2.1.4.

2.1.8 Motor circuits

2.1.8.1 A separate final sub-circuit is to be provided for every motor required for essential services and for every motor of 1 [kW] or more.

2.1.9 Motor control

2.1.9.1 Every electric motor is to be provided with an efficient means of starting and stopping so placed as to be easily accessible to the person controlling the motor.

2.1.9.2 Every motor required for essential services and every motor of 0.5 [kW] or more is to be provided with the control apparatus as mentioned in 2.1.9.4 to 2.1.9.8.

2.1.9.3 When motor control gear is being selected, the maximum current of the motor is to be taken as its rated full load current.

2.1.9.4 Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit breaker.
2.1.9.5 Where the primary means of isolation (viz. that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following provisions is to be made:

a) An additional means of isolation fitted adjacent to the motor; or

b) Provision made for locking the primary means of isolation in the OFF position; or

c) Provision made so that the fuses in each line can be readily removed and retained by authorized personnel.

2.1.9.6 Means to prevent the undesired restarting after a stoppage due to low volts or complete loss of volts are to be provided. This does not apply to motors where a dangerous condition might result from the failure to restart automatically e.g. steering gear motor. It is, however, to be ensured that the total starting current of motors having automatic re-start will not cause excessive voltage drop or overcurrent on the installation.

2.1.9.7 Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided. (This does not apply to steering gear motors).

2.1.9.8 Where fuses are installed to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

2.1.10 Remote stops for ventilation fans and pumps

2.1.10.1 Ventilating fans for machinery and cargo spaces are to be provided with means for stopping them from easily accessible control stations located outside such spaces.

2.1.10.2 Motors driving forced and induced draught fans, independently driven pumps delivering oil to main propulsion machinery for bearing lubrication and piston cooling, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps, fuel and lubricating oil purifiers and their attached pumps are to be fitted with remote controls situated outside the space concerned so that the electrical supply thereto can be disconnected in the event of fire arising in the space in which they are located.

2.1.10.3 In passenger ships all power ventilation systems, except cargo and machinery spaces ventilation, which is to be in accordance with 2.1.10.1, are to be fitted with master controls so that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable.

2.1.11 Steering gear

2.1.11.1 Where electrical control of the steering system is fitted, an independent alternative control system is to be installed. This may be a duplicate electrical control system or control by other means.

2.1.11.2 Provision is to be made on the bridge to transfer the steering control instantaneously to the alternative means of control.

2.1.11.3 Indicators for running indication of steering gear motors are to be installed on the bridge.

2.1.11.4 Audible and visual alarms are to operate at the steering positions for failure of steering gear power system and failure of steering gear control system.

2.1.12 Fire detection, alarm and extinguishing systems on passenger ships

2.1.12.1 Where electrically driven emergency fire pumps are installed in accordance with Ch.9 the supply to such pumps is not to pass through the main machinery space.

2.1.12.2 Any fire alarm system is to operate both audible and visual signals at the fire detection control station(s).

2.1.13 Navigation lights

2.1.13.1 Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted in the distribution board.

2.1.13.2 Automatic indication of failure is to be provided unless the lights are visible from the bridge.

2.1.13.3 Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.
2.1.14 Size of batteries and charging facilities

2.1.14.1 Where batteries are used for starting main engines, they are to be of adequate capacity to meet the requirements of Ch.4.

2.1.14.2 Adequate charging facilities are to be provided, and where batteries are charged from line voltage by means of a series resistor, protection against reversal of current is to be provided when the charging voltage is 20 per cent of line voltage or higher. Means are also to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

2.1.15 Heating and cooking equipment

2.1.15.1 Every heating or cooking appliance is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the appliance.

2.1.15.2 In the case of small heaters, for individual cabins or similar small dry accommodation spaces where the floor coverings, bulkheads and ceiling linings are of insulating materials, a single pole switch is acceptable.

2.1.15.3 Heating arrangements of the exposed element type are not to be used in any location.

2.1.16 Temporary external supply/shore connection

2.1.16.1 Where arrangements are provided for the supply of electric power from a source on shore or elsewhere, a connection box is to be installed in an easily accessible location in a manner suitable for the convenient reception of flexible cables from the external source. This box should contain a circuit-breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. The mechanical stress of the portable cable is to be conveyed directly to the metallic framework and not to electrical connectors. Suitable cables, permanently fixed, are to be provided, connecting the circuit breaker/isolating switch in the connection box to a linked switch and/or circuit breaker at the main switchboard.

2.1.16.2 For alternating current systems an earthed terminal is to be provided for the reception of three-phase external supplies with earthed neutrals.

2.1.16.3 The external connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

2.1.16.4 Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply. This device should be connected between the incoming connectors and the interrupting device in the connection box.

2.1.16.5 A notice is to be provided at the connection box giving complete information on the system of supply and the normal voltage (and frequency for alternating current) of the ship's installed system. Full details of the procedure for effecting the connection are to be given on this notice.

2.1.16.6 Alternate arrangements for providing a temporary external supply will be specially considered.

2.2 Protection

2.2.1 General

2.2.1.1 Installations are to be protected against accidental over-currents including short circuits. The choice, location and characteristics of the protective device are to provide complete and co-ordinated protection to ensure:-

a) Elimination of the fault to reduce damage to the system and hazard of fire.

b) Continuity of service so as to maintain, through the discriminative action of the protective devices, the supply to circuits not directly affected by the fault.

2.2.2 Protection against overload

2.2.2.1 Protection against overloads may be provided by circuit-breakers, automatic switches or fuses. The tripping characteristics of these devices are to be appropriate to the system. Fuses rated above 320 amperes are not to be used for protection against overload, but may be used for short-circuit protection.

2.2.3 Protection against short-circuit

2.2.3.1 Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

2.2.3.2 The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.
2.2.3.3 The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

2.2.3.4 Every protective device or contactor not intended for short circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short circuit to be removed.

2.2.3.5 In the absence of precise data of rotating machines the following short-circuit currents at the machine terminals are to be assumed. The short circuit current is to be the sum of short circuit currents of generators and that of motors;

a) Direct current systems
   Ten times full load current for generators normally connected (including spare),
   Six times full load current for motors simultaneously in service;

b) Alternating current systems.
   Ten times full load current for generators normally connected (including spare) - symmetrical RMS,
   Three times full load current for motors simultaneously in service.

2.2.4 Combined circuit-breakers and fuses

2.2.4.1 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted, provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

2.2.4.2 Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

2.2.4.3 The characteristics of the arrangement are to be such that:-

a) When the short-circuit current is broken, the circuit-breaker on the load side is not to be damaged and is to be capable of further service,

b) When the circuit-breaker is closed on the short-circuit current, the remainder of the installation is not to be damaged. However, it is admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

2.2.5 Protection of circuits

2.2.5.1 Short circuit protection is to be provided in each live pole of a direct current system and in each phase of an alternating current system.

2.2.5.2 Protection against overloads is to be provided as follows:-

a) Two-wire direct current or single-phase alternating current system - at least one line or phase,

b) Insulated three-phase alternating current system - at least two phases,

c) Earthed three-phase alternating current system - all three phases.

2.2.5.3 No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

2.2.5.4 These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

2.2.6 Protection of generators

2.2.6.1 In addition to over-current protection, the provisions of 2.2.6.2 to 2.2.6.7 are to be adhered to as a minimum.

2.2.6.2 For generators not arranged to run in parallel a multi-pole circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 [kW] a multi-pole linked switch with a fuse in each insulated pole on the generator side is to be provided. The fuse rating in such cases is to be maximum 125 per cent of the generator rated current.

2.2.6.3 For generators arranged to run in parallel a circuit-breaker arranged to open simultaneously all insulated poles is to be provided. This circuit-breaker is to be provided with:-

a) For direct current generators, instantaneous reverse-current protection operating at not more than 15 per cent rated current,

b) For alternating current generators -
i) A reverse-power protection, with time delay selected and set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with characteristics of primemovers.

ii) A device for protection against the effects of parallel connection in opposite phase.

2.2.6.4 The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the network, e.g. from winches. The reverse-power protection specified for alternating current generators may be replaced by other devices ensuring adequate protection of the prime movers.

2.2.6.5 Generator circuit-breakers are normally to be provided with under voltage release.

2.2.7 Protection of feeder circuits

2.2.7.1 Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit-breaker or multi-pole switch and fuses. The provisions of 2.2.2, 2.2.3 and 2.2.5 are to be complied with. The protective devices are to allow excess current to pass during the normal accelerating period of motors. Where multi-pole switch and fuses are used, the fuses are generally to be installed between the busbars and the switch.

