Rules for the Classification of Inland Waterway Ships and for Conformity to Directive 2016/1629/EU

Effective from 1 March 2019

Part C

Machinery, Systems and Fire Protection

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GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

- (i) Rules for the Classification of Ships or other special units;
- (ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
- (iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
- (iv) Guides to carry out particular activities connected with Services;
- (v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
- (i) sets forth and develops Rules;
- (ii) publishes the Register of Ships;
- (iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various G overnments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatemen t. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
- (i) in the selection of its Surveyors
- (ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of th e specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as p art of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificati on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaw orthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structur e, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certifi cation or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, t he Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any st atutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of cl ass, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific propert y of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

RULES FOR THE CLASSIFICATION OF INLAND WATERWAY SHIPS AND FOR CONFORMITY TO DIRECTIVE 2016/1629/EU

Part C
Machinery, Systems and Fire Protection

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Part C
Machinery, Systems and Fire Protection

Chapter 1
MACHINERY

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Application

1.1.1 Chapter 1 applies to the design, construction, installation, tests and trials of main propulsion and essential auxiliary machinery systems and associated equipment, boilers and pressure vessels, piping systems, and steering and manoeuvring systems installed on board classed vessels, as indicated in each Section of this Chapter.

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in:

- Part E, for the assignment of additional service and class notations.

1.3 Documentation to be submitted

1.3.1 Before the actual construction is commenced, the Manufacturer, Designer or ship builder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in the relevant Sections of this Chapter.

2 Design and construction

2.1 General

2.1.1 The machinery, boilers and other pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

2.2 Materials, welding and testing

2.2.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of Part D and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding the requirements given in [2.2.2] apply.

2.2.2 Welded machinery components

Welding processes and welders are to be approved by the Society in accordance with Part D.

References to welding procedures adopted are to be clearly indicated on the plans submitted for approval.

Joints transmitting loads are to be either:

- full penetration butt-joints welded on both sides, except when an equivalent procedure is approved, or
- full penetration T- or cruciform joints.

For joints between plates having a difference in thickness greater than 3 mm, a taper having a length of not less than 4 times the difference in thickness is required. Depending on the type of stress to which the joint is subjected, a taper equal to three times the difference in thickness may be accepted.

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0,7 times the thickness of the thinner plate on both sides.

In the case of welded structures including cast pieces, the latter are to be cast with appropriate extensions to permit connection, through butt-welded joints, to the surrounding structures, and to allow any radiographic and ultrasonic examinations to be easily carried out.

Where required, preheating and stress relieving treatments are to be performed according to the welding procedure specification.

2.3 Vibrations

2.3.1 Special consideration is to be given to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

2.4 Operation in inclined position

2.4.1 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the ship are, as fitted in the ship, be designed to operate when the ship is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Tab 1.

The Society may permit deviations from angles given in Tab 1, taking into consideration the type, size and service conditions of the ship.

Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged alongships. If this is not possible, the Manufacturer is to be informed at the time the machinery is ordered.

2.5 Ambient conditions

2.5.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 2, unless otherwise specified in each Section of this Chapter.

2.6 Power of machinery

2.6.1 Unless otherwise stated in each Section of this Chapter, where scantlings of components are based on power, the values to be used are determined as follows:

- for main propulsion machinery, the power/rotational speed for which classification is requested
- for auxiliary machinery, the power/rotational speed which is available in service.

2.7 Astern power

2.7.1 Sufficient power for going astern is to be provided to secure proper control of the ship in all normal circumstances.

The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the maximum ahead revolutions for a period of at least 30 min.

Table 1 : Inclination of ship

Installations, components	Angle of inclination (degrees) **(1)**			
	Athwartship		Fore and aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5 **(4)**	7,5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electrical and electronic appliances **(3)** and remote control systems	22,5 **(2)**	22,5 **(2)**	10	10

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartship inclination up to a maximum of 30°.
(3) Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur.
(4) Where the length of the ship exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees, where L is the length of ship, in metres, as defined in Pt B, Ch 1, Sec 2, [3.1.1].

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +45 **(2)**
On machinery components, boilers In spaces subject to higher or lower temperatures	According to specific local conditions
On exposed decks	between -25 and +45 **(1)**

WATER TEMPERATURE	
Coolant	Temperature (°C)
Sea water or, if applicable, sea water at charge air coolant inlet	up to +32

(1) Electronic appliances are to be designed for an air temperature up to 55°C (for electronic appliances see also Chapter 2).
(2) Different temperatures may be accepted by the Society in the case of ships intended for restricted service.

For main propulsion systems with reversing gears, controllable pitch propellers or electrical propeller drive, running astern is not to lead to an overload of propulsion machinery.

During the sea trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also Sec 12).

2.8 Safety devices

2.8.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2.8.2 Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided, where practicable, to protect against such excessive pressure.

2.8.3 Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shut-off arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

The Society may permit provisions for overriding automatic shut-off devices.

2.9 Fuels

2.9.1 Fuel oils employed for engines and boilers are to have a flashpoint (determined using the closed cup test) of not less than 60°C.

2.9.2 *(1/1/2018)*

The use of liquefied or compressed natural gas as fuel is allowed on other ship types subject to the specific requirements given in Pt C, Ch 1, Appendix 7 of Tasneef Rules for Ships or on ships in compliance with the latest edition of the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code), as amended, or equivalent arrangements.

The arrangement on ships of less than 500 gross tonnage is considered by the Society on a case by case basis. The use of other gases as fuel is considered by the Society on a case-by-case basis.

Note 1: The use of gas as fuel in ships requires additional acceptance by the Administration of the State whose flag the ship is entitled to fly.

When in Pt C, Ch 1, Appendix 7 of Tasneef Rules for Ships the SOLAS Convention is recalled it is to be substitute by the relevant statutory regulation applicable.

2.10 Use of asbestos

2.10.1 *(1/7/2015)*

New installation of materials which contain asbestos is prohibited.

3 Arrangement and installation on board

3.1 General

3.1.1 Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

3.2 Floors

3.2.1 Floors in engine rooms are to be metallic, divided into easily removable panels.

3.3 Bolting down

3.3.1 Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure a perfect fit.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain a perfect levelling and general alignment between the propulsion engines and their shafting (see Sec 5).

3.3.2 Chocking resins are to be type approved.

3.4 Safety devices on moving parts

3.4.1 Suitable protective devices are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid injuries to personnel.

3.5 Gauges

3.5.1 All gauges are to be grouped, as far as possible, near each manoeuvring position; in any event, they are to be clearly visible.

3.6 Ventilation in machinery spaces

3.6.1 Machinery spaces are to be sufficiently ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions, including heavy weather, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions.

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

3.7 Hot surfaces and fire protection

3.7.1 Surfaces, having temperature exceeding 60°C, with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

The insulation of hot surfaces is to be of a type and so supported that it does not crack or deteriorate when subject to vibration.

Fire protection, detection and extinction is to comply with the requirements of Chapter 3.

3.8 Machinery remote control, alarms and safety systems

3.8.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, the requirements of this Chapter apply.

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter and are to be witnessed by the Surveyor.

Where such tests cannot be performed in the workshop, the Society may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being tested or with particular features of the shipboard installation. In such cases, the Surveyor entrusted with the acceptance of machinery on board and the purchaser are to be informed in advance and the tests are to be carried out in accordance with the provisions of Part D relative to incomplete tests.

All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time as detailed in the other Sections of this Chapter.

4.2 Trials on board

4.2.1 Trials on board of machinery are detailed in Sec 12.

SECTION 2 DIESEL ENGINES

1 General

1.1 Application

1.1.1 Diesel engines listed below are to be designed, constructed, installed, tested and certified in accordance with the requirements of this Section, under the supervision and to the satisfaction of the Society's Surveyors:

a) main propulsion engines

b) engines driving electrical generators and other auxiliaries essential for safety and navigation and cargo pumps in tankers, when they develop a power of 110 kW and over.

All other engines are to be designed and constructed according to sound marine practice, with the equipment required in [2.3.4], [2.4.2], [2.6.1] [2.6.2], [2.6.5] and [2.6.7] and delivered with the relevant works' certificate (see Pt D, Ch 1, Sec 1, [4.2.3]).

Engines intended for propulsion of lifeboats and compression ignition engines intended for propulsion of rescue boats are to comply with the relevant Rule requirements.

In addition to the requirements of this Section, those given in Sec 1 apply.

1.2 Documentation to be submitted

1.2.1 For each type of engine that is required to be approved according to a) and b) of [1.1.1], the Manufacturer is to submit to the Society the documents listed in Tab 1.

Plans listed under items [2] and [3] in Tab 1 are also to contain details of the lubricating oil sump in order to demonstrate compliance with Sec 1, [2.4].

Where considered necessary, the Society may request the submission of further documents, including details of evidence of existing type approval or proposals for a type testing program in accordance with [4.2] and [4.3].

Where changes are made to an engine type for which the documents listed in Tab 1 have already been examined or approved, the engine Manufacturer is to resubmit to the Society for consideration and approval only those documents concerning the engine parts which have undergone substantial changes.

If the engines are manufactured by a licensee, the licensee is to submit, for each engine type, a list of all the drawings specified in Tab 1, indicating for each drawing the relevant number and revision status from both licensor and licensee.

Where the licensee proposes design modifications to components, the associated documents are to be submitted by the licensee to the Society for approval or for information purposes. In the case of significant modifications, the licensee is to provide the Society with a statement confirming the licensor's acceptance of the changes. In all cases, the licensee is to provide the Surveyor entrusted to carry out the testing, with a complete set of the documents specified in Tab 1.

1.3 Definitions

1.3.1 Engine type

In general, the type of an engine is defined by the following characteristics:

- the cylinder diameter
- the piston stroke
- the method of injection (direct or indirect injection)
- the kind of fuel (liquid, gaseous or dual-fuel)
- the working cycle (4-stroke, 2-stroke)
- the gas exchange (naturally aspirated or supercharged)
- the maximum continuous power per cylinder at the corresponding speed and/or brake mean effective pressure corresponding to the above-mentioned maximum continuous power
- the method of pressure charging (pulsating system or constant pressure system)
- the charging air cooling system (with or without intercooler, number of stages, etc.)
- cylinder arrangement (in-line or V-type).

1.3.2 Engine power

Diesel engines are to be designed such that their rated power running at rated speed can be delivered as a continuous net brake power. Diesel engines are to be capable of continuous operation within power range (1) of Fig 1 and of short-period operation in power range (2). The extent of the power range is to be stated by the engine Manufacturer.

In determining the power of all engines used on board inland waterway ships, the ambient conditions given in [1.3.3] are to be referred to.

Maximum continuous power P is understood to mean the net brake power which an engine is capable of delivering continuously, provided that the maintenance prescribed by the engine Manufacturer is carried out at the maintenance intervals stated by the engine Manufacturer.

To verify that an engine is rated at its continuous power, it is to be demonstrated on the test bed that the engine can run at an overload power corresponding to 110% of its rated power at corresponding speed for an uninterrupted period of 30 minutes.

Subject to the prescribed conditions, diesel engines driving electric generators are to be capable of overload operation even after installation on board.

Subject to the approval of the Society, diesel engines for special vessels and applications may be designed for a blocked continuous power which cannot be exceeded.

For main engines, a power diagram (Fig 1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

Figure 1 : Power/speed diagram

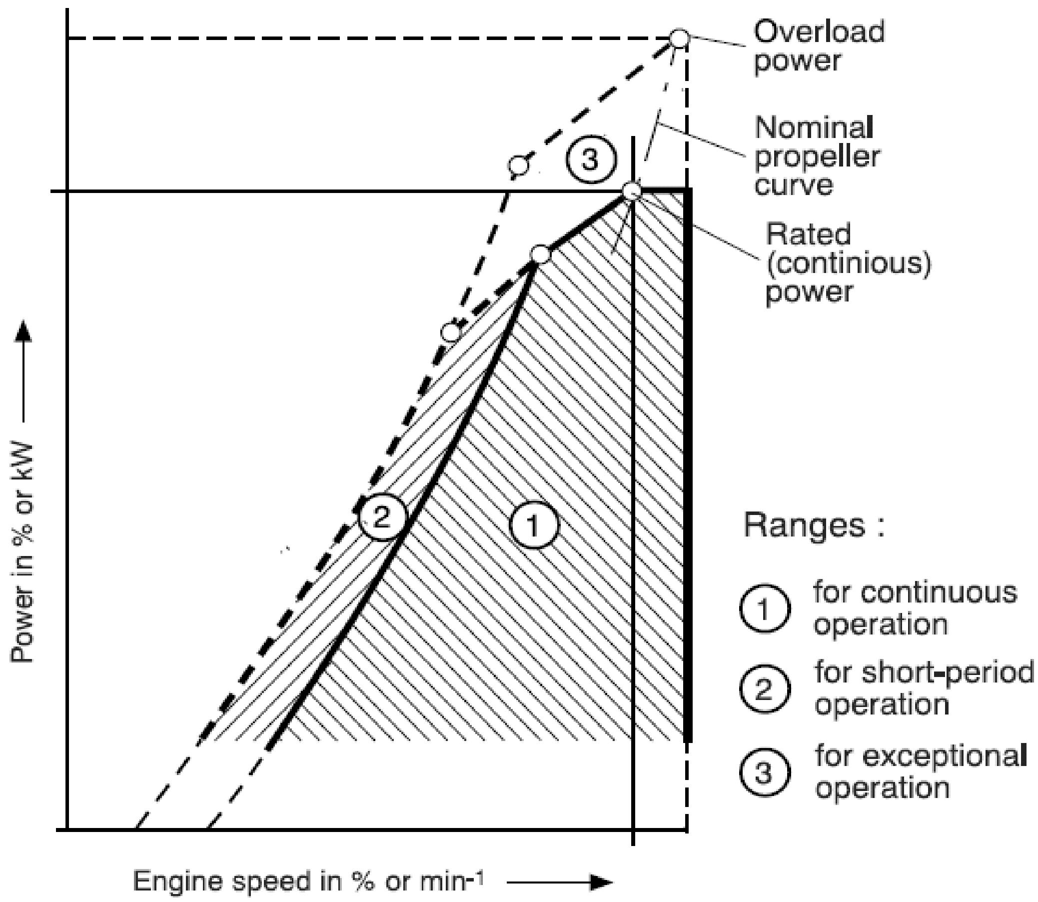


Table 1 : Documentation to be submitted

No.	I/A/A* **(1)**	Document
1	I	Engine particulars as per the Society form
2	I	Engine transverse cross-section
3	I	Engine longitudinal section
4	I	Bedplate/crankcase, cast or welded
5	I	Engine block
6	I	Tie rod
7	I	Cylinder head, assembly
8	I	Cylinder liner
9	A	Crankshaft, details, for each cylinder number
10	A	Crankshaft, assembly, for each cylinder number
11	A	Counterweights including fastening bolts
12	A	Connecting rod
13	I	Connecting rod assembly
14	I	Piston assembly
15	I	Camshaft drive assembly
16	A	Material specifications of main parts of engine
17	A **(1)**	Arrangement of foundation (for main engines only)
18	A	Schematic diagram of engine control and safety system
19	I	Shielding and insulation of exhaust pipes, assembly
20	A	Shielding of high pressure fuel pipes, assembly
21	A **(2)**	Crankcase explosion relief valves
22	I **(3)**	Operation and service manuals