2.2.7.2 Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

2.2.7.3 Motors of rating exceeding 0.5 [kW] are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. The overload protection may be replaced by an overload alarm, if desired by the Owner.

2.2.8 Protection of power transformers

2.2.8.1 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses. The rating of fuses or the setting for overcurrent releases of circuit breakers is not to exceed 125 per cent of rated primary current.

2.2.8.2 When transformers are arranged to operate in parallel, means are to be provided for isolation of the secondary circuits. Switches and circuit-breakers are to be capable of withstanding surge currents.

2.2.9 Protection of lighting circuits

2.2.9.1 Lighting circuits are to be provided with overload and short-circuit protection.

2.2.10 Protection of meters, pilot lamps, capacitors and control circuits

2.2.10.1 Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps, together with their connecting leads by means of protective devices fitted to each insulated pole or phase.

2.2.10.2 A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

2.2.11 Protection of batteries

2.2.11.1 Accumulator batteries other than engine starting batteries are to be protected against short circuit by devices, in each insulated pole, placed at a position adjacent to the battery compartment.

2.2.12 Protection of communication circuits

2.2.12.1 Communication circuits other than those supplied from primary batteries are to be protected against overload and short-circuit.
Section 3

Cables

3.1 General

3.1.1 Cables are to be in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

3.2 Insulating materials

3.2.1 Permitted insulating materials with maximum rated conductor temperatures are given in Table 3.2.1.

3.2.2 The rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

3.2.3 Where a rubber or rubber like material with maximum conductor temperature greater than 60°C is used, it is to be readily identifiable.

3.3 Sheaths and protective coverings

3.3.1 Cables are to be protected by one or more of the following, and the material of the sheath or protective covering is to be compatible with the material of the insulation:-

a) Sheath
   - Lead-alloy
   - Copper
   - Non-metallic

b) Protective covering
   - Steel-wire armour
   - Steel-tape armour
   - Metal-braid armour (basket weave)
   - Fibrous braid

3.3.2 Unsheathed cables, e.g. rubber insulated taped and braided or equivalent, may be used only if installed in conduit.

3.3.3 Non-metallic sheath : Polychloroprene compound, polyvinyl chloride compound and chlorosulphonated polyethylene may be used for impervious sheaths. Other compounds will be given due consideration.

3.3.4 Fibrous braid : Textile braid is to be of cotton, hemp, asbestos, glass or other equivalent fiber, and is to be of strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture and which is flame retarding.

---

<table>
<thead>
<tr>
<th>Table 3.2.1 : Insulating materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulating materials</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Elastomeric Compounds</td>
</tr>
<tr>
<td>Natural or synthetic rubber (general purpose)</td>
</tr>
<tr>
<td>Rubber</td>
</tr>
<tr>
<td>Butyl rubber</td>
</tr>
<tr>
<td>Ethylene propylene rubber</td>
</tr>
<tr>
<td>Silicone rubber</td>
</tr>
<tr>
<td>Thermoplastic Compounds</td>
</tr>
<tr>
<td>Polyvinyl chloride (general purpose)</td>
</tr>
<tr>
<td>Polyvinyl chloride (heat resisting quality)</td>
</tr>
<tr>
<td>Other Materials</td>
</tr>
<tr>
<td>Minerals</td>
</tr>
</tbody>
</table>

Notes:

1. Silicone rubber and mineral insulation may be used for higher temperatures (upto 150°C for silicone rubber and upto 250°C for mineral insulation) when installed where they are not liable to be touched by personnel. Proposals for such installations will be specially considered.

2. The temperature of the conductor is the combination of ambient temperature and temperature rise due to load.

3. Other insulating materials will be considered.
3.3.5 Cables fitted in the following locations:-
- Decks exposed to weather;
- Bathrooms;
- Cargo holds;
- Machinery spaces;
or any other location where water condensation or harmful vapour (e.g. oil vapour) may be present are to have an impervious sheath. In permanently wet situations, metallic sheaths are to be used for cables with hygroscopic insulation.

3.3.6 All cables are to be of flame-retardant type or fire-resisting type, except that non flame-retardant cables may be accepted for final circuits only where cables are installed in metallic conduits having internal diameter not exceeding 25 [mm] and provided the conduits are electrically and mechanically continuous.

3.4 Voltage rating

3.4.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

3.4.2 The voltage drop from the main switchboard bus bars to any point in the installation when the cables are carrying maximum current under normal conditions of service is not to exceed 6 per cent of the nominal voltage.

3.5 Current rating

3.5.1 The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on the plans submitted for approval.

3.5.2 In assessing the current rating of lighting circuits, every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 W, unless the fitting is so connected as to take only a lamp rated at less than 60 W.

3.5.3 Cables supplying winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating, cables for winch or crane motors may be half hour rated on the basis of the half hour [kW] rating of the motors.

Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour [kW] rating of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

3.5.4 The current ratings given in Tables 3.5.1 to 3.5.5 are based on the maximum operating conductor temperatures, given in Table 3.2.1. Alternatively current rating in accordance with an acceptable National or International Standard may be applied. See 3.1.1.

### Table 3.5.1: General purpose rubber and PVC insulation current rating (Based on ambient temp. 45°C)

<table>
<thead>
<tr>
<th>Nominal cross-section [mm²]</th>
<th>Single core amperes</th>
<th>2 core amperes</th>
<th>3 or 4 core amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1.5</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>17</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>29</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>16</td>
<td>54</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>25</td>
<td>71</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>35</td>
<td>87</td>
<td>74</td>
<td>61</td>
</tr>
<tr>
<td>50</td>
<td>105</td>
<td>89</td>
<td>74</td>
</tr>
<tr>
<td>70</td>
<td>135</td>
<td>115</td>
<td>95</td>
</tr>
<tr>
<td>95</td>
<td>165</td>
<td>140</td>
<td>116</td>
</tr>
<tr>
<td>120</td>
<td>190</td>
<td>162</td>
<td>133</td>
</tr>
<tr>
<td>150</td>
<td>220</td>
<td>187</td>
<td>154</td>
</tr>
<tr>
<td>185</td>
<td>250</td>
<td>213</td>
<td>175</td>
</tr>
<tr>
<td>240</td>
<td>290</td>
<td>247</td>
<td>203</td>
</tr>
<tr>
<td>300</td>
<td>335</td>
<td>285</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>d.c. a.c.</td>
<td>d.c. a.c.</td>
<td>d.c. a.c.</td>
</tr>
<tr>
<td>400</td>
<td>390</td>
<td>380</td>
<td>332</td>
</tr>
<tr>
<td></td>
<td>323</td>
<td>273</td>
<td>266</td>
</tr>
<tr>
<td>500</td>
<td>450</td>
<td>430</td>
<td>383</td>
</tr>
<tr>
<td></td>
<td>365</td>
<td>315</td>
<td>301</td>
</tr>
<tr>
<td>630</td>
<td>520</td>
<td>470</td>
<td>442</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>364</td>
<td>329</td>
</tr>
</tbody>
</table>

3.6 Correction factors for current rating

3.6.1 **Bunching of cables**: Where more than six cables belonging to the same circuit are bunched together a correction factor of 0.85 is to be applied.
### Table 3.5.2: Heat resisting PVC insulation current rating
(Based on ambient temp. 45°C)

<table>
<thead>
<tr>
<th>Nominal cross-section [mm²]</th>
<th>Single core amperes</th>
<th>2 core amperes</th>
<th>3 or 4 core amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>1.5</td>
<td>17</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>2.5</td>
<td>24</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>41</td>
<td>35</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>57</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>16</td>
<td>76</td>
<td>65</td>
<td>53</td>
</tr>
<tr>
<td>25</td>
<td>100</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>35</td>
<td>125</td>
<td>106</td>
<td>88</td>
</tr>
<tr>
<td>50</td>
<td>150</td>
<td>128</td>
<td>105</td>
</tr>
<tr>
<td>70</td>
<td>190</td>
<td>162</td>
<td>133</td>
</tr>
<tr>
<td>95</td>
<td>230</td>
<td>196</td>
<td>161</td>
</tr>
<tr>
<td>120</td>
<td>270</td>
<td>230</td>
<td>189</td>
</tr>
<tr>
<td>150</td>
<td>310</td>
<td>264</td>
<td>215</td>
</tr>
<tr>
<td>185</td>
<td>350</td>
<td>298</td>
<td>245</td>
</tr>
<tr>
<td>240</td>
<td>415</td>
<td>353</td>
<td>291</td>
</tr>
<tr>
<td>300</td>
<td>475</td>
<td>404</td>
<td>333</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>630</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3.5.3: Butyl insulation current rating
(Based on ambient temp. 45°C)