(1) Dimensions and materials of pipes, capacity and head of pumps and compressors and any additional functional information are to be included. The layout of the entire system is also required, if this is part of the goods to be supplied by the engine Manufacturer.
(2) Required only for engines with cylinder bore of 200 mm and above or crankcase gross volume of 0,6 m^3 and above.
(3) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(4) I : to be submitted for information, in duplicate.
A: to be submitted for approval, in four copies.
A* to be submitted for approval of materials and weld procedure specification, in four copies.

1.3.3 Ambient reference conditions

The power of engines as per [1.3.2] is to be referred to the following conditions:

- barometric pressure = 0,1 MPa
- relative humidity = 60%
- ambient air temperature = 45°C
- sea water temperature (and temperature at inlet of sea water cooled charge air cooler) = 32°C.

The engine Manufacturer is not expected to provide the above ambient conditions at a test bed. The rating is to be adjusted according to a recognised standard accepted by the Society.

1.3.4 Same type of engines

Two diesel engines are considered to be of the same type when they do not substantially differ in design and construction characteristics, such as those listed in the engine type definition as per [1.3.1], it being taken for granted that the documentation concerning the essential engine components listed in [1.2] and associated materials employed has been submitted, examined and, where necessary, approved by the Society.

2 Design and construction

2.1 Materials

2.1.1 Crankshaft materials

In general, crankshafts are to be of forged steel having a tensile strength not less than 400 N/mm^2 and not greater than 1000 N/mm^2.

The use of forged steels of higher tensile strength is subject to special consideration by the Society in each case.

The Society, at its discretion and subject to special conditions (such as restrictions in ship navigation), may accept crankshafts made of cast carbon steel, cast alloyed steel or spheroidal or nodular graphite cast iron of appropriate quality and manufactured by a suitable procedure having a tensile strength as follows:

a) between 400 N/mm^2 and 560 N/mm^2 for cast carbon steel

b) between 400 N/mm^2 and 700 N/mm^2 for cast alloyed steel.

The acceptable values of tensile strength for spheroidal or nodular graphite cast iron will be considered by the Society on a case by case basis.

2.2 Crankshaft

2.2.1 Check of the scantling

The check of crankshaft strength is to be carried out in accordance with Pt C, Ch 1, App 1 of the Rules for the Classification of Ships.

2.3 Crankcase

2.3.1 Strength

Crankcase construction and crankcase doors are to be of sufficient strength to withstand anticipated crankcase pressures that may arise during a crankcase explosion taking into account the installation of explosion relief valves required in [2.3.4]. Crankcase doors are to be fastened sufficiently securely for them not be readily displaced by a crankcase explosion.

2.3.2 Ventilation and drainage

Ventilation of the crankcase, or any arrangement which could produce a flow of external air within the crankcase, is in principle not permitted.

Where provided, crankcase ventilation pipes are to be as small as practicable to minimise the inrush of air after a crankcase explosion.

If forced extraction of the oil mist atmosphere gases from the crankcase is provided (for mist smoke detection purposes, for instance), the vacuum in the crankcase is not to exceed 2,5 x 10^{-4} N/mm^2.

To avoid interconnection between crankcases and the possible spread of fire following an explosion, crankcase ventilation pipes and oil drain pipes for each engine are to be independent of any other engine.

Lubricating oil drain pipes from the engine sump to the drain tank are to be submerged at their outlet ends.

2.3.3 Warning notice

A warning notice is to be fitted either on the control stand or, preferably, on a crankcase door on each side of the engine.

This warning notice is to specify that, whenever overheating is suspected within the crankcase, the crankcase doors or sight holes are not to be opened before a reasonable time has elapsed, sufficient to permit adequate cooling after stopping the engine.

2.3.4 Relief valves

a) Diesel engines of a cylinder diameter of 200 mm and above or a crankcase gross volume of 0,6 m^3 and above are to be provided with crankcase explosion relief valves according to the requirements of this item [2.3.4].

   The total volume of the stationary parts within the crankcase may be discounted in estimating the crankcase gross volume (rotating and reciprocating components are to be included in the gross volume).

b) Relief valves are to be provided with lightweight spring-loaded valve discs or other quick-acting and self-closing devices to relieve a crankcase of pressure in the event of an internal explosion and to prevent the inrush of air thereafter.

   The valve discs in relief valves are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

   Relief valves are to be designed and constructed to open quickly and be fully open at a pressure not greater than 0,02 N/mm^2.

   The free area of each crankcase explosion relief valve is not to be less than 45 cm^2. The aggregate free area of the valves fitted on an engine is not to be less than 115 cm^2 per cubic metre of the crankcase gross volume.

   Relief valves are to be provided with a flame arrester that permits flow for crankcase pressure relief and prevents passage of flame following a crankcase explosion.

   Relief valves are to be type approved. Type testing is to be carried out in a configuration that represents the installation arrangements that will be used on an engine in accordance with with Pt C, Ch 1, App 5 of the Rules for the Classification of Ships.

   Where relief valves are provided with arrangements for shielding emissions from the valve following an explosion, the valve is to be type tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valve.

c) Relief valves are to be provided with a copy of the Manufacturer's installation and maintenance manual that is pertinent to the size and type of valve being supplied for installation on a particular engine.

The manual is to contain the following information:

1) Description of valve with details of function and design limits
2) Copy of type test certification
3) Installation instructions
4) Maintenance in service instructions to include testing and renewal of any sealing arrangements
5) Actions required after a crankcase explosion.

A copy of the installation and maintenance manual required above is to be provided on board ship.

Plans showing details and arrangements of crankcase explosion relief valves are to be submitted for approval in accordance with Tab 1.

Valves are to be provided with suitable markings that include the following information:

- Name and address of Manufacturer
- Designation and size
- Month/Year of manufacture
- Approved installation orientation.

d) Engines of a cylinder diameter of 200 mm and above, but not exceeding 250 mm, are to have at least one valve near each end; however, for engines with more than 8 crankthrows, an additional valve is to be fitted near the middle of the engine.

Engines of a cylinder diameter of 250 mm and above, but not exceeding 300 mm, are to have at least one valve in way of each alternate crankthrow, with a minimum of two valves.

Engines of a cylinder diameter exceeding 300 mm are to have at least one valve in way of each main crankthrow.

e) Additional relief valves are to be fitted on separate spaces of the crankcase, such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces is 0,6 m^3 or above.

Scavenge spaces in open connection to the cylinders are to be fitted with explosion relief valves.

2.3.5 Oil mist detection/monitoring arrangements

All the cylinders of engines with a cylinder bore > 230 mm are to be fitted with cylinder overpressure control valves.

The response threshold of these valves is to be set at not more than 40% above the combustion pressure at rated power.

The cylinder overpressure control valves may be replaced by efficient acoustic or visual cylinder overpressure warning devices.

These are to have been type-tested by the Society. No fuel can ignite at the engine or at any hot component located in the vicinity.

Where there are multi-engine installations, each engine is to be provided with oil mist detection/monitoring and a dedicated alarm.

2.4 Systems

2.4.1 General

In addition to the requirements of the present sub-article, those given in Sec 8 are to be satisfied.

Flexible hoses in the fuel and lubricating oil system are to be limited to the minimum and are to be type approved.

Unless otherwise stated in Sec 8, propulsion engines are to be equipped with external connections for standby pumps for:

- fuel oil supply
- lubricating oil and cooling water circulation.

2.4.2 Fuel oil system

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

In fuel oil systems for propulsion machinery, filters are to be fitted and arranged so that an uninterrupted supply of filtered fuel oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Sec 8.

On main engines with a rated power of up to 220 kW, fitted with a lubricating oil line supplied from the engine oil sump, simplex filters may be fitted provided that they are equipped with a pressure alarm behind the filter and provided also that the filter can be changed during operation.

For this purpose, a bypass with manually operated shut-off valves is to be provided. The switch positions are to be clearly recognisable.

a) Lubricating oil filters for auxiliary engines. For auxiliary engines, simplex filters are sufficient.

b) Fuel filters for main engines. The supply lines to fuel injection pumps are to be fitted with switch-over duplex filters or automatic filters.

c) Fuel filters for auxiliary engines. For auxiliary engines, simplex filters are sufficient.

d) Filter arrangements. Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in the immediate proximity of hot components. Where the arrangement stated above is unfeasible, the rotating parts and the hot components are to be sufficiently shielded. Drip pans of suitable size are to be mounted under fuel filters. The same applies to lubricating oil filters if oil can escape when the filter is opened. Switch-over filters with two or more filter chambers are to be fitted with devices ensuring a safe relief of pressure before opening and venting when a chamber is placed in service. Shut-off valves are normally to be used for this purpose. It is to be clearly discernible which filter chambers are in service and which are out of operation at any time.

All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a shielded piping system capable of containing fuel from a high pressure line failure. A shielded pipe incorporates an outer pipe into which the high pressure fuel pipe is placed forming a permanent assembly.

The shielded piping system is to include a means for collection of leakages and arrangements are to be provided for an alarm to be given in the event of a fuel line failure.

e) Where, on V-type engines, the fuel system is located between the rows of cylinders, suitable shielding and drainage ducts for leaking fuel are to be provided.

Leaking fuel is to be safely drained away at zero excess pressure. Care is to be taken to ensure that leaking fuel cannot become mixed with the engine lubricating oil.

If flexible hoses are used for shielding purposes, these are to be approved by the Society.

When, in fuel oil return piping, the pulsation of pressure with peak-to-peak values exceeds 2 MPa, shielding of this piping is also required as above.

2.4.3 Lubricating oil system

Efficient filters are to be fitted in the lubricating oil system when the oil is circulated under pressure.

In such lubricating oil systems for propulsion machinery, filters are to be arranged so that an uninterrupted supply of filtered lubricating oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Sec 8.

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

The relief valves may be omitted provided that the filters can withstand the maximum pressure that the pump may develop.

Where necessary, the lubricating oil is to be cooled by means of suitable coolers.

2.4.4 Charge air system

Requirements relevant to design, construction, arrangement, installation, tests and certification of exhaust gas turbochargers are to be in conformity with Society Rules.

2.5 Starting air system

2.5.1 The requirements given in [3.1] apply.

Table 2 : Remote control of machinery installations

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring				
Identification of system parameter	Alarm	Indication local	Alarms wheel-house **(4)**	Indication wheelhouse	Shut down
MAIN ENGINE					
Engine speed: All Engines		X			
Engine Power > 220kW	HH	X	G		X
Shhaft revolution indicator		X		X	
Lubricating oil pressure	L	X	G		
Lubricating oil temperature	H	X	G		
Fresh cooling water system inlet pressure **(1)**	L	X	G		
Fresh cooling water system outlet pressure **(1)**	H	X	G		
Fuel oil temperature for engines running on HFO	L	X	G		
Exhaust gas temperature (single cylinder when the dimensions permit)		X			
Starting air pressure	L	X	G	X	
Charge air pressure		X			
Control air pressure		X		X	

(1) A combination of level/indication tank and indication/alarm cooling water temperature can be considered as equivalent with consent of the Society
(2) Exemptions can be given for diesel engines with a power of 50 kW and below
(3) Openings of clutches can, with the consent of the Society, be considered as equivalent
(4) Group of alarms are to be detailed in the machinery space or control room (if any)

2.6 Control and monitoring

2.6.1 Main engine room control platform

The minimum indicators to be fitted on the engine room control platform for propulsion engines are summarised in Table 1.

The following indicators are to be provided:

- lubricating oil temperature
- coolant temperature
- fuel temperature at engine inlet only for engines running on heavy fuel oil
- exhaust gas temperature, wherever the dimensions permit, at each cylinder outlet and at the turbocharger inlet/outlet.

In the case of geared transmissions or controllable pitch propellers, the scope of the control equipment is to be extended accordingly.

The permissible pressures are to be indicated in red on the pressure gauges, as are any critical speed ranges on the tachometers

A machinery alarm system is to be installed for the pressures and temperatures specified above, with the exception of the charge air pressure, the control air pressure and the exhaust gas temperature.

2.6.2 Main engine control from the bridge

a) Indicators are given in Table 1. In addition, the alarm system required under the last paragraph of [2.6.1] is to signal faults on the bridge.

   An indicator in the engine room and on the bridge is to show that the alarm system is operative.

b) Auxiliary engine control

   At least the following indications are to be provided:

   - engine speed
   - lubricating oil pressure
   - cooling water pressure
   - cooling water temperature.

   In addition, engines of over 50 kW power are to be equipped with an engine alarm system responding to the lubricating oil pressure and to the pressure or flow rate of the cooling water or a failure of the cooling fan, as applicable.

2.6.3 Governors of main and auxiliary engines

Each engine, except auxiliary engines for driving electric generators, to which [2.6.5] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed the rated speed by more than 15%.

2.6.4 Overspeed protective devices of main and auxiliary engines

In addition to the speed governor, each

- main propulsion engine having a rated power of 220kW and above, which can be declutched or which drives a controllable pitch propeller, and
- auxiliary engine having a rated power of 220kW and above, except those for driving electric generators, for which [2.6.6] applies

is to be fitted with a separate overspeed protective device so adjusted that the engine cannot exceed the rated speed n by more than 20%; arrangements are to be made to test the overspeed protective device.

Equivalent arrangements may be accepted subject to special consideration by the Society in each case.

The overspeed protective device, including its driving mechanism or speed sensor, is to be independent of the governor.

2.6.5 Governors for auxiliary engines driving electric generators

a) Auxiliary engines intended for driving electric generators are to be fitted with a speed governor which prevents transient frequency variations in the electrical network in excess of ±10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

   When a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by [2.6.4].

b) At all loads between no load and rated power, the permanent speed variation is not to be more than 5% of the rated speed.

c) Prime movers are to be selected in such a way that they meet the load demand within the ship's mains and, when running at no load, can satisfy the requirement in item a) above if suddenly loaded to 50% of the rated power of the generator, followed by the remaining 50% after an interval sufficient to restore speed to steady state. Steady state conditions (see Note 1) are to be achieved in not more than 5 s.

Note 1: Steady state conditions are those at which the envelope of speed variation does not exceed ±1% of the declared speed at the new power.

d) Application of the the electrical load in more than 2 load steps can only be allowed if the conditions within the ship's mains permit the use of those auxiliary engines which can only be loaded in more than 2 load steps (see Fig 2 for guidance) and provided that this is already allowed for in the designing stage.

   This is to be verified in the form of system specifications to be approved and to be demonstrated at ship's trials. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after blackout and to the sequence in which it is connected

   This also applies to generators to be operated in parallel and where the power is to be transferred from one generator to another, in the event that any one generator is to be switched off.

e) Emergency generator sets must satisfy the governor conditions as per items a) and b), even when:

   1) their total consumer load is applied suddenly, or

2) their total consumer load is applied in steps, provided that:
   - the total load is supplied within 45 seconds of power failure on the main switchboard, and
   - the maximum step load is declared and demonstrated, and
   - the power distribution system is designed such that the declared maximum step loading is not exceeded, and
   - compliance of time delays and loading sequence with the above is demonstrated at ship's trials.

f) For alternating current generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

   For alternating current generating sets intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

2.6.6 Overspeed protective devices of auxiliary engines driving electric generators

In addition to the speed governor, auxiliary engines of rated power equal to or greater than 220 kW driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

This device is to automatically shut down the engine.

2.6.7 Use of electronic governors

a) Type approval

   Electronic governors and their actuators are to be type approved by the Society, according to Pt C, Ch 3, Sec 6 of the Rules for the Classification of Ships.

b) Electronic governors for main propulsion engines

   If an electronic governor is fitted to ensure continuous speed control or resumption of control after a fault, an additional separate governor is to be provided unless the engine has a manually operated fuel admission control system suitable for its control.

   A fault in the governor system is not to lead to sudden major changes in propulsion power or direction of propeller rotation.

   Alarms are to be fitted to indicate faults in the governor system.

   The acceptance of electronic governors not in compliance with the above requirements will be considered by the Society on a case by case basis, when fitted on ships with two or more main propulsion engines.

c) Electronic governors for auxiliary engines driving electric generators

   In the event of a fault in the electronic governor system the fuel admission is to be set to “zero”.

   Alarms are to be fitted to indicate faults in the governor system.

   The acceptance of electronic governors fitted on engines driving emergency generators will be considered by the Society on a case by case basis.

3 Arrangement and installation

3.1 Starting arrangements

3.1.1 Mechanical compressed air starting

a) Main engines which are started with compressed air are to be equipped with at least two starting air compressors. At least one of the air compressors is to be driven independently of the main engine and is to supply at least 50% of the total capacity required. The total capacity of the starting air compressors is to be such that the starting air receivers can be charged to their final pressure within one hour (the receivers being at atmospheric pressure at the start of the charging operation). Normally, compressors of equal capacity are to be installed. If the main engine is started with compressed air, the available starting air is to be divided between at least two starting air receivers of approximately equal size which can be used independently of each other.

b) The total capacity of air receivers is to be sufficient to provide, without replenishment, not less than 12 consecutive starts alternating between ahead and astern of each main engine of the reversible type, and not less than 6 consecutive starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

   The number of starts refers to the engine in cold and ready-to-start condition (all the driven equipment that cannot be disconnected is to be taken into account).

   No special starting air storage capacity needs to be provided for auxiliary engines in addition to the starting air storage capacity specified above. The same applies to pneumatically operated regulating and manoeuvring equipment and to the air requirements of Tyfon units.

   Other consumers with a high air consumption may be connected to the starting air system only if the stipulated minimum supply of starting air for the main engines remains assured.

c) The main starting air arrangements for main propulsion or auxiliary diesel engines are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes. To this end, the following safety devices are to be fitted:
   - An isolating non-return valve, or equivalent, at the starting air supply connection to each engine.

- A bursting disc or flame arrester:
  - in way of the starting valve of each cylinder, for direct reversing engines having a main starting air manifold
  - at least at the supply inlet to the starting air manifold, for non-reversing engines.

  The bursting disc or flame arrester above may be omitted for engines having a bore not exceeding 230 mm.

Other protective devices will be specially considered by the Society.

The requirements of this item c) do not apply to engines started by pneumatic motors.

d) Coolers are to be so designed that the temperature of the compressed air does not exceed 160°C at the discharge of each stage of multi-stage compressors or 200°C at the discharge of single-stage compressors..

Unless they are provided with open discharges, the cooling water spaces of compressors and coolers are to be fitted with safety valves or rupture discs of sufficient cross-sectional area.

High-pressure stage air coolers are not to be located in the compressor cooling water space.

Every compressor stage is to be equipped with a suitable safety valve which cannot be blocked and which prevents the maximum permissible working pressure from being exceeded by more than 10% even when the delivery line has been shut off. The setting of the safety valve is to be secured to prevent unauthorised alteration. Each compressor stage is to be fitted with a suitable pressure gauge, the scale of which is to indicate the relevant maximum permissible working pressure.

3.1.2 Electrical starting

a) Where main internal combustion engines are arranged for electrical starting, at least one independent set of starter batteries is to be provided for each engine.

   Each battery is to be capable of starting the main engine when in cold and ready to start condition.

   The capacity of batteries is to be sufficient for at least 6 start - VP operations within 30 min, without recharging.

b) Electrical starting arrangements for auxiliary engines are to have one independent battery; the capacity of the batteries is to be sufficient for at least three starts within 30 minutes.

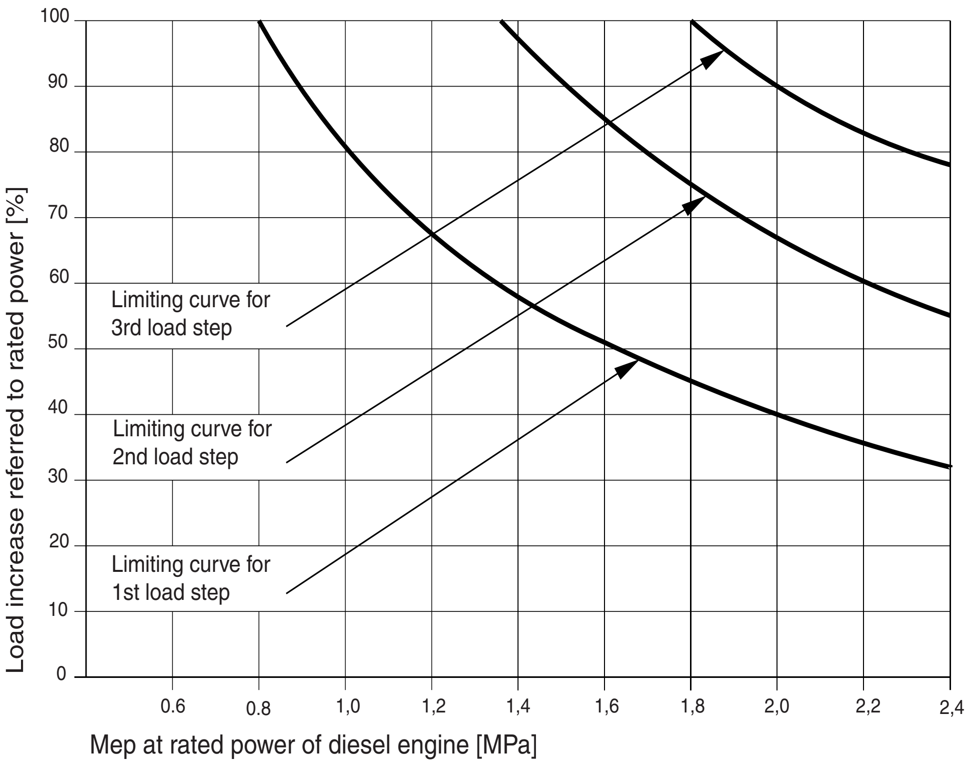
c) Where the arrangement stated above is unfeasible, the rotating parts and the hot components are to be sufficiently shielded.

Where machinery installations comprise 2 or more electrically started main engines, the starting equipment for auxiliary engines can also be supplied from the latter's starter batteries. Separate circuits are to be installed for this purpose.

The starter batteries may only be used for starting (and possibility for preheating) as well as for monitoring equipment associated with the engine.

Arrangements are to be made to ensure that batteries are kept charged and monitored at all times.

Figure 2 : Limiting curves for loading 4-stroke diesel engines step by step from no load to rated power as a function of the brake mean effective pressure



3.1.3 Special requirements for starting arrangements for emergency generating sets

a) Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to them Society is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

b) Each emergency generating set arranged to be automatically started shall be equipped with starting devices approved by the Society with a stored energy capability of at least three consecutive starts.

The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

c) The stored energy is to be maintained at all times, as follows:

- electrical and hydraulic starting systems shall be maintained from the emergency switchboard
- compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard
- all of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

d) Where automatic starting is not required, manual starting, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, is permissible where this can be demonstrated as being effective.

e) When manual starting is not practicable, the requirements of (b) and (c) are to be complied with, except that starting may be manually initiated.

3.2 Turning gear

3.2.1 Each engine is to be provided with hand-operated turning gear; where deemed necessary, the turning gear is to be both hand and mechanically-operated.

The turning gear engagement is to inhibit starting operations.

3.3 Trays

3.3.1 Trays fitted with means of drainage are to be provided in way of the lower part of the crankcase and, in general, in way of the parts of the engine, where oil is likely to spill in order to collect the fuel oil or lubricating oil dripping from the engine.

3.4 Exhaust gas system

3.4.1 In addition to the requirements given in Sec 8, the exhaust system is to be efficiently cooled or insulated in such a way that the surface temperature does not exceed 220°C (see also Sec 1, [3.7]).

4 Type tests, material tests, workshop inspection and testing, certification

4.1 Type tests - General

4.1.1 Upon finalisation of the engine design for production of every new engine type intended for installation on board ships, one engine is to be presented for type testing as required below.

A type test carried out for a particular type of engine at any place in any manufacturer's works will be accepted for all engines of the same type (see [1.3.4]) built by licensees and licensors.

In any case, one type test suffices for the whole range of engines having different numbers of cylinders.

Engines which are subjected to type testing are to be tested in accordance with the scope specified below, it being taken for granted that:

- the engine is optimised as required for the conditions of the type test
- the investigations and measurements required for reliable engine operation have been carried out during preliminary internal tests by the engine Manufacturer
- the documentation to be submitted as required in [1.2] has been examined and, when necessary, approved by the Society and the latter has been informed about the nature and extent of investigations carried out during pre-production stages.

4.1.2 At the request of the Manufacturer, an increase in power and/or mean effective pressure up to a maximum of 10% may be accepted by the Society for an engine previously subjected to a type test without any further such test being required, provided the engine reliability has been proved successfully by the service experience of a sufficient number of engines of the same type.

For the purpose of the acceptance of the above performance increase, the Manufacturer is in any case to submit for examination and, where necessary, approval, the documentation listed in [1.2] relevant to any components requiring modification in order to achieve the increased performance.

4.2 Type tests of engines not admitted to an alternative inspection scheme

4.2.1 General

Engines which are not admitted to testing and inspections according to an alternative inspection scheme (see Pt D, Ch 1, Sec 1, [3.2]) are to be type tested in the presence of a Surveyor in accordance with the requirements of this item [4.2].

a) Stage A - Preliminary internal tests carried out by the Manufacturer.