<table>
<thead>
<tr>
<th>Nominal cross-section [mm²]</th>
<th>Single core amperes</th>
<th>2 core amperes</th>
<th>3 or 4 core amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>1.5</td>
<td>19</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>2.5</td>
<td>26</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>45</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>63</td>
<td>54</td>
<td>44</td>
</tr>
<tr>
<td>16</td>
<td>84</td>
<td>71</td>
<td>59</td>
</tr>
<tr>
<td>25</td>
<td>110</td>
<td>94</td>
<td>77</td>
</tr>
<tr>
<td>35</td>
<td>140</td>
<td>119</td>
<td>98</td>
</tr>
<tr>
<td>50</td>
<td>165</td>
<td>140</td>
<td>116</td>
</tr>
<tr>
<td>70</td>
<td>215</td>
<td>183</td>
<td>151</td>
</tr>
<tr>
<td>95</td>
<td>260</td>
<td>221</td>
<td>182</td>
</tr>
<tr>
<td>120</td>
<td>300</td>
<td>255</td>
<td>210</td>
</tr>
<tr>
<td>150</td>
<td>340</td>
<td>289</td>
<td>238</td>
</tr>
<tr>
<td>185</td>
<td>390</td>
<td>332</td>
<td>273</td>
</tr>
<tr>
<td>240</td>
<td>460</td>
<td>391</td>
<td>322</td>
</tr>
<tr>
<td>300</td>
<td>530</td>
<td>450</td>
<td>371</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>630</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The tables provide the maximum current ratings for heat resisting PVC and Butyl insulation based on the nominal cross-sections, considering ambient temperatures of 45°C.
Table 3.5.4: Ethylene propylene rubber, cross-linked polyethylene insulation current rating (Based on ambient temp. 45°C)

<table>
<thead>
<tr>
<th>Nominal cross-section [mm²]</th>
<th>Single core amperes</th>
<th>2 core Amperes</th>
<th>3 or 4 core amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>1.5</td>
<td>20</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>2.5</td>
<td>28</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>48</td>
<td>41</td>
<td>34</td>
</tr>
<tr>
<td>10</td>
<td>67</td>
<td>57</td>
<td>47</td>
</tr>
<tr>
<td>16</td>
<td>90</td>
<td>77</td>
<td>63</td>
</tr>
<tr>
<td>25</td>
<td>120</td>
<td>102</td>
<td>84</td>
</tr>
<tr>
<td>35</td>
<td>145</td>
<td>123</td>
<td>102</td>
</tr>
<tr>
<td>50</td>
<td>180</td>
<td>153</td>
<td>126</td>
</tr>
<tr>
<td>70</td>
<td>225</td>
<td>191</td>
<td>158</td>
</tr>
<tr>
<td>95</td>
<td>275</td>
<td>234</td>
<td>193</td>
</tr>
<tr>
<td>120</td>
<td>320</td>
<td>272</td>
<td>224</td>
</tr>
<tr>
<td>150</td>
<td>365</td>
<td>310</td>
<td>256</td>
</tr>
<tr>
<td>185</td>
<td>415</td>
<td>353</td>
<td>291</td>
</tr>
<tr>
<td>240</td>
<td>490</td>
<td>417</td>
<td>343</td>
</tr>
<tr>
<td>300</td>
<td>560</td>
<td>476</td>
<td>392</td>
</tr>
<tr>
<td>d.c. 400</td>
<td>650</td>
<td>553</td>
<td>536</td>
</tr>
<tr>
<td>a.c. 445</td>
<td>441</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>740</td>
<td>629</td>
<td>578</td>
</tr>
<tr>
<td>630</td>
<td>840</td>
<td>714</td>
<td>629</td>
</tr>
</tbody>
</table>

Table 3.5.5: Silicon rubber, mineral insulation current rating (Based on ambient temp. 45°C)

<table>
<thead>
<tr>
<th>Nominal cross-section [mm²]</th>
<th>Single core amperes</th>
<th>2 core Amperes</th>
<th>3 or 4 core amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>1.5</td>
<td>24</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>2.5</td>
<td>32</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>47</td>
<td>39</td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>64</td>
<td>53</td>
</tr>
<tr>
<td>16</td>
<td>100</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>25</td>
<td>135</td>
<td>115</td>
<td>95</td>
</tr>
<tr>
<td>35</td>
<td>165</td>
<td>140</td>
<td>116</td>
</tr>
<tr>
<td>50</td>
<td>200</td>
<td>175</td>
<td>140</td>
</tr>
<tr>
<td>70</td>
<td>255</td>
<td>217</td>
<td>179</td>
</tr>
<tr>
<td>95</td>
<td>310</td>
<td>264</td>
<td>217</td>
</tr>
<tr>
<td>120</td>
<td>360</td>
<td>306</td>
<td>252</td>
</tr>
<tr>
<td>150</td>
<td>410</td>
<td>349</td>
<td>287</td>
</tr>
<tr>
<td>185</td>
<td>470</td>
<td>400</td>
<td>329</td>
</tr>
<tr>
<td>240</td>
<td>570</td>
<td>485</td>
<td>400</td>
</tr>
<tr>
<td>300</td>
<td>660</td>
<td>560</td>
<td>460</td>
</tr>
</tbody>
</table>
Table 3.6.1 : Correction factors for temperature

<table>
<thead>
<tr>
<th>Insulation</th>
<th>Correction factor for ambient temperature in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Rubber or PVC (general purpose)</td>
<td>1.53</td>
</tr>
<tr>
<td>PVC (heat-resisting quality)</td>
<td>1.29</td>
</tr>
<tr>
<td>Butyl rubber</td>
<td>1.25</td>
</tr>
<tr>
<td>Ethylene propylene rubber, cross-linked polyethylene</td>
<td>1.22</td>
</tr>
<tr>
<td>Mineral, silicone rubber</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
1. For cables in refrigerated chambers and holds and for vessels restricted to service in non-tropical waters, correction factors for 35°C may be acceptable.
2. Correction factors for intermediate values of the ambient temperature can be ascertained by interpolation.

Table 3.6.2 : Correction factors for intermittent rating

<table>
<thead>
<tr>
<th>Correction factor</th>
<th>Half-hour rating</th>
<th>One-hour rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With metallic sheath [mm²]</td>
<td>Without metallic sheath [mm²]</td>
</tr>
<tr>
<td>1.00</td>
<td>Upto 20</td>
<td>Upto 75</td>
</tr>
<tr>
<td>1.10</td>
<td>21 - 40</td>
<td>76 - 125</td>
</tr>
<tr>
<td>1.15</td>
<td>41 - 65</td>
<td>126 - 180</td>
</tr>
<tr>
<td>1.20</td>
<td>66 - 95</td>
<td>181 - 250</td>
</tr>
<tr>
<td>1.25</td>
<td>96 - 120</td>
<td>251 - 320</td>
</tr>
<tr>
<td>1.30</td>
<td>131 - 170</td>
<td>321 - 400</td>
</tr>
<tr>
<td>1.35</td>
<td>171 - 220</td>
<td>401 - 500</td>
</tr>
<tr>
<td>1.40</td>
<td>221 - 270</td>
<td>-</td>
</tr>
</tbody>
</table>

3.6.2 Ambient temperature : The current ratings in Table 3.5.1 to 3.5.5 are based on an ambient temperature of 45°C. For other values of ambient temperature the correction factors shown in Table 3.6.1, are to be applied.

3.6.3 Intermittent service : Where the load is intermittent, the correction factors in Table 3.6.2 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

3.7 Testing

3.7.1 Tests in accordance with an acceptable National or International Standard are to be made at the manufacturer's works prior to dispatch.

3.8 Connections between entrained ships

3.8.1 Cables are to be suitable for use in the connections between entrained ships i.e., are to be flexible, robust and of commensurate cross-section area.
3.8.2 The connection is to include provisions for the continuity of out-of-balance or earth-fault current return. The connecting device is to include provisions to ensure that this circuit is closed before, and opened after, the live circuits.

3.8.3 Terminal plugs and sockets, if used, are to be so arranged that any exposed pins cannot be energized.

3.8.4 Where hull-return systems are used, hull polarity is to be compatible.

3.9 Installation of cables

3.9.1 Cable runs are to be, as far as practicable, straight and accessible and as high as possible above bilges.

3.9.2 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable reaches temperature higher than that permitted for the lowest temperature-rated cable in the group.

3.9.3 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

3.9.4 The minimum internal radius of bends of installed cables is to be generally in accordance with following:

| d = overall diameter of cable | 4d | for cables without braiding, armouring or other metal sheath and with an overall diameter not exceeding 25 [mm] |
| 6d | for all other cables |

3.9.5 Cables are to be effectively supported and secured in a manner that prevents damage to their coverings.

3.9.6 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

3.9.7 The distance between supports, for horizontal as well as vertical runs of cables, is to be chosen according to the type/size of cable, but generally in accordance with Table 3.9.1.