   Stage A includes functional tests and collection of operating values including the number of testing hours during the internal tests, the results of which are to be presented to the Surveyor during the type test. The number of testing hours of components which are inspected according to [4.2.5] is to be stated by the Manufacturer.

b) Stage B - Type approval test

   The type approval test is to be carried out in the presence of the Surveyor.

c) Stage C - Inspection of main engine components.

After completion of the test programme, the main engine components are to be inspected.

The engine Manufacturer is to compile all results and measurements for the engine tested during the type test in a type test report, which is to be submitted to the Society.

4.2.2 Stage A - Internal tests (function tests and collection of operating data)

During the internal tests the engine is to be operated at the load points considered important by the engine Manufacturer and the relevant operating values are to be recorded (see item (a)).

The load points may be selected according to the range of application (see Fig 3).

If an engine can be satisfactorily operated at all load points without using mechanically driven cylinder lubricators, this is to be verified.

For engines which may operate on heavy fuel oil, their suitability for this is to be proved to the satisfaction of the Society.

a) Functional tests under normal operating conditions

   Functional tests under normal operating conditions include:

   1) The load points 25%, 50%, 75%, 100% and 110% of the maximum continuous power for which type approval is requested, to be carried out:

      - along the nominal (theoretical) propeller curve and at constant speed, for propulsion engines
      - at constant speed, for engines intended for generating sets.

   2) The limit points of the permissible operating range.

      These limit points are to be defined by the engine Manufacturer.

   The maximum continuous power P is defined in [1.3.2].

b) Tests under emergency operating conditions

   For turbocharged engines, the achievable continuous output is to be determined for a situation when one turbocharger is damaged, i.e.:

   - for engines with one turbocharger, when the rotor is blocked or removed;
   - for engines with two or more turbochargers, when the damaged turbocharger is shut off.

4.2.3 Stage B - Type approval tests in the presence of the Surveyor

During the type test, the tests listed below are to be carried out in the presence of the Surveyor and the results are to be recorded in a report signed by both the engine Manufacturer and the Surveyor.

Any departures from this programme are to be agreed upon by the engine Manufacturer and the Society.

a) Load points

   The load points at which the engine is to be operated according to the power/speed diagram (see Fig 3) are those listed below. The data to be measured and recorded when testing the engine at various load points are to include all necessary parameters for engine operation.

   The operating time per load point depends on the engine characteristics (achievement of steady-state condition) and the time for collection of the operating values.

   Normally, an operating time of 0,5 hour per load point can be assumed.

   At the maximum continuous power as per the following item (1) an operating time of two hours is required. Two sets of readings are to be taken at a minimum interval of one hour.

   1) Test at maximum continuous power P: i.e. 100% output at 100% torque and 100% speed, corresponding to load point 1 in the diagram in Fig 3.
   2) Test at 100% power at maximum permissible speed, corresponding to load point 2 in the diagram in Fig 3.
   3) Test at maximum permissible torque (normally 110% of nominal torque T) at 100% speed, corresponding to load point 3 in the diagram in Fig 3; or test at maximum permissible power (normally 110% of P) and speed according to the nominal propeller curve, corresponding to load point 3a in the diagram in Fig 3.
   4) Test at minimum permissible speed at 100% of torque T, corresponding to load point 4 in the diagram in Fig 3.
   5) Test at minimum permissible speed at 90% of torque T, corresponding to load point 5 in the diagram in Fig 3.
   6) Tests at part loads, e.g. 75%, 50%, 25% of maximum continuous power P and speed according to the nominal propeller curve, corresponding to load points 6, 7 and 8 in the diagram in Fig 3; and tests at the above part loads and at speed n with constant governor setting, corresponding to load points 9, 10 and 11 in the diagram in Fig 3.

b) Tests under emergency operating conditions

These are tests at maximum achievable power when operating along the nominal propeller curve and when operating with constant governor setting for speed n, in emergency operating conditions as stated in [4.2.2] (b).

c) Additional tests

- Test at lowest engine speed according to the nominal propeller curve.
- Starting tests for non-reversible engines, or starting and reversing tests for reversible engines.
- Governor tests.
- Testing of the safety system, particularly for overspeed and low lubricating oil pressure.

For engines intended to be used for emergency services, supplementary tests may be required to the satisfaction of the Society. In particular, for engines intended to drive emergency generating sets, additional tests and/or documents may be required to prove that the engine is capable of being readily started at a temperature of 0°C.

4.2.4 Evaluation of test results

The results of the tests and checks required by [4.2.3] will be evaluated by the attending Surveyor. Normally the main operating data to be recorded during the tests are those listed in [4.3.4].

In particular, the maximum combustion pressure measured with the engine running at the maximum continuous power P is not to exceed the value taken for the purpose of checking the scantlings of the engine crankshaft, according to the applicable requirements of Pt C, Ch 1, App 1 of the Rules for the Classification of Ships.

The values of temperatures and pressures of media, such as cooling water, lubricating oil, charge air, exhaust gases, etc., are to be within limits which, in the opinion of the Surveyor, are appropriate for the characteristics of the engine tested.

4.2.5 Stage C - Inspection of main engine components

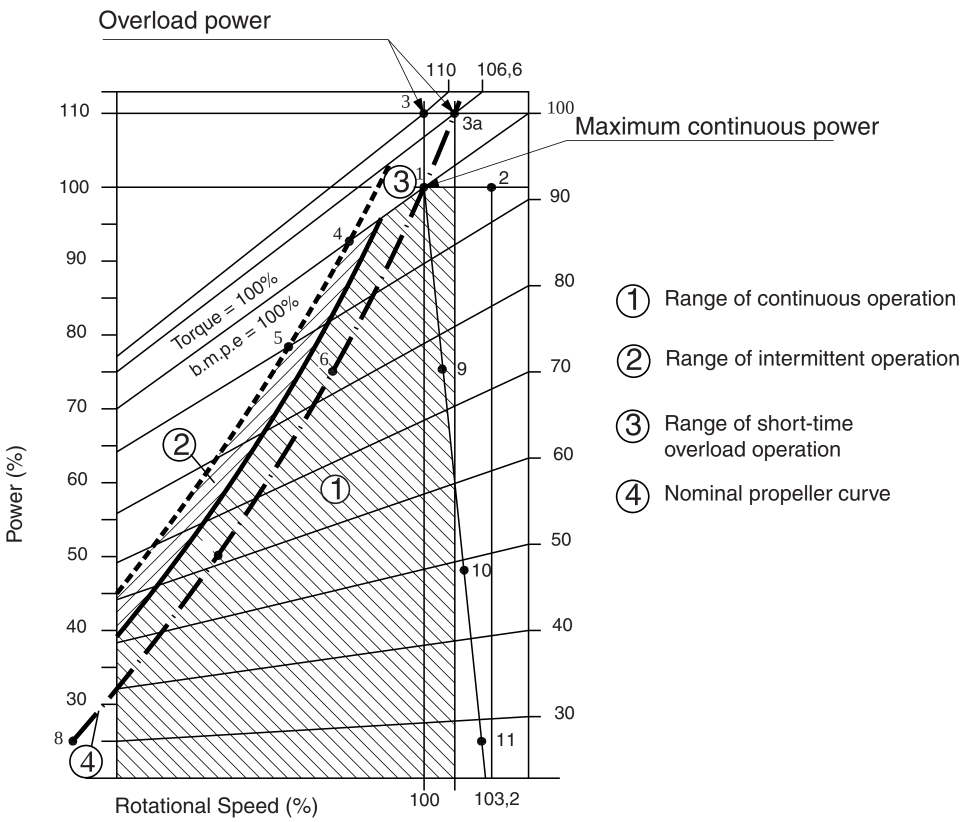
Immediately after the test run as per [4.2.3], the components of one cylinder for in-line engines, and two cylinders for V-type engines, are to be presented for inspection to the Surveyor.

The following main engine components are to be inspected:

- piston removed and dismantled
- crosshead bearing, dismantled
- crank bearing and main bearing, dismantled
- cylinder liner in the installed condition
- cylinder head and valves, disassembled
- control gear, camshaft and crankcase with opened covers.

Where deemed necessary by the Surveyor, further dismantling of the engine may be required.

Figure 3 : Power/speed diagram



4.3 Type tests of engines admitted to an alternative inspection scheme

4.3.1 General

Engines for which the Manufacturer is admitted to testing and inspections according to an alternative inspection scheme (see Pt D, Ch 1, Sec 1, [3.2]) and which have a cylinder bore not exceeding 300 mm are to be type tested in the presence of a Surveyor in accordance with the requirements of this item [4.3].

The selection of the engine to be tested from the production line is to be agreed upon with the Surveyor.

4.3.2 Type test

The programme of the type test is to be in general as specified below, P being the maximum continuous power and n the corresponding speed. The maximum continuous power is that stated by the engine Manufacturer and accepted by the Society, as defined in [1.3.2].

a) 80 hours at power P and speed n
b) 8 hours at overload power (110% of power P)
c) 10 hours at partial loads (25%, 50%, 75% and 90% of power P)
d) 2 hours at intermittent loads
e) starting tests
f) reverse running for direct reversing engines
g) testing of speed governor, overspeed device and lubricating oil system failure alarm device;
h) testing of the engine with one turbocharger out of action, when applicable
i) testing of the minimum speed along the nominal (theoretical) propeller curve, for main propulsion engines driving fixed pitch propellers, and of the minimum speed with no brake load, for main propulsion engines driving controllable pitch propellers or for auxiliary engines.

The tests at the above-mentioned outputs are to be combined together in working cycles which are to be repeated in succession for the entire duration within the limits indicated.

In particular, the overload test, to be carried out at the end of each cycle, is to be of one hour's duration and is to be carried out alternately:

- at 110% of the power P and 103% of the speed n
- at 110% of the power P and 100% of the speed n.

The partial load tests specified in (c) are to be carried out:

- along the nominal (theoretical) propeller curve and at constant speed, for propulsion engines
- at constant speed, for engines intended for generating sets.

For engines intended to be used for emergency services, supplementary tests may be required, to the satisfaction of the Society. In particular, for engines intended to drive emergency generating sets, additional tests and/or documents may be required to prove that the engine is capable of being readily started at a temperature of 0°C, as required in [3.1.3].

In the case of prototype engines, the duration and programme of the type test will be specially considered by the Society.

4.3.3 In cases of engines for which the Manufacturer submits documentary evidence proving successful service experience or results of previous bench tests, the Society, at its discretion, may allow a type test to be carried out in the presence of the Surveyor according to a programme to be agreed upon in each instance.

In the case of engines which are to be type approved for different purposes and performances, the programme and duration of the type test will be decided by the Society in each case to cover the whole range of engine performances for which approval is requested, taking into account the most severe values.

4.3.4 During the type test, at least the following particulars are to be recorded:

a) ambient air temperature, pressure and atmospheric humidity in the test room
b) cooling raw water temperature at the inlet of heat exchangers
c) characteristics of fuel and lubricating oil used during the test
d) engine speed
e) brake power
f) brake torque
g) maximum combustion pressure
h) indicated pressure diagrams, where practicable
i) exhaust smoke (with a smoke meter deemed suitable by the Surveyor)
j) lubricating oil pressure and temperature
k) cooling water pressure and temperature
l) exhaust gas temperature in the exhaust manifold and, where facilities are available, from each cylinder
m) minimum starting air pressure necessary to start the engine in cold condition.

In addition to the above, for supercharged engines the following data are also to be measured and recorded:

- turbocharger speed
- air temperature and pressure before and after turbocharger and charge air coolers
- exhaust gas temperatures and pressures before and after turbochargers and cooling water temperature at the inlet of charge air coolers.

4.3.5 Inspection of main engine components and evaluation of test results

The provisions of [4.2.4] and [4.2.5] are to be complied with, as far as applicable.

Table 3 : Material components

Minimum required characteristics	Components
Forged steel $R_m \geq 360$ N/mm^3	Cranckshaft Connecting rods Tie rods Bolts and studs
Forged steel rounds $R_m \geq 360$ N/mm^3	Tie rods Bolts and studs
Nodular cast iron, preferably ferritic grades	Engine blocks Bedpaltes Cylinders covers Flywheels Valve bodies and similar parts
Lamellar cast iron $R_m \geq 360$ N/mm^3	Engine blocks Bedpaltes Cylinders covers Liners Flywheels
Shipbuilding steel All grade D for paltes ≤ 25 mm thick	Welded bedpaltes Welded engine blocks
Shipbuilding steel All grade D for paltes > 25 mm thick or equivalent structural steel, cast in the fully killed condition and normalised	
weldable cast steel	Bearing transverse girders

4.4 Material and non-destructive tests

4.4.1 Material tests

Engine material components are to be in accordance with Tab 3 and in compliance with the requirements of Part D.

Evidence is to be supplied that the materials used meet the requirements of the Society's Rules for Materials and Welding.

This evidence may take the form of a Manufacturer's acceptance certificate.

In addition, crankshafts and connecting rods are to be subjected to non-destructive crack tests at the works and the results placed on record.

Where there is reason to doubt the satisfactory nature of an engine component, further additional tests according to recognised procedures may be stipulated.

4.4.2 Hydrostatic tests

Parts of engines under pressure are to be hydrostatically tested at the test pressure specified for each part in Tab 4.

4.5 Workshop inspections and testing

4.5.1 General

In addition to the type test, diesel engines are to be subjected to works trials, which are to be witnessed by the Surveyor except where an alternative inspection scheme has been granted or where otherwise decided by the Society on a case-by-case basis.

For all stages at which the engine is to be tested, the relevant operating values are to be measured and recorded by the engine Manufacturer.

In each case all measurements conducted at the various load points are to be carried out at steady operating conditions.

The readings for 100% of the rated power P at the corresponding speed n are to be taken twice at an interval of at least 30 minutes.

At the discretion of the Surveyor, the program of trials given in [4.5.2], [4.5.3] or [4.5.4] may be expanded depending on the engine application.

Table 4 : Test pressure of engine parts

	Parts under pressure	Test pressure (MPa) **(1)** **(2)**
1	Cylinder cover, cooling space **(3)**	0,7
2	Cylinder liner, over the whole length of cooling space	0,7
3	Cylinder jacket, cooling space	0,4 (but not less than 1,5 p)
4	Exhaust valve, cooling space	0,4 (but not less than 1,5 p)
5	Piston crown, cooling space **(3)** **(4)**	0,7
6	Fuel injection system a) Fuel injection pump body, pressure side b) Fuel injection valve c) Fuel injection pipes	 1,5 p (or p + 30, if lesser) 1,5 p (or p + 30, if lesser) 1,5 p (or p + 30, if lesser)
7	Hydraulic system • Piping, pumps, actuators etc. for hydraulic drive of valves	 1,5 p
8	Scavenge pump cylinder	0,4
9	Turbocharger, cooling space	0,4 (but not less than 1,5p)
10	Exhaust pipe, cooling space	0,4 (but not less than 1,5 p)
11	Engine driven air compressor (cylinders, covers, intercoolers and aftercoolers) a) Air side b) Water side	 1,5 p 0,4 (but not less than 1,5 p)
12	Coolers, each side **(5)**	0,4 (but not less than 1,5 p)
13	Engine driven pumps (oil, water, fuel, bilge)	0,4 (but not less than 1,5 p)

(1) In general, parts are to be tested at the hydraulic pressure indicated in the Table. Where design or testing features may call for modification of these testing requirements, special consideration will be given by the Society.
(2) p is the maximum working pressure, in MPa , in the part concerned.
(3) For forged steel cylinder covers and forged steel piston crowns, test methods other than hydrostatic testing may be accepted, e.g. suitable non-destructive tests and documented dimensional tests.
(4) Where the cooling space is sealed by the piston rod, or by the piston rod and the shell, the pressure test is to be carried out after assembly.
(5) Turbocharger air coolers need to be tested on the water side only.

4.5.2 Main propulsion engines driving propellers

Main propulsion engines are to be subjected to trials to be performed as follows:

a) at least 60 min, after having reached steady conditions, at rated power P and rated speed n

b) 30 min, after having reached steady conditions, at 110% of rated power P and at a speed equal to 1,032 of rated speed

c) tests at 90% (or normal continous cruise power), 75%, 50% and 25% of rated power P, carried out:
   - at the speed corresponding to the nominal (theoretical) propeller curve, for engines driving fixed pitch propellers
   - at constant speed, for engines driving controllable pitch propellers

d) idle run

e) starting and reversing tests (when applicable)

f) testing of the speed governor and of the independent overspeed protective device

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system is to be so adjusted that the engine cannot deliver more than 100% of the rated power at the corresponding speed (overload power cannot be obtained in service).

4.5.3 Engines driving electric generators used for main propulsion purposes

Engines driving electric generators are to be subjected to trials to be performed with a constant governor setting, as follows:

a) at least 60 min, after having reached steady conditions, at 100% of rated power P and rated speed n

b) 45 min, after having reached steady conditions, at 110% of rated power and rated speed

c) 75%, 50% and 25% of rated power P, carried out at constant rated speed n

d) idle run

e) starting tests

f) testing of the speed governor ([2.6.5]) and of the independent overspeed protective device (when applicable)

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system of diesel engines driving electric generators is to be adjusted such that overload (110%) power can be produced but not exceeded in service after installation on board, so that the governing characteristics, including the activation of generator protective devices, can be maintained at all times.

4.5.4 Engines driving auxiliary machinery

Engines driving auxiliary machinery are to be subjected to the tests stated in [4.5.2] or [4.5.3] for variable speed and constant speed drives, respectively.

Note 1: After running on the test bed, the fuel delivery system of diesel engines driving electric generators is to be adjusted such that overload (110%) power can be produced but not exceeded in service after installation on board, so that the governing characteristics, including the activation of generator protective devices, can be fulfilled at all times.

4.5.5 Inspection of engine components

After the works trials, several components are to be selected for inspection by the Manufacturer or by the Surveyor if the works trials are witnessed.

4.5.6 Parameters to be measured

The data to be measured and recorded, when testing the engine at various load points, are to include all necessary parameters for engine operation. The crankshaft deflection is to be verified when this check is required by the Manufacturer during the operating life of the engine.

4.5.7 Testing report

In the testing report for each engine the results of the tests carried out are to be compiled and the reference number and date of issue of the Type Approval Certificate (see [4.6]), relevant to the engine type, are always to be stated; the testing report is to be issued by the Manufacturer and enclosed with the testing certificate as per [4.6].

4.6 Certification

4.6.1 Type Approval Certificate and its validity

After the satisfactory outcome of the type tests and inspections specified in [4.2] or [4.3], the Society will issue to the engine manufacturer a "Type Approval Certificate" valid for all engines of the same type.

The Society reserves the right to consider the test carried out on one engine type valid also for engines having a different cylinder arrangement, following examination of suitable, detailed documentation submitted by the Manufacturer and including bench test results.

4.6.2 Testing certification

a) Engines admitted to an alternative inspection scheme

   Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for components and tests indicated in Tab 3 and 4 and for works trials as per [4.5].

b) Engines not admitted to an alternative inspection scheme

   Society's certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests of components in Tab 3 and for works trials as per [4.5].

   Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for non-destructive and hydrostatic tests of components in Tab 3 and Tab 4.

In both cases a) and b), the Manufacturer is to supply:

a) the following information:
   - engine type
   - rated power
   - rated speed
   - driven equipment
   - operating conditions
   - list of auxiliaries fitted on the engine

b) a statement certifying that the engine is in compliance with that type tested. The reference number and date of the Type Approval Certificate are also to be indicated in the statement.

SECTION 3 BOILERS AND PRESSURE VESSELS

1 General

1.1 Principles

1.1.1 Scope of the Rules

The boilers and other pressure vessels, associated piping systems and fittings shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

1.1.2 Tests

All boilers and other pressure vessels including their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time (see also [7]).

1.1.3 Protection against overpressure

Where main or auxiliary boilers and other pressure vessels or any parts thereof may be subject to dangerous overpressure, means shall be provided where practicable to protect against such excessive pressure.

1.2 Application

1.2.1 Boilers and pressure vessels covered by the Rules

The requirements of this Section apply to:

- all boilers and other steam generators, including the associated fittings and mountings with the exception of those indicated in [1.2.2]
- pressure vessels of metallic construction and heat exchangers, including the associated fittings and mountings with the exception of those indicated in [1.2.2].

1.2.2 Boilers and pressure vessels not covered by the Rules

The following boilers and pressure vessels are not covered by the Rules and will be considered on a case by case basis:

a) boilers with design pressure $p > 10$ MPa

b) pressure vessels intended for radioactive material

c) small pressure vessels included in self-contained domestic equipment.

1.2.3 Pressure vessels not requiring design approval

Plan approval is not required for pressure vessels of class 3 (as specified in [1.4]), having design pressure $p \le 1$ MPa and product $p\ V \le 150$ (V being the internal volume, in dm^3, calculated deducting the volume of tube bundles, if any).

However, the Society reserves the right to apply all or part of the requirements of this Section to class 3 heat exchangers and pressure vessels, depending on the criticality of the equipment and/or of the system of which they are part.

1.2.4 Pressure vessels covered in other parts of the Rules

Specific requirements relative to pressure vessels for liquefied gases and pressure vessels for refrigerating plants are stipulated in Part E, Chapter 1, Sec 14.

1.3 Definitions

1.3.1 Pressure vessel

Pressure vessel is a welded or seamless container used for the containment of fluids at a pressure above or below the ambient pressure and at any temperature. Fluid power cylinders in hydraulic or pneumatic plants are also considered pressure vessels.

1.3.2 Fired pressure vessel

Fired pressure vessel is a pressure vessel which is completely or partially exposed to fire from burners or combustion gases.

1.3.3 Unfired pressure vessel

Any pressure vessel which is not a fired pressure vessel is an unfired pressure vessel.

1.3.4 Boiler

a) Boiler is one or more fired pressure vessels and associated piping systems used for generating steam or hot water at a temperature above 120°C by means of heat resulting from combustion of fuel or from combustion gases.

b) Any equipment directly connected to the boiler, such as economisers, superheaters, and safety valves, is considered as part of the boiler, if it is not separated from the steam generator by means of any isolating valve. Piping connected to the boiler is considered part of the boiler upstream of the isolating valve and part of the associated piping system downstream of the isolating valve.

1.3.5 Steam generator

Steam generator is a heat exchanger and associated piping used for generating steam. In general, in these Rules, the requirements for boilers are also applicable for steam generators, unless otherwise indicated.

1.3.6 Heat exchanger

Heat exchanger is a pressure vessel used to heat or cool a fluid with another fluid. In general heat exchangers are composed of a number of adjacent chambers, the two fluids flowing separately in adjacent chambers. One or more chambers may consist of bundles of tubes.

1.3.7 Superheaters, economisers, reheaters, de-superheaters

Superheaters, economisers, reheaters and de-superheaters are heat exchangers associated with a boiler.

1.3.8 Incinerator

Incinerator is a shipboard facility for incinerating solid garbage approximating in composition to household garbage and liquid garbage deriving from the operation of the ship (e.g. domestic garbage, cargo-associated garbage, maintenance garbage, operational garbage, cargo residue, and fishing gear), as well as for burning sludge with a flash point above 60°C.

These facilities may be designed to use the heat energy produced.

1.3.9 Design pressure

The design pressure is the pressure used by the manufacturer to determine the scantlings of the vessel. This pressure cannot be taken less than the maximum working pressure and is to be limited by the set pressure of the safety valve, as prescribed by the applicable Rules.

1.3.10 Design temperature

a) Design temperature is the actual metal temperature of the applicable part under the expected operating conditions, as modified in Tab 1. This temperature is to be stated by the manufacturer and is to take account of the effect of any temperature fluctuations which may occur during the service.

b) The design temperature is to be not less than the temperatures stated in Tab 1, unless specially agreed between the manufacturer and the Society on a case by case basis.

   For boilers the design temperature is to be not less than 250 °C.

1.3.11 Boiler heating surface

Heating surface is the area of that part of the boiler through which the heat is supplied to the medium, measured on the side exposed to fire or hot gas.

Table 1 : Minimum design temperature

TYPE OF VESSEL	MINIMUM DESIGN TEMPERATURE
Pressure parts of pressure vessels and boilers not heated by hot gases or adequately protected by insulation	Maximum temperature of the internal fluid
Pressure vessel heated by hot gases	25°C in excess of the temperature of the internal fluid
Water tubes of boilers mainly subjected to convection heat	25°C in excess of the temperature of the saturated steam
Water tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to convection heat	35°C in excess of the temperature of the saturated steam
Superheater tubes of boilers mainly subjected to radiant heat	50°C in excess of the temperature of the saturated steam
Economiser tubes	35°C in excess of the temperature of the internal fluid
For combustion chambers of the type used in wet-back boilers	50°C in excess of the temperature of the internal fluid
For furnaces, fire-boxes, rear tube plates of dry-back boilers and other pressure parts subjected to similar rate of heat transfer	90°C in excess of the temperature of the internal fluid

Table 2 : Pressure vessels classification

Equipment	class 1	class 2	class 3
Boilers	$p > 0,35$ MPa	$p \leq 0,35$ MPa	-
Steam heated generators or steam generators heated by another fluid	$p > 1,15$ MPa, or $p.D > 1500$	All steam generators which are not class 1	-
Pressure vessels and heat exchangers	$p > 4$ MPa, or $t_A > 40$ mm, or $T > 350$°C	$1,75 < p \leq 4$ MPa, or $15 < t_A \leq 40$ mm, or $150 < T \leq 350$°C, or $p.t_A > 15$	All pressure vessels and heat exchangers which are not class 1 or 2
Pressure vessels for toxic substances	All	-	-
Pressure vessels for corrosive substances	$p > 4$ MPa, or $t_A > 40$ mm, or $T > 350$°C	All pressure vessels which are not class 1	-
Note 1: Whenever the class is defined by more than one characteristic, the equipment is to be considered belonging to the highest class of its characteristics, independently of the values of the other characteristics.			

1.3.12 Maximum steam output

Maximum steam output is the maximum quantity of steam that can be produced continuously by the boiler or steam generator operating under the design steam conditions.

1.3.13 Toxic and corrosive substances

Toxic and corrosive substances are those which are listed in the IMO "International Maritime Dangerous Goods Code (IMDG Code)", as amended.

1.3.14 Ductile material

For the purpose of this Section, ductile material is a material having an elongation over 12%.

Table 3 : Drawings to be submitted for boilers and steam generators

No.	A/I	Item
1	I	General arrangement plan including valves and fittings
2	A	Material specifications
3	A	Sectional assembly
4	A	Evaporating parts
5	A	Superheater
6	A	De-superheater
7	A	Economiser
8	A	Air heater
9	A	Tubes and tube plates
10	A	Nozzles and fittings
11	A	Safety valves and their arrangement
12	A	Boiler seating
13	I	Fuel oil burning arrangement
14	I	Forced draft system
15	I	Refractor or insulation arrangement
16	A	Boiler instrumentation, monitoring and control system
17	A	Type of safety valves and their lift, discharge rate and setting
18	A	Welding details, including at least: • Typical weld joint design • Welding procedure specifications • Post-weld heat treatment
Note 1: A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.4 Classes

1.4.1 Boilers and pressure vessels are classed as indicated in Tab 2 in consideration of their service, characteristics and scantlings. The symbols used in the table have the following meanings:

p : Design pressure, in MPa

T : Design temperature, in °C

D : Inside diameter of the vessel, in mm

t_A : Actual thickness of the vessel, in mm

1.5 Alternative standards

1.5.1

a) All boilers and pressure vessels are to be designed, constructed, installed and tested in accordance with the applicable requirements of this Section.

b) The acceptance of national and international standards as an alternative to the requirements of this Section may be considered by the Society on a case by case basis.