3.10 Mechanical protection of cables

3.10.1 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g. armour or sheath) is adequate to withstand the possible damage.

<table>
<thead>
<tr>
<th>Table 3.9.1 : Distance between supports</th>
</tr>
</thead>
<tbody>
<tr>
<td>External diameter of cable</td>
</tr>
<tr>
<td>[mm]</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

3.10.2 Cables, in spaces where there is exceptional risk of mechanical damage (e.g. on weather decks, in cargo hold areas and inside the cargo holds) and also below the floor in engine room, are to be suitably protected, even if armoured, unless the steel structure affords adequate protection.

3.10.3 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

3.11 Earthing of metal coverings

3.11.1 Metal coverings of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits, where earthing at the supply end only will be considered adequate. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

3.11.2 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings, is to be ensured.

3.11.3 The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

3.12 Penetration of bulkheads and decks by cables

3.12.1 Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. In either case, the watertight integrity and strength of the bulkheads and decks are to be maintained. Where cables with polyvinyl chloride insulation are being installed, particular care is to be taken
to avoid damage to the sheathing during the fitting of watertight bulkhead glands.

3.12.2 Where cables pass through non-watertight bulkheads or structural steel, the holes are to be bushed, in order to protect the cables, with lead or other approved material which will prevent damage to the cables by abrasion. If the steel is 6 [mm] thick, adequately rounded edges may be accepted as the equivalent of bushing.

3.12.3 Cables passing through decks are to be protected by deck tubes or ducts.

3.12.4 Materials used for glands and bushings are to be such that there is no risk of corrosion.

3.12.5 Where rectangular holes are cut in bulkheads or structural steel the corners are to be adequately rounded.

3.13 Installation of cables in pipes and conduits

3.13.1 Installation of cables in pipes and conduits is to be carried out in such a manner that there is no damage to the cable covering.

3.13.2 Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

3.13.3 The internal radius of bend of pipes and conduit is to be not less than that laid down for cables, provided that for pipes exceeding 64 [mm] diameter the internal radius of bend is not less than twice the diameter of the pipe.

3.13.4 The drawing-in factor (ratio of the sum of the cross-sectional areas of the cables, based on their external diameter, to the internal cross-section area of the pipe) is not to exceed 0.4.

3.13.5 Expansion joints are to be provided where necessary.

3.13.6 Cable pipes and conduits are to be adequately and effectively protected against corrosion. Where necessary, openings are to be provided at the highest and lowest points to permit air circulation and to prevent accumulation of water.

3.13.7 Where cables are laid in trunks, the trunks are to be so constructed as not to afford passage for fire from one deck or compartment to another.

3.13.8 Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

3.14 Cables for alternating current

3.14.1 Generally, multi-core cables are to be used in A.C. installations. Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 amperes the requirements of 3.14.2 to 3.14.8 are to be complied with.

3.14.2 Cables are to be either non-armoured or armoured with non-magnetic material.

3.14.3 If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

3.14.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

3.14.5 When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any case, the distance between the external covering of two adjacent cables is not to be greater than one diameter.

3.14.6 In the case of circuits using two or more parallel connected cables per phase, all cables are to have the same length and cross sectional area.

3.14.7 Where single core cables of rating exceeding 50 amperes are used, magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates, all cables of the same circuit are to pass through the plate or gland so constructed that there is no magnetic material between the cables, and suitable clearance is provided between the cable core and magnetic material. This clearance, wherever practicable, is not to be less than 75 [mm] when the current exceeds 300 amperes. For currents between 50 amperes and 300 amperes the clearance may be proportionately reduced.

3.14.8 If single-core cables of current rating greater than 250 amperes are run along a steel bulkhead, wherever practicable the cables should be spaced away from the steel.
3.15 Cable ends

3.15.1 The ends of all conductors of cross-sectional area greater than 4 [mm²] are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

3.15.2 Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture.

3.15.3 Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

3.16 Joints and branch circuits in cable systems

3.16.1 Cable runs are normally not to include joints. However, if a joint is necessary it is to be carried so that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals and busbars are to be of dimensions adequate for the cable rating.

Section 4

Switchboards

4.1 General

4.1.1 Switchboards, section boards and distribution boards are to be constructed of, or enclosed with non-flammable, non-hydroscopic material and are to be so installed that live parts are sufficiently guarded and adequate space is provided for maintenance. Also they are to be protected where necessary in way of pipes etc.

4.1.2 All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labeled for identification purposes. An indelible label is to be permanently secured adjacent to every fuse and every circuit breaker and marked with particulars of the full load current of the generator, motor or cable which the fuse or circuit breaker protects. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. Name plates are to be of flame retardant material.

4.2 Instruments

4.2.1 Sufficient instrumentation is to be provided for measuring voltage, current, frequency and, for alternating current generators above 50 [kW].

4.2.2 Where alternating current generators are required to operate in parallel, synchronising arrangements are to be fitted.

4.3 Instrument transformers

4.3.1 The secondary windings of instrument transformers are to be earthed.

4.4 Switchgear

4.4.1 Circuit breakers and switches are to be of the air break type and are to be constructed in accordance with an acceptable National or International Standard.

4.4.2 Report of tests to establish the capacity of circuit-breakers are to be submitted for consideration when required.

4.4.3 Overcurrent releases are to be calibrated in amperes and settings marked on the circuit-breaker.

4.5 Fuses

4.5.1 Fuses are to comply with an acceptable National or International Standard.

4.5.2 Fuse links and fuse bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labeled with the current carrying capacity of the circuit protected by it and with the appropriate approved size of fuse or replaceable element.

4.6 Testing

4.6.1 Before installation, switchboards complete or in sections with all components are to pass the following tests at the manufacturer's works and a certificate furnished. A high voltage test is to be carried out in all switching and control apparatus for systems greater than 60V with a test voltage of 1000V plus twice the rated voltage with a minimum of 2000V at any frequency between 25 and 100 Hz for one minute applied between (a) all current-carrying
parts connected together and earth and (b) between current carrying parts of opposite polarity or phases.

4.6.2 For systems of 60V or less the test shall be at 500V for one minute.

4.6.3 Instruments and ancillary apparatus may be disconnected during the high voltage test.

4.6.4 Immediately after the high voltage test, the insulation resistance between (a) all current-carrying parts connected together and earth and (b) between current carrying parts of opposite polarity or phase, shall not be less than 1 Megohm when tested with a direct current voltage of at least 500V.

4.6.5 Functional tests. The correct functions of the installation components in line with the connections intended to be made have to be checked as far as possible.

Section 5

Control Gear

5.1 General

5.1.1 Control gear is to comply with an acceptable National or International Standard, amended where necessary for ambient temperature.

5.1.2 Control gear, including isolating and reversing switches, is to be so arranged that shunt field circuits are not disconnected without adequate discharging path being provided.

5.2 Testing

5.2.1 Control gear and resistors are to be tested by the manufacturers with a high voltage applied between the earthed frame and all live parts and a certificate furnished by them to this effect. For operating voltages above 55 V, the test voltage is to be 1000 V plus twice the rated voltage with a minimum of 2000 V. The voltage is to be alternating at any frequency between 25 and 100 Hz and is to be maintained for one minute without failure.

5.2.2 Control gear and resistors operating at 55 V or below are to be tested to 500 V for one minute.

5.2.3 Immediately after the high voltage test, the insulation resistance between (a) all current-carrying parts connected together and earth, and (b) between current-carrying parts of opposite polarity or phase, is not to be less than 1 megohm when tested with a direct current voltage of at least 500 V.

5.2.4 Instruments and ancillary apparatus may be disconnected during the high voltage test.

5.2.5 Functional Test: The correct functions of the installation components in line with the connections intended to be made, have to be checked as far as possible.

Section 6

Rotating Machines Construction and Testing

6.1 General

6.1.1 Rotating machines are to be constructed in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

6.2 Rating

6.2.1 Ship's service generators including their exciters, and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 6.3 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform, and when tested under rated load conditions the temperature rise is not to exceed the values in 6.3. Alternatively limits of temperature rise in accordance with an acceptable National or International Standard may be applied.
6.3 Temperature rise

6.3.1 The limits of temperature rise specified in Table 6.3.1 are based on a cooling air temperature of 45°C and a cooling water temperature of 30°C.

6.3.2 If the temperature of the cooling medium is known to exceed the value given in 6.3.1, the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium.

6.3.3 If the temperature of the cooling medium is known to be permanently less than the value given in 6.3.1, the permissible temperature rise may be increased by an amount equal to the difference between the declared temperature and that given in 6.3.1 up to a maximum of 15°C.

<table>
<thead>
<tr>
<th>Item</th>
<th>Part of machines</th>
<th>Method of measurement of temperature</th>
<th>Temperature rise in air-cooled machines °C</th>
<th>Insulation Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a)</td>
<td>a.c. windings</td>
<td>R</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>1 (b)</td>
<td>Field windings of a.c. and d.c. machines having d.c. excitation other than those in Items 2 and 3</td>
<td>R</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>1 (c)</td>
<td>Windings of armatures having commutators</td>
<td>R</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>Field windings of turbine-type machines having d.c. excitation</td>
<td>R</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 (a)</td>
<td>Low-resistance field windings of more than one layer and compensating windings</td>
<td>T,R</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>3 (b)</td>
<td>Single-layer windings with exposed bare surfaces</td>
<td>T,R</td>
<td>55</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>E</td>
</tr>
<tr>
<td>4</td>
<td>Permanently short-circuited insulated windings</td>
<td>T</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>Permanently short-circuited windings uninsulated</td>
<td>T</td>
<td>The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Iron core and other parts not in contact with windings</td>
<td>-</td>
<td>The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Iron core and other parts in contact with windings</td>
<td>T</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>8</td>
<td>Commutators and slip-rings open or enclosed</td>
<td>T</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70</td>
<td>B</td>
</tr>
</tbody>
</table>

Notes:

1. T = Thermometer method
   R = Resistance method

2. When Class F or Class H insulation is employed, the permitted temperature rises are respectively 20°C and 40°C higher than the values given for Class B insulation.

3. Classes of insulation are to be in accordance with IEC Publication 85 (1957) - "Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their Thermal Stability in Service".
6.4 Direct current service generators

6.4.1 Shunt wound direct current generators are to be provided with automatic voltage regulators.

6.4.2 Direct current generators used for charging batteries without series-regulating resistors are to be either:-

a) Shunt wound, or

b) Compound wound with switches arranged so that the series winding can be switched out of service.

6.4.3 If terminal voltage is required to be manually adjusted to ensure satisfactory operation of generators, then, facilities are to be provided at the switchboard or at an appropriate and convenient control position to enable such adjustments to be made.

6.4.4 For each direct current generator, whilst being driven by its prime mover, at any temperature within the working range, the means provided is to be capable of adjusting the voltage at any load between no load and full load to within:-

a) 1.0 per cent of rated voltage for generators of rating less than 100 [kW],

b) 0.5 per cent of rated voltage for generators of rating exceeding 100 [kW].

6.4.5 The inherent regulation of service generators is to be such that the following conditions are fulfilled:-

a) For shunt or stabilised shunt wound generators when the voltage has been set at full load, the steady voltage at no load is not to exceed 115 per cent of the full load value, and the voltage obtained at any intermediate value of load is not to exceed the no-load value.

b) For compound wound generators with the generator at full load operating temperature, and starting at 20 per cent load with voltage within 1 per cent of rated voltage, then at full load the voltage is to be within 2.5 per cent of rated voltage. The average of the ascending and descending load/voltage curves between 20 per cent load and full load is not to vary more than 4 per cent from rated voltage.

6.4.6 Generators are to be capable of delivering continuously the full load current and normal rated voltage at the terminals when running at full load engine speed at all ambient temperatures up to the specified maximum.

6.4.7 Generators required to run in parallel are to be stable from no load up to the total combined load of the group, and load sharing is to be satisfactory.

6.4.8 The series winding of each two-wire generator is to be connected to the negative terminal.

6.4.9 Equalizer connections are to have a cross-sectional area appropriate to the system but in no case less than 50 per cent of that of the negative connection from the generator to the switchboard.

6.5 Alternating current service generators

6.5.1 Each alternating current service generator, unless of the self regulating type, is to be provided with automatic means of voltage regulation.

6.5.2 The voltage regulation of any alternating current generator with its regulating equipment is to be such that at all loads from zero to full load the voltage at rated power factor is maintained under steady conditions within 2.5 per cent of rated voltage.

6.5.3 Alternating current generators required to run in parallel are to be stable from 20 per cent full load [kW] up to the total combined full load [kW] of the group, and load sharing is to be such that the load on any generator does not normally differ from its proportionate share of the total load by more than 15 per cent of the rated power factor is maintained under steady conditions within 2.5 per cent of rated voltage.

6.5.4 When generators are operated in parallel, the KVA loads of the individual generating sets are not to differ from their proportionate share of the total KVA load by more than 5 per cent of the rated KVA output of the largest machine when operating at 0.8 power factor.

6.6 Inspection and testing

6.6.1 On machines for essential services tests are to be carried out in accordance with the relevant standard and a certificate furnished by the manufacturers.

6.6.2 Generators and motors of 100 [kW] or over intended for essential services are to be inspected by the Surveyors during manufacture and testing.
Section 7

Transformers - Construction and Testing

7.1 General

7.1.1 Transformers are to be in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

7.1.2 Transformers are to be of the dry, natural air cooled type. Proposals for the use of liquid cooled transformers will be subject to special consideration.

7.2 Installation

7.2.1 Transformers are to be placed in easily accessible well ventilated spaces free from any gaseous or acid fumes. They are to be clear of non-protected ignitable materials, and so arranged as to be protected against shocks and any damage resulting from water, oil, liquid fuel, steam etc.

7.3 Construction

7.3.1 Transformers are to be double wound except those for motor starting.

7.3.2 Each transformer is to be provided with a nameplate of corrosion-resistant metal giving information on make, type, serial number, insulation class and any other technical data necessary for the application of the transformer.

7.4 Regulation

7.4.1 The inherent regulation at 0.8 power factor is not to exceed 5 per cent.

7.4.2 Regulation of the complete system is to comply with 3.4.2.

7.5 Short circuit

7.5.1 All transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 seconds with rated primary voltage and frequency without damage.

7.6 Tests

7.6.1 Transformers for essential services are to be tested by the manufacturer in accordance with the relevant standard and test certificates supplied.

Section 8

Miscellaneous Equipment

8.1 Accumulator batteries

8.1.1 Construction

8.1.1.1 The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the motion of the ship and to prevent emission of acid or alkaline spray.

8.1.1.2 All batteries are to be provided with durable labels of flame retardant material, giving information on the application for which the battery is intended, voltage and capacity.

8.1.2 Location

8.1.2.1 Alkaline batteries and lead acid batteries of the vented type are not to be installed in the same compartment.

8.1.2.2 Large batteries are to be installed in a space assigned to them only. A box on deck would meet this requirement if adequately ventilated and provided with means to prevent ingress of water.

8.1.2.3 Engine starting batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery compartment, they are to be installed so that adequate ventilation is ensured.

8.1.3 Installation

8.1.3.1 Batteries should be so arranged that each cell or crate of cells is accessible from the top and at least one side.
8.1.3.2 Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the vessel. Adequate space for circulation of air is to be ensured.

8.1.3.3 Where acid is used as the electrolyte a tray of acid resisting material is to be provided below the cells unless the deck below is similarly protected.

8.1.3.4 The interiors of all compartments including the shelves, are to be painted with corrosion resistant paint.

8.1.3.5 A permanent notice is to be fitted to all compartments prohibiting naked lights and smoking in the compartment.

8.1.3.6 Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

8.1.4 Ventilation

8.1.4.1 Battery compartments, lockers and boxes are to be adequately ventilated by an independent ventilating system to avoid accumulation of flammable gases. Particular attention should be given to the fact that these gases are lighter than air and tend to accumulate at the top of the spaces.

8.1.4.2 Natural ventilation may be employed if ducts can be run directly from the top of the compartment to the open air with no part of the duct more than 45 degrees from the vertical. If natural ventilation is impracticable, mechanical ventilation is to be installed. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

8.1.4.3 Necessary precautions are to be taken to prevent sparking due to possible contact by the ventilation fan blades with fixed parts.

8.1.4.4 All openings through the battery compartment bulkheads or decks, other than ventilation openings, are to be effectively sealed to reduce the possibility of escape of gas from the battery compartment into the ship.

8.2 Luminaries

8.2.1 General

8.2.1.1 Lighting fittings installed in engine rooms or similar spaces where they are exposed to the risk of mechanical damage are to be provided with suitable grilled mechanical guards to protect their lamps and glass globes against such damage.

8.2.1.2 Precautions are to be taken so that a lamp for one voltage cannot be inserted in a lampholder for another voltage.