1.6 Documentation to be submitted

1.6.1 Boilers

The plans listed in Tab 3 are to be submitted.

The drawings listed in Tab 3 are to contain at least: the constructional details of all pressure parts, such as shells, headers, tubes, tube plates, nozzles; all strengthening members, such as stays, brackets, opening reinforcements and covers; installation arrangements, such as saddles and anchoring system; as well as the information and data indicated in Tab 4.

1.6.2 Other pressure vessels and heat exchangers

The plans listed in Tab 5 are to be submitted.

The drawings listed in Tab 5 are to contain at least the constructional details of all pressure parts, such as shells, headers, tubes, tube plates, nozzles, opening reinforcements and covers, and of all strengthening members, such as stays, brackets and reinforcements.

Table 4 : Information and data to be submitted for boilers and steam generators

No.	Item
1	Design pressure and temperature
2	Pressure and temperature of the superheated steam
3	Pressure and temperature of the saturated steam
4	Maximum steam production per hour
5	Evaporating surface of the tube bundles and water-walls
6	Heating surface of the economiser, superheater and air-heater
7	Surface of the furnace
8	Volume of the combustion chamber
9	Temperature and pressure of the feed water
10	Type of fuel to be used and fuel consumption at full steam production
11	Number and capacity of burners

Table 5 : Drawings, information and data to be submitted for pressure vessels and heat exchangers

No.	A/I	Item
1	I	General arrangement plan including nozzles and fittings
2	A	Sectional assembly
3	A	Material specifications
4	A	Welding details, including at least: • Typical weld joint design • Welding procedure specifications • Post-weld heat treatments
5	I	Design data, including at least design pressure and design temperatures (as applicable)
6	A	For seamless (extruded) pressure vessels, the manufacturing process including: • A description of the manufacturing process with indication of the production controls normally carried out in the manufacturer's works • Details of the materials to be used (specification, yield point, tensile strength, impact strength, heat treatment) • Details of the stamped marking to be applied
7	I	Type of fluid or fluids contained
Note 1: A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.6.3 Incinerators

Incinerators will be considered on a case by case basis, based on their actual arrangement, using the applicable requirements for boilers and pressure vessels.

2 Design and Construction - Principles

2.1 Materials

2.1.1 Materials for high temperatures

a) Materials for pressure parts having a design temperature exceeding the ambient temperature are to have mechanical and metallurgical properties adequate for the design temperature. Their allowable stress limits are to be determined as a function of the temperature, according to [3.1].

b) When the design temperature of pressure parts exceeds 400°C, alloy steels are to be used. Other materials are subject to special consideration by the Society.

2.1.2 Materials for low temperatures

Materials for pressure parts having a design temperature below the ambient temperature are to have notch toughness properties suitable for the design temperature.

2.1.3 Cast iron

Grey cast iron is not to be used for:

a) class 1 and class 2 pressure vessels

b) class 3 pressure vessels with design pressure $p > 0,7$MPa or product $pV > 15$, where V is the internal volume of the pressure vessel in m^3

c) Bolted covers and closures of pressure vessels having a design pressure $p > 1$MPa, except for covers intended for boiler shells, for which [2.2.3] applies.

Spheroidal cast iron may be used subect to the agreement of the Society following special consideration. However, it is not to be used for parts having a design temperature exceeding 350°C.

2.1.4 Valves and fittings for boilers

a) Ductile materials are to be used for valves and fittings intended to be mounted on boilers. The material is to have mechanical and metallurgical characteristics suitable for the design temperature and for the thermal and other loads imposed during the operation.

b) Grey cast iron is not to be used for valves and fittings which are subject to dynamic loads, such as safety valves and blow-down valves, and in general for fittings and accessories having design pressure p exceeding 0,3 MPa and design temperature T exceeding 220°C.

c) Spheroidal cast iron is not to be used for parts having a design temperature T exceeding 350°C.

d) Bronze is not to be used for parts having design temperature T exceeding 220°C for normal bronzes and 260°C for bronzes suitable for high temperatures. Copper and aluminium brass are not to be used for fittings with design temperature T above 200°C and copper-nickel for fittings with design temperature T exceeding 300°C.

2.1.5 Alternative materials

In the case of boilers or pressure vessels constructed in accordance with one of the standards considered acceptable by the Society as per [1.5], the material specifications are to be in compliance with the requirements of the standard used.

2.2 Boilers and other steam generators

2.2.1 Insulation of headers and combustion chambers

Those parts of headers and/or combustion chambers which are not protected by tubes and are exposed to radiant heat or to high temperature gases are to be covered by suitable insulating material.

2.2.2 Connections of tubes to drums and tube plates

Tubes are to be adequately secured to drums and/or tube plates by expansion, welding or other appropriate procedure.

a) Where the tubes are secured by expanding or equivalent process, the height of the shoulder bearing the tube, measured parallel to the tube axis, is to be at least 1/5 of the hole diameter, but not less than 9 mm for tubes normal to the tube plate or 13 mm for tubes angled to the tube plate. The tubes ends are not to project over the other face of the tube plate more than 6 mm.

b) The tube ends intended to be expanded are to be partially annealed when the tubes have not been annealed by the manufacturer.

2.2.3 Access arrangement

a) Boilers are to be provided with openings in sufficient number and size to permit internal examination, cleaning and maintenance operations. In general, all pressure vessels which are part of a boiler with inside diameter exceeding 1200 mm, and those with inside diameter exceeding 800 mm and length exceeding 2000 mm, are to be provided with access manholes.

b) Manholes are to be provided in suitable locations in the shells, headers, domes, and steam and water drums, as applicable. The "net" (actual hole) dimension of elliptical or similar manholes is to be not less than 300 mm x 400 mm. The "net" diameter of circular manholes (actual hole) cannot be less than 400 mm. The edges of manholes are to be adequately strengthened to provide compensation for vessel openings.

c) In pressure vessels which are part of a boiler and are not covered by the requirement in a) above, or where an access manhole cannot be fitted, at least the following openings are to be provided, as far as practicable:

- Head holes: minimum dimensions: 220mm x 320mm (320 mm diameter if circular)
- Handholes: minimum dimensions: 87mm x 103mm
- Sight holes: minimum diameter: 50 mm.

d) Sight holes may only be provided when the arrangement of manholes, head holes, or handholes is impracticable.

e) Covers for manholes and other openings are to be made of ductile steel, dished or welded steel plates or other approved design. Grey cast iron may be used only for small openings, such as handholes and sight holes, provided the design pressure p does not exceed 1 MPa and the design temperature T does not exceed 220°C.

f) Covers are to be of self-closing internal type. Small opening covers of other type may be accepted by the Society on a case by case basis.

g) Covers of the internal type are to have a spigot passing through the opening. The clearance between the spigot and the edge of the opening is to be uniform for the whole periphery of the opening and is not to exceed 1,5 mm. Fig 1 shows a typical arrangement.

h) Closing devices of internal type covers, having dimensions not exceeding 180mm x 230mm, may be fitted with a single fastening bolt or stud. Larger closing devices are to be fitted with at least two bolts or studs. For fastening bolt or stud arrangement see Fig 1.

i) Covers are to be designed so as to prevent the dislocation of the required gasket by the internal pressure. Only continuous ring gaskets may be used for packing.

2.2.4 Fittings

a) In general, cocks and valves are to be designed in accordance with the requirements in Sec 8, [2.7.2].

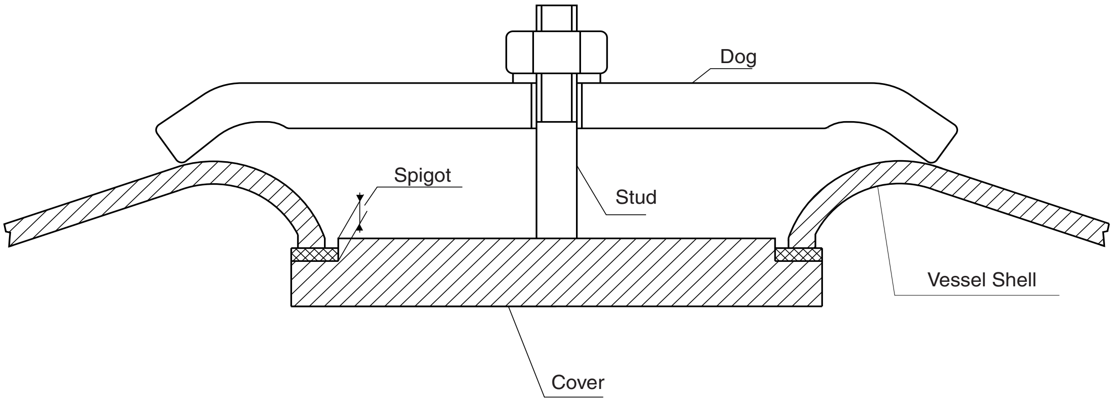
b) Cocks, valves and other fittings are to be connected directly or as close as possible to the boiler shell.

c) Cocks and valves for boilers are to be arranged in such a way that it can be easily seen when they are open or closed and so that their closing is obtained by a clockwise rotation of the actuating mechanism.

2.2.5 Boiler burners

Burners are to be arranged so that they cannot be withdrawn unless the fuel supply to the burners is cut off.

Figure 1 : Opening cover



2.2.6 Allowable water levels

a) In general, for water tube boilers the lowest permissible water level is just above the top row of tubes when the water is cold. Where the boiler is designed not to have fully submerged tubes, when the water is cold, the lowest allowable level indicated by the manufacturer is to be indicated on the drawings and submitted to the Society for consideration.

b) For fire tube boilers with combustion chamber integral with the boiler, the minimum allowable level is to be at least 50 mm above the highest part of the combustion chamber.

c) For vertical fire tube boilers the minimum allowable level is 1/2 of the length of the tubes above the lower tube sheet.

2.2.7 Steam outlets

a) Each boiler steam outlet, if not serving safety valves, integral superheaters and other appliances which are to have permanent steam supply during boiler operation, is to be fitted with an isolating valve secured either directly to the boiler shell or to a standpipe of substantial thickness, as short as possible, and secured directly to the boiler shell.

b) The number of auxiliary steam outlets is to be reduced to a minimum for each boiler.

c) Where several boilers supply steam to common mains, the arrangement of valves is to be such that it is possible to positively isolate each boiler for inspection and maintenance. In addition, for water tube boilers, non-return devices are to be fitted on the steam outlets of each boiler.

d) Where steam is used for essential auxiliaries (such as whistles, steam operated steering gears, steam operated electric generators, etc.) and when several boilers are fitted on board, it is to be possible to supply steam to these auxiliaries with any one of these boilers out of operation.

e) Each steam stop valve exceeding 150 mm nominal diameter is to be fitted with a bypass valve.

2.2.8 Feed check valves

a) Each fired boiler supplying steam to essential services is to be fitted with at least two feed check valves connected to two separate feed lines. For unfired steam generators a single feed check valve may be allowed.

b) Feed check valves are to be secured directly to the boiler or to an integral economiser. Water inlets are to be separated. Where, however, feed check valves are secured to an economiser, a single water inlet may be allowed provided that each feed line can be isolated without stopping the supply of feed water to the boiler.

c) Where the economisers may be bypassed and cut off from the boiler, they are to be fitted with pressure-limiting type valves, unless the arrangement is such that excessive pressure cannot occur in the economiser when cut off.

d) Feed check valves are to be fitted with control devices operable from the stokehold floor or from another appropriate location. In addition, for water tube boilers, at least one of the feed check valves is to be arranged so as to permit automatic control of the water level in the boiler.

e) Provision is to be made to prevent the feed water from getting in direct contact with the heated surfaces inside the boiler and to reduce, as far as possible and necessary, the thermal stresses in the walls.

2.2.9 Blow-down devices

a) Each boiler is to be fitted with at least one bottom blow-down valve or cock and, where necessary, with a similar valve or cock for scumming from the surface. These valves or cocks are to be secured directly to the boiler shell and are to be connected to overboard discharge pipes.

b) The diameter of valves or cocks and of the connected piping is not to be less than 20 mm and need not be more than 40 mm.

c) Where the bottom blow-down valve may not be directly connected to the boiler shell in water tube boilers, the valve may be placed immediately outside the boiler casing with a pipe of substantial thickness suitably supported and protected from the heat of the combustion chamber.

d) Where two or more boilers have the bottom blow-down and surface scumming-off valves connected to the same discharge, the relevant valves and cocks are to be of the non-return type to prevent the possibility of the contents of one boiler passing to another.

2.2.10 Drains

Each superheater, whether or not integral with the boiler, is to be fitted with cocks or valves so arranged that it is possible to drain it completely.

2.2.11 Water sample

a) Every boiler shall be provided with means to supervise and control the quality of the feed water. Suitable arrangements shall be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

b) For this purpose, boilers are to be fitted with at least one water sample cock or valve. This device is not to be connected to the water level standpipes.

c) Suitable inlets for water additives are to be provided in each boiler.

2.2.12 Marking of boilers

a) Each boiler is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

- the design pressure
- the design temperature
- the test pressure and the date of the test

b) Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.

c) For lagged vessels, these markings are also to appear on a similar plate fitted above the lagging.