8.2.1.3 Incandescent lamps are to be in accordance with the following:

<table>
<thead>
<tr>
<th>Type</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>B22</td>
<td>upto 250 V and 200 W</td>
</tr>
<tr>
<td>E27</td>
<td>upto 250 V and 200 W</td>
</tr>
<tr>
<td>E40</td>
<td>upto 210 V and 3000 W</td>
</tr>
</tbody>
</table>

8.2.1.4 Lampholders are to be constructed of flame-retarding and non-hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders (E40) are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable as given in Table 3.2.1.

8.2.1.5 The ratings of tubular fluorescent lamps are not to exceed 250 V and 80 W.

8.3 Accessories - Construction and testing

8.3.1 Enclosures

8.3.1.1 Enclosures are to be of metal or of flame-retardant insulating materials.

8.3.2 Inspection and draw boxes

8.3.2.1 If metal conduit systems are used, inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

8.3.3 Socket outlets and plugs

8.3.3.1 Socket outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

8.3.3.2 All socket outlets of current rating 16 amperes or more are to be provided with a switch.

8.3.3.3 Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment, an effective means of earthing is to be provided at the socket outlet.

8.3.3.4 In all wet situations socket outlets and plugs are to be effectively shielded against rain
and spray and are to be provided with means for maintaining this quality after removal of the plug.

8.4 Heating and cooking equipment

8.4.1 General

8.4.1.1 Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

8.5 Lightning conductors

8.5.1 Lightning conductors are to be fitted to each mast of all wood, composite and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts, unless the mast is partly or completely insulated from the ship's hull.

8.5.2 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. Soldered connections are not acceptable.

8.5.3 The resistance of the lightning conductors, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0.02 ohms.

8.5.4 The lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 100 [mm²] and are to be riveted with copper rivets or fastened with copper clamps to an appropriate copper spike of not less than 13 [mm] in diameter and projecting at last 150 [mm] above the top of the mast. The lower end of the lightning conductor is to be securely clamped to a copper plate having an area of at least 0.2 [m²], fixed to the ship's hull well below the light load waterline in such a manner that it is immersed under all conditions of heel. In steel ships fitted with wooden masts, the lower end of the lightning conductor is to be securely clamped to the nearest metal forming part of the hull.

Section 9

Trials

9.1 General

9.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service the tests and trials specified in this Section are to be carried out. These tests and trials are intended to demonstrate the general condition of the installation at the time of completion. They are in addition to any acceptance tests which may have been carried out at the manufacturer's works.

9.2 Insulation resistance measurement

9.2.1 Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohm-meter of the generator type applying a voltage of at least 500 V. Where a circuit incorporates capacitors of more than 2 µF total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

9.2.2 Power and light circuits: The insulation resistance between all insulated poles and earth and, where practicable, between poles, is to be at least 1 megaohm. The installation may be subdivided and appliances may be disconnected if initial tests produce results less than this figure.

9.2.3 Low voltage circuits: Circuits operating at less than 55 V are to have an insulation resistance of at least 0.33 megaohm.

9.2.4 Switchboards, Section boards and distribution boards: The insulation resistance is to be at least 1 megaohm when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open, all fuse links for pilot lamps, earth fault-indicating lamps, voltmeters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

9.2.5 Generators and motors: The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded. The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 megaohm.
9.3 Earth continuity

9.3.1 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

9.4 Performance

9.4.1 It is to be established that the provisions of the Rules have been complied with respect to the criteria mentioned in this sub-section.

9.4.2 Temperatures of joints, connections, circuit-breakers and fuses.

9.4.3 The operation of engine governors, synchronising devices, overspeed trips, reverse-current, reverse-power, over-current and under-voltage trips and other safety devices.

9.4.4 Satisfactory commutation, excitation and performance of each generator throughout a run at full rated load.

9.4.5 Voltage regulation of every generator when full rated load is suddenly thrown off.

9.4.6 For alternating current and direct current generators, satisfactory parallel operation and [kW] load sharing of all generators capable of being operated in parallel at all loads up to normal working load. For alternating current generators satisfactory parallel operation and KVA load sharing of all generators capable of being operated in parallel at all loads up to normal working load.

9.4.7 All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

9.5 Voltage drop

9.5.1 Voltage drop is to be measured, where necessary, to verify that this is not excessive.

End Of Chapter
Chapter 9

Fire Protection, Detection and Extinction

Contents

Section

1 General
2 Fire Protection
3 Fire Detection
4 Fire Extinction

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to all ship types.

1.1.2 Special attention is drawn to National and International Statutory Requirements of countries where the ship is registered or operating and which are outside the scope of classification as defined in these Rules.

1.1.3 Consideration will be given to the acceptance of the statutory requirements of National Authorities as an alternative to the requirements of this Chapter.

1.1.4 Consideration will be given to special cases where the arrangements are equivalent to those required by these Rules.

1.1.5 Consideration will be given to the acceptance of the approval of a National Authority in respect of fire insulating materials, fire fighting appliances and items of equipment as an alternative to the relevant requirements of this Chapter.

1.2 Plans and information

1.2.1 The plans and information detailed in 1.2.2 to 1.2.4, where applicable, are to be submitted for approval together with all relevant details like Rule dimensions of the ship L, B and D and the number of passengers.

1.2.2 For fire protection of all ships, a general arrangement plan, showing the disposition of machinery spaces, accommodation and service spaces, oil fuel and lubricating oil tanks and means of escape, is to be submitted.

1.2.3 For fire protection of passenger ships additional plans and information are to be submitted as detailed below:

- A general arrangement plan showing the main fire zones, escape stairways, fire doors and the fire compartmentation bulkheads and decks within the main fire zones;
- A plan showing the details of construction of the fire protection bulkheads and decks and the particulars of any surface laminates employed;
- Copies of the Certificates of Approval by National Authorities in respect of all ‘A’ and ‘B’ Class fire divisions, non-combustible materials and materials having low flame-spread characteristics, fire doors, which are to be used but have not been approved by IRS;
- A ventilation plan showing the ducts and any dampers in them, and the position of the controls for stopping the system;
- A plan showing any sprinkler system and/or detection system;
- A plan showing any remote control for the fire doors;
- A plan showing the location and arrangement of the emergency stop for the oil fuel unit and/or lubricating oil pumps and
for closing the valves on the pipes from oil fuel tanks; and

− A plan of the fire alarm system.

1.2.4 For fire extinguishing in all ships, the following plans are to be submitted:

− A general arrangement plan showing the disposition of all the fire fighting equipment including the fire main, the portable and non-portable extinguishers and the types used; and

− plan showing the layout and construction of the fire main, including the fire pumps, valves, pipe sizes and materials.

1.3 Definitions

1.3.1 Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces.

1.3.2 'A' class divisions are those divisions formed by bulkheads and decks which comply with the following:

a) they are to be constructed of steel or other equivalent material;

b) they are to be suitably stiffened;

c) they are to be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test;

d) they are to be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 139°C above the original temperature, nor will the temperature at any point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

− Class 'A-30' - 30 minutes
− Class 'A-15' - 15 minutes
− Class 'A-0' - 0 minutes

e) a test of prototype bulkhead or deck may be required to ensure that it meets the above requirements for integrity and temperature rise.

1.3.3 'B' Class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following:

a) they are to be so constructed as to be capable of preventing the passage of flame to the end of the first one half-hour of the standard fire test;

b) they are to have an insulation value such that the average temperature of the unexposed side will not rise more than 139°C above the original temperature nor will the temperature at any point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

− Class 'B-15' - 15 minutes
− Class 'B-0' - 0 minutes

c) they are to be constructed of approved non-combustible materials and all materials entering into the construction and erection of 'B' class divisions are to be non-combustible, with the exception that combustible veneers may be permitted provided they meet other requirements of this Chapter;

d) a test of a prototype division may be required to ensure that it meets the above requirements for integrity and temperature rise.

1.3.4 'C' class divisions are divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. Combustible veneers are permitted provided they meet other requirements of this Chapter.

1.3.5 Continuous 'B' class ceilings or linings are those 'B' class ceilings or linings which terminate only at an 'A' or 'B' class division.

1.3.6 Cargo spaces are all spaces used for cargo (including cargo oil tanks) and trunks to such spaces.

1.3.7 Control stations are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized.

1.3.8 Ferry is a passenger ship intended for short distances and with embarkation/
disembarkation facilities at either end of the ship.

1.3.9 **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 according to an established test procedure. Any other material is a combustible material.