2.3 Boiler and steam generator safety valves

2.3.1 Safety valve arrangement

a) Every steam boiler and every steam generator with a total heating surface of 50 m^2 and above is to be provided with not less than two spring loaded safety valves of adequate capacity. For steam boilers and steam generators having heating surface less than 50 m^2, only one safety valve need be fitted.

b) Where a superheater is an integral part of the boiler, at least one safety valve is to be located on the steam drum and at least one at the superheater outlet. The valves fitted at the superheater outlet may be considered as part of the boiler safety valves required in a) provided that their capacity does not account for more than 25% of the total capacity required in [2.3.2], unless specially considered by the Society.

c) Where fitted, superheaters which may be shut-off from the boiler, are to be provided with at least one safety valve; such valve(s) cannot be considered as part of the boiler safety valves required in a).

d) In the case of boilers fitted with a separate steam accumulator, safety valves may be fitted on the accumulator if no shut-off is provided between it and the boiler and if the connecting pipe is of a size sufficient to allow the whole steam production to pass through, without increasing the boiler pressure more than 10% above the design pressure.

2.3.2 Orifice minimum aggregate area

a) The minimum aggregate area of the orifices of the safety valves in way of the seat is to be determined by the appropriate formula below.

- Saturated steam:

$$A = c \cdot \frac{d}{h} \cdot \frac{W}{10{,}2 \cdot p + 1}$$

- Superheated steam:

$$A_S = c \cdot \frac{d}{h} \cdot \frac{W_S}{10{,}2 \cdot p + 1} \cdot \left(1 + \frac{T_S}{556}\right)$$

where:

A : Aggregate area, in mm^2, of the orifices in way of the seat, for saturated steam safety valves

A_S : Aggregate area, in mm^2, as defined above, for superheated steam safety valves

p : Maximum working pressure of the boiler or other steam generator, in MPa

p_S : Maximum working pressure of the superheated steam, in MPa

W : Maximum steam production, in kg/h.

The value of W is to be based on evaporating capacities (referring to evaporating surfaces of the boiler concerned) not less than the following:

- 14 kg/(m^2 × h) for exhaust gas heated boilers
- 29 kg/(m^2 × h) for coal fired or oil fired boilers
- 60 kg/(m^2 × h) for water walls of oil fired boilers

W_S : Steam relieving capacity, in kg/h, of the valves fitted at the superheater outlet. This capacity is to be such that, during the discharge of safety valves, a sufficient quantity of steam is circulated through the superheater to avoid damage

d/h : Ratio of the actual orifice diameter in way of the seat to the actual lift of the safety valve plug. The values of d/h are to be taken not less than 4 and not greater than 24.

For valves of common type, or where the lift of the plug is not known, the value d/h = 24 is to be used

c : 0,875 for safety valves whose relieving capacity has not been ascertained experimentally as specified hereunder

0,485/Z where Z is the flow coefficient, for valves of large relieving capacity ascertained experimentally as directed by the Society, in the presence of the Surveyor. The flow coefficient Z is to be taken as the ratio of 90% of the experimentally checked relieving capacity to the theoretical relieving capacity calculated with a flow coefficient equal to 1. Values of Z higher than 0,88 are not to be used

T_S : Temperature of superheated steam, in °C

b) The orifice diameter in way of the safety valves seat is not to be less than 40 mm. Where only one safety valve need be fitted, the orifice minimum diameter is not to be less than 50 mm. Valves of large relieving capacity with 15 mm minimum diameter may be accepted for boilers with steam production not exceeding 2000 kg/h.

c) Independently of the above requirements, the aggregate capacity of the safety valves is to be such as to discharge all the steam that can be generated without causing a transient pressure rise of more than 10% over the design pressure.

2.3.3 Safety valves operated by pilot valves

The arrangement on the superheater of large relieving capacity safety valves, operated by pilot valves fitted in the saturated steam drum, is to be specially considered by the Society.

2.3.4 Steam heated steam generator protection

Steam heated steam generators are also to be protected against possible damage resulting from failure of the heating coils. In this case, the area of safety valves calculated as stated in [2.3.2] may need to be increased to the satisfaction of the Society, unless suitable devices limiting the flow of steam in the heating coils are provided.

2.3.5 Safety valve setting

a) Safety valves are to be set under steam in the presence of the Surveyor to a pressure not higher than 1,03 times the design pressure.

b) Safety valves are to be so constructed that their setting may not be increased in service and their spring may not be expelled in the event of failure. In addition, safety valves are to be provided with simple means of lifting the plug from its seat from a safe position in the boiler or engine room.

c) Where safety valves are provided with means for regulating their relieving capacity, they are to be so fitted that their setting cannot be modified when the valves are removed for surveys.

2.3.6 Safety valve fitting on boiler

a) The safety valves of a boiler are to be directly connected to the boiler and separated from other valve bodies.

b) Where it is not possible to fit the safety valves directly on the superheater headers, they are to be mounted on a strong nozzle fitted as close as practicable to the superheater outlet. The cross-sectional area for passage of steam through restricted orifices of the nozzles is not to be less than 1/2 the aggregate area of the valves, calculated with the formulae of [2.3.2], when $d/h \geq 8$, and not less than the aggregate area of the valves, when $4 \leq d/h < 8$.

c) Safety valve bodies are to be fitted with drain pipes of a diameter not less than 20 mm for double valves, and not less than 12 mm for single valves, leading to the bilge or to the hot well. Valves or cocks are not to be fitted on drain pipes.

2.3.7 Exhaust pipes

a) The minimum cross-sectional area of the exhaust pipes of safety valves which have not been experimentally tested is not to be less than 11,5 h/d times the aggregate area as calculated by the formulae in [2.3.2]. However, this area is not to be less than 1,1 times the safety valve aggregate area.

b) The minimum cross-sectional area of the exhaust pipes of large relieving capacity safety valves whose capacity has been experimentally tested is to be not less than $18\ Z \times h/d$ times the aggregate area calculated by the formulae in [2.3.2].

c) The cross-sectional area of the exhaust manifold of safety valves is to be not less than the sum of the areas of the individual exhaust pipes connected to it.

d) Silencers fitted on exhaust manifolds are to have a free passage area not less than that of the manifolds.

e) The strength of exhaust manifolds and pipes and associated silencers is to be such that they can withstand the maximum pressure to which they may be subjected, which is to be assumed not less than 1/4 of the safety valve setting pressure.

f) In the case that the discharges from two or more valves are led to the same exhaust manifold, provision is to be made to avoid the back pressure from the valve which is discharging influencing the other valves.

g) Exhaust manifolds are to be led to the open and are to be adequately supported and fitted with suitable expansion joints or other means so that their weight does not place an unacceptable load on the safety valve bodies.

2.4 Pressure vessels

2.4.1 Access arrangement

The access requirements for boilers stated in [2.2.3] are also applicable for other pressure vessels.

2.4.2 Safety valves

a) Pressure vessels which are part of a system are to be provided with safety valves, or equivalent devices, if they are liable to be isolated from the system safety devices. This provision is also to be made in all cases in which the vessel pressure can rise, for any reason, above the design pressure. See also [6.3] for grouped pressure vessels.

b) In particular, air pressure vessels which can be isolated from the safety valves ensuring their protection in normal service are to be fitted with another safety device, such as a rupture disc or a fusible plug, in order to ensure their discharge in case of fire. This device is to discharge to the open.

c) Safety devices ensuring protection of pressure vessels in normal service are to be rated to operate before the pressure exceeds the maximum working pressure by more than 5%.

2.4.3 Protection of heat exchangers

Special attention is to be paid to the protection against overpressure of vessels, such as heat exchangers, which have parts that are designed for a pressure which is below that to which they might be subjected in the case of rupture of the tubular bundles or coils contained therein and that have been designed for a higher pressure.

2.4.4 Corrosion protection

Vessels and equipment containing media that might lead to accelerated corrosion are to be suitably protected.

2.4.5 Drainage

a) Each air pressure vessel is to be fitted with a drainage device allowing the evacuation of any oil or water accumulated in the vessel.

b) Drainage devices are also to be fitted on other vessels, in particular steam vessels, in which condensation water is likely to accumulate.

2.4.6 Marking

a) Each pressure vessel is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

- the design pressure
- the design temperature
- the test pressure and the date of the test

b) Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.

c) For smaller pressure vessels the indication of the design pressure only may be sufficient.

2.5 Thermal oil heaters and other pressure vessels associated with thermal oil installations

2.5.1 General

a) The following requirements apply to thermal oil heaters in which organic liquids (thermal oils) are heated by oil fired burners, exhaust gases or electricity to temperatures below their initial boiling point at atmospheric pressure.

b) Thermal oils are only to be used within the limits set by the manufacturer.

c) Means are to be provided for manual operation. However, at least the temperature control device on the oil side and flow monitoring are to remain operative even in manual operation.

d) Means are to be provided to take samples of thermal oil.

2.5.2 Thermal oil heaters

a) Heaters are to be so constructed that neither the surfaces nor the thermal oil becomes excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

b) The surfaces which come into contact with the thermal oil are to be designed for the design pressure, subject to the minimum pressure of 1 MPa.

c) Copper and copper alloys are not permitted.

d) Heaters heated by exhaust gas are to be provided with inspection openings at the exhaust gas intake and outlet.

e) Oil fired heaters are to be provided with inspection openings for examination of the combustion chamber. The opening for the burner may be considered as an inspection opening, provided its size is sufficient for this purpose.

f) Heaters are to be fitted with means enabling them to be completely drained.

g) Thermal oil heaters heated by exhaust gas are to be fitted with a permanent system for extinguishing and cooling in the event of fire, for instance a pressure water spraying system.

2.5.3 Safety valves

Each heater is to be equipped with at least one safety valve having a discharge capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During discharge the pressure may not increase above 10% over the design pressure.

2.5.4 Pressure vessels

The design pressure of all vessels which are part of a thermal oil system, including those open to the atmosphere, is to be taken not less than 0,2 MPa.

2.5.5 Equipment of the expansion, storage and drain tanks

For the equipment to be installed on expansion, storage and drain tanks, see Sec 8, [11].

2.5.6 Marking

Each thermal oil heater and other pressure vessels which are part of a thermal oil installation are to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):

a) Heaters
- Maximum allowable heating power
- Design pressure
- Maximum allowable discharge temperature
- Minimum flow rate
- Liquid capacity

b) Vessels
- Design pressure
- Design temperature
- Capacity.

2.6 Special types of pressure vessels

2.6.1 Seamless pressure vessels (bottles)

Each bottle is to be marked with the following information:

- Name or trade name of the manufacturer
- Serial number
- Type of gas
- Capacity
- Test pressure
- Empty weight
- Test stamp.

2.6.2 Steam condensers

a) The water chambers and steam spaces are to be fitted with doors for inspection and cleaning.

b) Where necessary, suitable diaphragms are to be fitted for supporting tubes.

c) Condenser tubes are to be removable.

d) High speed steam flow, where present, is to be prevented from directly striking the tubes by means of suitable baffles.

e) Suitable precautions are to be taken in order to avoid corrosion on the circulating water side and to provide an efficient grounding.

3 Design and construction - Scantlings

3.1 General

3.1.1 Design calculations are to be performed according to the Society's Rules or to international codes such as ASME, British Standards or harmonised European Standards accepted by the Society, taking into consideration the special requirements for steam boilers installed on inland waterway vessels.

Applicable statutory requirements of the Flag State Authority are to be observed additionally.

3.2 Permissible stresses

3.2.1 Permissible stress tables

The permissible stresses K, in N/mm², for steels, to be used in the formulae of this Section, may be determined from Tab 6, Tab 7, Tab 8 and Tab 9, where R_m is the ultimate strength of the material in N/mm². For intermediate values of the temperature, the value of K is to be obtained by linear interpolation.