1.3.10 **Steel or other equivalent material.** Where the words steel or other equivalent material occur, ‘equivalent material’ means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable fire exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

1.3.11 **A Standard Fire Test** is one in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time temperature curve. The specimen is to have an exposed surface of not less than 4.65 [m²] and height (or length of deck) of 2.44 [m], resembling as closely as possible the intended construction and including where appropriate at least one joint. The standard time temperature curve is defined by a smooth curve drawn through the following temperature points measured above the initial furnace temperature:

- at the end of first 5 minutes - 556°C
- at the end of first 10 minutes - 659°C
- at the end of first 15 minutes - 718°C
- at the end of first 30 minutes - 821°C
- at the end of first 60 minutes - 925°C

1.3.12 **Low flame spread** means that the surface thus described will adequately restrict the spread of flame, this being determined by an acceptable test procedure.

1.3.13 **Machinery spaces** are all spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.3.14 **Main vertical zones** are those sections into which the hull, superstructure, and deckhouses are divided by ‘A’ class divisions, the mean length of which on any deck does not in general exceed 40 [m].

1.3.15 **Oil fuel unit** is the equipment used for the preparation of oil fuel for delivery to an oil fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 [N/mm²] gauge.

1.3.16 **Public spaces** are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

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

1.3.17.1 **Open ro/ro cargo spaces** are ro/ro spaces either open at both ends, or open at one end and provided with adequate natural ventilation effective over their entire length through permanent openings in the side plating or deckhead to the satisfaction of IRS.

1.3.17.2 **Closed ro/ro cargo spaces** are ro/ro cargo spaces which are neither open ro/ro cargo spaces nor exposed weather decks.

1.3.18 **Service spaces** are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of machinery spaces, and similar spaces and trunks to such spaces.

1.4 **Ship types**

1.4.1 **Passenger ship** is a ship which carries more than twelve passengers, a passenger being every person other than:

- the master and members of the crew or other persons employed or engaged in any capacity on board a ship on the business of the ship; and
- a child under one year of age.

1.4.2 **Cargo ship** is any ship which is not a passenger ship or a fishing vessel.
1.4.3 **Oil tanker** is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of a flammable nature.

1.4.4 **Combination carrier** is a tanker designed to carry oil or alternatively solid cargoes in bulk.

1.4.5 **Fishing vessel** is a vessel used for catching living resources of the sea.

1.4.6 **Chemical tanker** is a ship constructed or adapted for the carriage in bulk of liquid chemicals listed subsequently in the Rules.

1.4.7 **Gas carrier** is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas.

## Section 2

### Fire Protection

#### 2.1 General

2.1.1 The hull, superstructure, structural bulkheads, decks and deckhouses are to be constructed of steel, except that consideration will be given to the use of other suitable material in special cases, having in mind the risk of fire.

2.1.2 Bulkheads of galleys and stores, containing highly combustible materials such as paints and oils, are to be constructed of steel or other equivalent material, where adjacent to accommodation spaces and emergency generator rooms.

2.1.3 Fuel oil and lubricating oil tanks are not to have common vertical boundaries with accommodation spaces.

2.1.4 Deck coverings within accommodation spaces on the decks, forming the crown of machinery and cargo spaces, are to be of a type which will not readily ignite.

2.1.5 Pipes conveying oil or combustible liquids are to be of an approved material having regard to the fire risk. Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges and other outlets where the failure of the material in the event of fire would give rise to danger of flooding.

#### 2.2 Paints and similar coatings

2.2.1 Paints, varnishes and similar preparations having a nitro-cellulose or other highly flammable base are not to be used in accommodation and machinery spaces.

#### 2.3 Ventilation

2.3.1 Power ventilation of machinery spaces is to be capable of being stopped from an easily accessible position outside the machinery spaces.

#### 2.4 Means of escape

2.4.1 In general, two means of escape are to be provided in machinery and accommodation spaces.

2.4.2 Stairways are to be constructed of steel or equivalent material. They may be lined with suitable material.

2.4.3 Stairways and ladderways, in and from all passenger and crew spaces and spaces in which crew are normally employed, are to be arranged to provide ready means of escape to suitable open deck areas.

2.4.4 Passenger spaces situated below the main deck are to have, in addition to the stairways required by 2.4.3, at least one emergency escape.

2.4.5 A space intended or equipped for more than 30 but less than 50 passengers, and having one exit only, is to be provided with an emergency escape.

2.4.6 A space intended or equipped for more than 50 passengers, or having sleeping accommodation for 12 or more passengers, is to have not less than two exits, one of which may be replaced by two emergency escapes.

#### 2.5 Additional requirements for passenger ships

2.5.1 Accommodation and service spaces are generally to be separated from high fire risk areas such as machinery spaces and galleys by ‘A-30’ Class divisions. For passenger ships employed on large lakes or estuaries, where the distance to the nearest shore is substantial, a greater degree of integrity against the passage of fire may be required.

2.5.2 Corridor bulkheads and separation bulkheads between cabins are to be constructed...
of steel or ‘B’ Class divisions. Corridor bulkheads are to extend from deck to deck or alternatively to a non-combustible ceiling.

2.5.3 If an approved sprinkler installation is fitted the requirements of 2.5.2 need not be complied with.

2.5.4 The spaces above ceilings and behind linings are to be provided with draft stops of incombustible material spaced not more than 10 [m] apart.

2.5.5 Stairways inside accommodation and service spaces which penetrate more than one deck are to be enclosed by casings constructed of steel or ‘B’ Class divisions. Stairways which penetrate only a single deck are to be protected in a similar way at least at one level. Doors in these casings are to have the same integrity against fire and are to be of the automatic closing type.

2.5.6 The ship is to be divided into vertical fire zones not exceeding 40 [m] in length.

2.5.7 The fire zone divisions are generally to be constructed of steel or ‘B’ Class divisions and are to be fitted with doors having the same integrity against fire and being of the automatic closing type. For passenger ships employed on large lakes or estuaries, where the distance to the nearest shore is substantial, a greater degree of integrity against the passage of fire may be required.

2.5.8 On ships equipped with sleeping cabins for passengers, a general alarm system is to be provided.

2.5.9 Ventilation systems

2.5.9.1 Ventilation inlets and outlets are to be provided with fire dampers or steel closing appliances.

2.5.9.2 Fire dampers are to be fitted in ventilation trunks and ducts where they pass through main fire zone bulkheads, stairway casings or engine room bulkheads; dampers are to have local controls, capable of being operated from both sides of the bulkheads.

2.6 Un-propelled vessels

2.6.1 For ships with no crew and passengers, no fire protection, detection or fire extinguishing arrangements are required.

2.6.2 Ships having accommodation and being manned are to comply with the requirements of this Section and Sec.4 in so far as applicable.

Section 3

Fire Detection

3.1 Cargo ships

3.1.1 Fire detection systems are generally not required. Where a fire detection system is fitted, the arrangements are generally to comply with Pt.4, Ch.9 of the Rules and Regulations for the Construction And Classification of Steel Ships.

3.1.2 In case of oil and chemical tankers, where it is proposed to apply centralized bridge or automatic controls to propulsion machinery or essential auxiliaries, and it is intended that the machinery spaces will not be continuously manned whilst in service, an approved fire detection system is to be fitted in the machinery spaces on ships having propulsion machinery of 750 [kW] or more.

3.2 Passenger ships

3.2.1 Ships equipped with sleeping cabins for passengers are to be fitted with an approved fire detection system in public spaces, service spaces, alleyways in accommodation spaces, baggage and store rooms and similar spaces. This requirement may be dispensed with if the spaces concerned are fitted with an approved automatic sprinkler system.

3.2.2 On ships equipped with sleeping cabins for passengers, where it is proposed to apply centralized bridge or automatic controls to propulsion machinery or essential auxiliaries, or it is intended that the machinery spaces will not be continuously manned with any auxiliaries in service, an approved fire detection system is to be fitted in these spaces.
Section 4

Fire Extinction

4.1 All ships

4.1.1 Fire pumps

4.1.1.1 Provision is to be made for pumping water for fire extinguishing.

4.1.1.2 Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that, if they are subject to occasional duty for the transfer or pumping of fuel oil, suitable change-over arrangements are fitted to preclude the admission of oil into the fire main.

4.1.1.3 The fire pump suction is to be so arranged that the pump will operate efficiently at the lightest draught likely to be encountered in service.

4.1.1.4 The capacity of power fire pumps is to be not less than 10 [m³/h].

4.1.1.5 Relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

4.1.1.6 In ships having a value LxBxD of less than 150 [m³], at least one pump is to be available for fire extinguishing service, which may be either a hand pump, or a main engine driven pump where the engine can be declutched, or an independently driven pump.

4.1.1.7 In ships having a value LxBxD of 150 [m³] and over, but less than 1500 [m³], at least one power driven pump is to be provided which may be independently driven, or main engine driven where the engine can be declutched.

4.1.1.8 In ships having a value LxBxD of 1500 [m³] and over, not less than two power driven pumps are to be provided, one of which may be main engine driven where the engine can be declutched.

4.1.2 Fire main

4.1.2.1 A fire main is to be provided so that at least one jet of water can reach any part of the ship.

4.1.2.2 Materials readily rendered ineffective by heat are not to be used for fire mains. Where steel pipes are used they are to be galvanized internally and externally. Cast iron pipes are not to be used.

4.1.3 Hydrants

4.1.3.1 The number and position of the hydrants are to be such that at least one jet of water from a single length of hose may reach any part of the ship normally accessible to the passengers and crew while the ship is being navigated.

4.1.3.2 The positions of hydrants and valves or cocks are to be such that they are always readily accessible.

4.1.3.3 All water pipes for fire extinguishing are to be provided with drain valves for use in frosty weather. The valves are to be located where they will not be damaged by cargo.

4.1.4 Fire hoses and nozzles

4.1.4.1 Fire hoses are to be of approved material. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their length, in general, is not to exceed 18 [m]. Each hose is to be provided with a nozzle and the necessary fittings and tools, are to be kept ready for use in conspicuous positions near the water service hydrants or connections.

4.1.4.2 In general, not less than two fire hoses with dual purposes nozzles (jet/spray) of not less than 12 [mm] bore are to be provided.

4.1.4.3 The jet throw at the nozzle is to be about 12 [m].

4.1.5 Portable fire extinguishers

4.1.5.1 All fire extinguishers are to be of an approved type.
4.1.5.2 The extinguishing medium employed is to be suitable for extinguishing fires in the compartments in which they are intended to be used.

4.1.5.3 The extinguishers required for use in the machinery spaces of ships burning oil as fuel are to be of a type discharging foam, dry powder or other approved media suitable for extinguishing oil fires.

4.1.5.4 Fire extinguishers, containing an extinguishing medium which, either in itself or when in use, gives off gases harmful to persons, are not to be used.

4.1.5.5 The capacity of required portable fluid extinguishers is to be not more than 13.5 litres and not less than 9 litres. Other extinguishers are to be at least as portable as the 13.5 litre fluid extinguishers and are to have a fire extinguishing capability at least equivalent of a 9 litres fluid extinguisher.

4.1.5.6 Extinguishers are to be stowed in readily accessible positions.

4.1.5.7 The number and distribution of extinguishers are to be at least as follows:

- One in the wheelhouse;
- One near each entrance to accommodation spaces;
- One near the entrance to service spaces containing heating/cooking equipment or any other equipment having similar fire risk when not directly accessible from the accommodation;
- One near each entrance to machinery spaces;
- One in a suitable position below deck in the machinery space where the total power of the machinery exceeds 100 [kW] but is not greater than 750 [kW];
- One additional extinguisher in the machinery space when the total power of the machinery exceeds 750 [kW] and thereafter one further extinguisher for each 750 [kW] or part thereof.

4.1.5.8 The number of extinguishers to be provided on deck will be considered in relation to the hazardous nature of the cargo but, in general, when dangerous cargo is carried, two extinguishers are to be provided, one of which is to be positioned in the fore part and one in the after part of the ship.

4.1.5.9 It is recommended that spare charges are provided for 50 per cent of the required portable extinguishers which can be readily recharged on board.

4.1.6 Non-portable fire extinguishers

4.1.6.1 Proposals to provide non-portable extinguishers in machinery spaces will receive special consideration.

4.1.7 Fixed fire extinguishing systems

4.1.7.1 Fixed fire extinguishing systems are not required.

4.1.7.2 Proposals to fit such systems will be specially considered. They are, in general, to comply with the requirements laid down in Pt.4, Ch.9 of the Rules and Regulations for the Construction and Classification of Steel Ships, as applicable.

4.1.7.3 When a fixed fire smothering system is fitted, provision is to be made for closing all openings which might admit air to the spaces so protected. The means provided are to be capable of operation from a safe position outside such spaces.

4.2 Additional requirements for Roll-on/Roll-off ships

4.2.1 When it is intended to carry motor vehicles with fuel for their own use in their tanks, two portable extinguishers are to be provided on each vehicle deck, one of which is to be positioned in the fore part and one in the after part of the ship.

4.3 Additional requirements for ferries

4.3.1 Two portable extinguishers are to be provided, one of which is to be positioned in the fore part and one in the after part of the ship.
4.4 Additional requirements for oil and chemical tankers

4.4.1 Following additional requirements are to be complied with:

- One portable extinguisher is to be provided in each pump room.
- One portable extinguisher is to be provided in each space containing an oil fired boiler for cargo heating purposes.
- Fire fighting equipment on deck may be required, depending on the type of cargo intended to be carried, which will be specially considered.

4.4.2 For chemical tankers of Type IIA and IIIA, the following additional requirements are applicable:

- The fire main on deck in the cargo zone is to be provided with not less than three hydrants, together with hoses of suitable length fitted with spray nozzles. The arrangement shall be such as to permit two jets of water to be directed simultaneously on all parts of the deck over the cargo zone, such jets being produced by different hydrants fitted with hoses and jet nozzles.

4.5 Additional requirements for liquefied gas carriers

4.5.1 The requirements of 4.4 are to be complied with.

4.6 Additional requirements for passenger ships

4.6.1 Fire pumps

4.6.1.1 Special consideration will be given to the number and position of pumps, including emergency pumps, depending on the size of the ship, number of passengers and the proposed service.

4.6.1.2 The capacity of fire pumps is, in general, to be not less than 20 [m$^3$/h].

4.6.2 Portable fire extinguishers

4.6.2.1 An adequate number of suitable portable fire extinguishers are to be distributed throughout crew and passenger spaces.

4.6.3 Non-portable fire extinguishers

4.6.3.1 On ships equipped with sleeping cabins for 12 or more passengers the fitting of one 40 litre non-portable foam fire extinguisher in each engine room is recommended.

4.6.4 Fireman’s outfit

4.6.4.1 Ships equipped with sleeping cabins for passengers are to be provided with at least one fireman’s outfit, consisting of a breathing apparatus, a lifeline, a safety lamp and an axe, all to be of approved type.

End Of Chapter
Chapter 10

Spare Gear

Contents

Section

1 General

Section 1

General

1.1 General

1.1.1 Adequate spare parts for the propelling and essential auxiliary machinery together with necessary tools for maintenance and repair are to be readily available for use.

1.1.2 Spare parts are to be supplied and their location is to be the responsibility of the Owner but must take in to account the design and arrangements of the machinery and the intended service and operation of the ship. Account should also be taken of the recommendations of the machinery manufacturer and any applicable statutory requirements of the country of registration of the ship.

1.2 Table of spare parts

1.2.1 For guidance purposes spare parts for main and auxiliary machinery installations are shown in the following Tables:-

− Table 1.2.1 - Spare parts for main internal combustion engines;

− Table 1.2.2 - Spare parts for auxiliary boilers;

− Table 1.2.3 - Spare parts for auxiliary air compressors.

Table 1.2.1 : Main internal combustion engines

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Spare Part</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main thrust block</td>
<td>Pads for one face of thrust block</td>
<td>1 set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complete white metal thrust shoe of solid ring type</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inner and outer race with rollers, where roller thrust bearings are fitted</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Cylinder valves</td>
<td>Exhaust valves, complete with casings, seats, springs and other fittings</td>
<td>1 set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for one cylinder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air inlet valves, complete with casings, seats, springs and other fittings</td>
<td>1 set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for one cylinder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Starting air valve, complete with casing, seat, springs and other fittings</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for one cylinder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relief valve, complete</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel valves of each size and type fitted complete with all fittings, for</td>
<td>1/4 set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>one engine</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Special gaskets and packing of each size and type fitted for cylinder cover</td>
<td>1 set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and cylinder liner for one cylinder</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.2.2: Auxiliary boilers

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Spare Part</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tube stoppers or plugs</td>
<td>Tube stoppers or plugs, of each size used, for boiler superheater and economiser tubes</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Fire bars</td>
<td>Fire bars for one boiler, where coal fired</td>
<td>Half set</td>
</tr>
<tr>
<td>3</td>
<td>Oil fuel burners</td>
<td>Oil fuel burners complete, for one boiler</td>
<td>1 set</td>
</tr>
</tbody>
</table>

### Table 1.2.3: Auxiliary air compressor

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Spare Part</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Piston rings</td>
<td>Rings of each size fitted for one piston</td>
<td>1 set</td>
</tr>
<tr>
<td>2</td>
<td>Valves</td>
<td>Suction and delivery valves, complete, of each size fitted</td>
<td>Half set</td>
</tr>
</tbody>
</table>

End Of Chapter