Table 6 : Permissible stresses K for carbon steels intended for boilers and thermal oil heaters

Carbon steel	T (°C)	≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm² Grade HA	t ≤ 15 mm	133	109	107	105	94	77	73	72
	15 mm < t ≤ 40 mm	128	106	105	101	90	77	73	72
	40 mm < t ≤ 60 mm	122	101	99	95	88	77	73	72
R_m = 360 N/mm² Grades HB, HD	t ≤ 15 mm	133	127	116	103	79	79	72	69
	15 mm < t ≤ 40 mm	133	122	114	102	79	79	72	69
	40 mm < t ≤ 60 mm	133	112	107	99	79	79	72	69
R_m = 410 N/mm² Grade HA	t ≤ 15 mm	152	132	130	126	112	94	89	86
	15 mm < t ≤ 40 mm	147	131	124	119	107	94	89	86
	40 mm < t ≤ 60 mm	141	120	117	113	105	94	89	86
R_m = 410 N/mm² Grades HB, HD	t ≤ 15 mm	152	147	135	121	107	95	88	84
	15 mm < t ≤ 40 mm	152	142	133	120	107	95	88	84
	40 mm < t ≤ 60 mm	152	134	127	117	107	95	88	84
R_m = 460 N/mm² Grades HB, HD	t ≤ 15 mm	170	164	154	139	124	111	104	99
	15 mm < t ≤ 40 mm	169	162	151	137	124	111	104	99
	40 mm < t ≤ 60 mm	162	157	147	136	124	111	104	99
R_m = 510 N/mm² Grades HB, HD	t ≤ 60 mm	170	170	169	159	147	134	125	112

Table 7 : Permissible stresses K for carbon steels intended for other pressure vessels

Carbon steel	T (°C)	≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm² Grade HA	t ≤ 15 mm	133	117	115	112	100	83	78	77
	15 mm < t ≤ 40 mm	133	114	113	108	96	83	78	77
	40 mm < t ≤ 60 mm	130	108	105	101	94	83	78	77
R_m = 360 N/mm² Grades HB, HD	t ≤ 15 mm	133	133	123	110	97	85	77	73
	15 mm < t ≤ 40 mm	133	131	122	109	97	85	77	73
	40 mm < t ≤ 60 mm	133	119	115	106	97	85	77	73
R_m = 410 N/mm² Grade HA	t ≤ 15 mm	152	141	139	134	120	100	95	92
	15 mm < t ≤40 mm	152	134	132	127	114	100	95	92
	40 mm < t ≤ 60 mm	150	128	121	112	112	100	95	92
R_m = 410 N/mm² Grades HB, HD	t ≤ 15 mm	152	152	144	129	114	101	94	89
	15 mm < t ≤ 40 mm	152	152	142	128	114	101	94	89
	40 mm < t ≤ 60 mm	152	143	139	125	114	101	94	89
R_m = 460 N/mm² Grades HB, HD	t ≤ 15 mm	170	170	165	149	132	118	111	105
	15 mm < t ≤ 40 mm	170	170	161	147	132	118	111	105
	40 mm < t ≤ 60 mm	170	167	157	145	132	118	111	105
R_m = 510 N/mm² Grades HB, HD	t ≤ 60 mm	189	189	180	170	157	143	133	120

Table 8 : Permissible stresses K for alloy steels intended for boilers and thermal oil heaters

Alloy steel	T(°C)	≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	153	143	134	125	106	100	94	91	89	87	36			
1Cr 0,5Mo	t ≤ 60 mm	167	167	157	144	137	128	119	112	106	104	103	55	31	19	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	170	167	157	147	144	137	131	125	119	115	112	61	41	30	22
2,25Cr 1Mo **(2)**	t ≤ 60 mm	170	167	164	161	159	147	141	130	128	125	122	61	41	30	22

(1) Normalised and tempered
(2) Normalised and tempered or quenched and tempered

Table 9 : Permissible stresses K for alloy steels intended for other pressure vessels

Alloy steel	T(°C)	≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	159	153	143	133	113	107	100	97	95	93	38			
1Cr 0,5Mo	t ≤ 60 mm	167	167	167	154	146	137	127	119	113	111	110	59	33	20	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	183	174	167	157	154	146	140	133	127	123	119	65	44	32	23
2,25Cr 1Mo **(2)**	t ≤ 60 mm	174	174	174	172	170	157	150	139	137	133	130	65	44	32	23

(1) Normalised and tempered
(2) Normalised and tempered or quenched and tempered

3.2.2 Direct determination of permissible stresses

The permissible stresses K, where not otherwise specified, may be taken as indicated below.

a) Steel:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{2,7}$$

$$K = \frac{R_{S,MIN,T}}{A}$$

$$K = \frac{S_A}{A}$$

where:

$R_{m,20}$: Minimum tensile strength at ambient temperature (20°C), in N/mm²

$R_{S,MIN,T}$: Minimum between R_{eH} and $R_{p\ 0,2}$ at the design temperature T, in N/mm²

S_A : Average stress to produce creep rupture in 100000 hours, in N/mm², at the design temperature T

A : Safety factor taken as follows, when reliability of $R_{S,MIN,T}$ and S_A values are proved to the Society's satisfaction:

- 1,6 for boilers and other steam generators
- 1,5 for other pressure vessels
- specially considered by the Society if average stress to produce creep rupture in more than 100000 hours is used instead of S_A

In the case of steel castings, the permissible stress K, calculated as above, is to be decreased by 20%. Where steel castings are subjected to non-destructive tests, a smaller reduction up to 10% may be taken into consideration by the Society.

b) Spheroidal cast iron:

The permissible stress is be to the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{4,8}$$

$$K = \frac{R_{S,MIN,T}}{3}$$

c) Grey cast iron:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,20}}{10}$$

d) Copper alloys:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,T}}{4}$$

where:

$R_{m,T}$: Minimum tensile strength at the design temperature T, in N/mm²

e) Aluminium and aluminium alloys:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,T}}{4}$$

$$K = \frac{R_{e,H}}{1,5}$$

where:

$R_{e,H}$: Minimum yield stress, in N/mm²

f) Additional conditions:

- In special cases the Society reserves the right to apply values of permissible stress K lower than those specified above.
- In the case of boilers or other steam generators, the permissible stress K is not to exceed 170 N/mm².
- For materials other than those listed above the permissible stress is to be agreed with the Society on a case by case basis.

4 Design and construction - Fabrication and welding

4.1 General

4.1.1 Base materials

a) These requirements apply to boilers and pressure vessels made of steel of weldable quality.

b) Fabrication and welding of vessels made of other materials will be the subject of special consideration.

4.1.2 Welding

a) Welding is to be performed in accordance with welding procedures approved by the Society.

b) Manual and semi-automatic welding is to be performed by welders qualified by the Society.

c) The conditions under which the welding procedures, welding equipment and welders operate are to correspond to those specified in the relevant approvals or qualifications.

d) Both ordinary and special electric arc welding processes are covered in the following requirements.

4.1.3 Cutting of plates

a) Plates are to be cut by flame cutting, mechanical machining or a combination of both processes. For plates having a thickness less than 25 mm, cold shearing is admitted provided that the sheared edge is removed by machining or grinding for a distance of at least one quarter of the plate thickness with a minimum of 3 mm.

b) For flame cutting of alloy steel plates, preheating is to be carried out if necessary.

c) The edges of cut plates are to be examined for laminations, cracks or any other defect detrimental to their use.

4.1.4 Forming of the plates

a) The forming processes are to be such as not to impair the quality of the material. The Society reserves the right to require the execution of tests to demonstrate the suitability of the processes adopted. Forming by hammering is not allowed.

b) Unless otherwise justified, cold formed shells are to undergo an appropriate heat treatment if the ratio of internal diameter after forming to plate thickness is less than 20. This heat treatment may be carried out after welding.

c) Before or after welding, hot formed plates are to be normalised or subjected to another treatment suitable for their steel grade, if hot forming has not been carried out within an adequate temperature range.

d) Plates which have been previously butt-welded may be formed under the following conditions:

- Hot forming:

after forming, the welded joints are to be subjected to radiographic examination or equivalent. In addition, mechanical tests of a sample weld subjected to the same heat treatment are to be carried out.

- Cold forming

  cold forming is only allowed for plates having a thickness not exceeding:

  - 20 mm for steels having minimum ultimate tensile strength R_m between 360 N/mm^2 and 410 N/mm^2
  - 15 mm for steels having R_m between 460N/mm^2 and 510N/mm^2 as well as for steels 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo;

  cold forming is not allowed for steels 1Cr0,5Mo and 2,25Cr1Mo.

- Weld reinforcements are to be carefully ground smooth prior to forming.
- A proper heat treatment is to be carried out after forming, if the ratio of internal diameter to thickness is less than 36, for steels: 460 N/mm^2, 510 N/mm^2, 0,3Mo, 1Mn 0,5Mo, 1Mn 0,5MoV and 0,5Cr 0,5Mo.
- After forming, the joints are to be subjected to radiographic examination or equivalent and to a magnetic particle or liquid penetrant test.

4.2 Welding design

4.2.1 Main welded joints

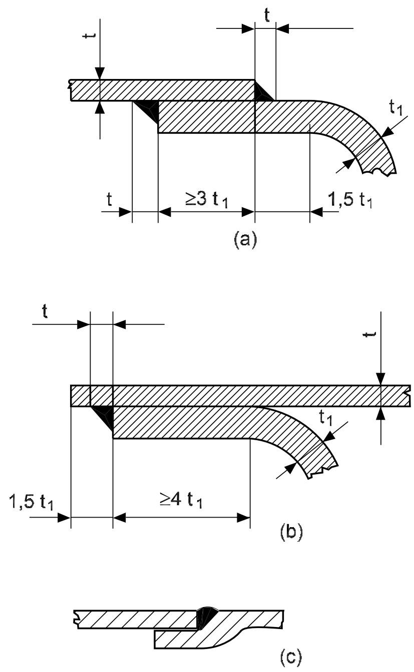
a) All joints of class 1 and 2 pressure parts of boilers and pressure vessels are to be butt-welded, with the exception of welding connecting flat heads or tube sheets to shells, for which partial penetration welds or fillet welds may be accepted.

b) Joints of class 3 pressure vessels are also subject to the requirement in a), however connection of dished heads to shells by lap welds may be accepted. Fig 2 shows some acceptable details of circumferential lap welds for class 3 pressure vessels.

4.2.2 Shell longitudinal and circumferential welds

Longitudinal and circumferential joints are to be welded from both sides of the plate. Welding from one side may be allowed only when there is evidence that the welding process permits a complete penetration and a sound weld root. If a backing strip is used, it is to be removed after welding and prior to any non-destructive examination. However, the backing strip may be retained in circumferential joints of class 2 vessels, having a thickness not exceeding 15 mm, and of class 3 vessels, provided that the material of the backing strip is such as not to adversely affect the weld.

Figure 2 : Example of acceptable lap-joints



Details (b) and (c) may be used only for pressure vessels having internal diameter less than 600mm.

4.2.3 Plates of unequal thickness

a) If plates of unequal thickness are butt-welded and the difference between thicknesses is more than 3 mm, the thicker plate is to be smoothly tapered for a length equal to at least four times the offset, including the width of the weld. For longitudinal joints the tapering is to be made symmetrically on both sides of the plate in order to obtain alignment of middle lines.

b) If the joint is to undergo radiographic examination, the thickness of the thicker plate is to be reduced to that of the thinner plate next to the joint and for a length of at least 30 mm.

4.2.4 Dished heads

a) For connection of a hemispherical end with a cylindrical shell, the joint is to be arranged in a plane parallel to that of the largest circle perpendicular to the axis of the shell and at such a distance from this plane that the tapering of the shell made as indicated in [4.2.3] is wholly in the hemisphere.

b) For torispherical ends made of parts assembled by welding, no welded joint is normally admitted along a parallel in the knuckle nor at a distance less than 50 mm from the beginning of the knuckle.

4.2.5 Welding location

The location of main welded joints is to be chosen so that these joints are not submitted to appreciable bending stresses.

4.2.6 Accessories and nozzles

a) Attachment of accessories by welds crossing main welds or located near such welds is to be avoided;

where this is impracticable, welds for attachment of accessories are to completely cross the main welds rather than stop abruptly on or near them.

b) Openings crossing main joints or located near main joints are also to be avoided as far as possible.

c) Doubling plates for attachment of accessories such as fixing lugs or supports are to be of sufficient size to ensure an adequate distribution of loads on pressure parts; such doubling plates are to have well rounded corners. Attachment of accessories such as ladders and platforms directly on the walls of vessels such that they restrain their free contraction or expansion is to be avoided.

d) Welded connections of nozzles and other fittings, either with or without local compensation, are to be of a suitable type, size and preparation in accordance with the approved plans.

4.2.7 Connections of stays to tube plates

a) Where stays are welded, the cross-sectional area of the weld is to be at least 1,25 times the cross-section of the stay.

b) The cross-sectional area of the end welding of welded stay tubes is to be not less than 1,25 times the cross-sectional area of the stay tube.

4.2.8 Type of weldings

For the type and size of welding, reference is to be made to the "Rules for the Classification of Ships".

4.3 Miscellaneous requirements for fabrication and welding

4.3.1 Welding position

a) As far as possible, welding is to be carried out in the downhand horizontal position and arrangements are to be foreseen so that this can be applied in the case of circumferential joints.

b) When welding cannot be performed in this position, tests for qualification of the welding process and the welders are to take account thereof.

4.3.2 Cleaning of parts to be welded

a) Parts to be welded are, for a distance of at least 25mm from the welding edges, to be carefully cleaned in order to remove any foreign matter such as rust, scale, oil, grease and paint.

b) If the weld metal is to be deposited on a previously welded surface, all slag or oxide is to be removed to prevent inclusions.

4.3.3 Protection against adverse weather conditions

a) Welding of pressure vessels is to be done in a sheltered position free from draughts and protected from cold and rain.

b) Unless special justification is provided, no welding is to be performed if the temperature of the base metal is less than 0°C.

4.3.4 Interruption in welding

If, for any reason, welding is stopped, care is to be taken on restarting to obtain a complete fusion.

4.3.5 Backing weld

When a backing weld is foreseen, it is to be carried out after suitable chiseling or chipping at the root of the first weld, unless the welding process applied does not call for such an operation.

4.3.6 Appearance of welded joints

a) Welded joints are to have a smooth surface without under-thickness; their connection with the plate surface is to be gradual without undercutting or similar defects.

b) The weld reinforcement of butt welds, on each side of the plate, is not to exceed the following thickness:
   - 2,5mm for plates having a thickness not exceeding 12mm
   - 3mm for plates having a thickness greater than 12mm but less than 25mm
   - 5mm for plates having a thickness at least equal to 25mm.

4.4 Preparation of parts to be welded

4.4.1 Preparation of edges for welding

a) Grooves and other preparations of edges for welding are to be made by machining, chipping or grinding. Flame cutting may also be used provided that the zones damaged by this operation are removed by machining, chipping or grinding. For alloy steel plates, preheating is to be provided, if needed, for flame cutting.

b) Edges prepared are to be carefully examined to check that there are no defects detrimental to welding.

4.4.2 Abutting of parts to be welded

a) Abutting of parts to be welded is to be such that surface misalignment of plates does not exceed:
   - 10% of the thickness of the plate with a maximum of 3 mm for longitudinal joints
   - 10% of the thickness of the plate plus 1 mm with a maximum of 4 mm for circumferential joints.

b) For longitudinal joints, middle lines are to be in alignment within 10% of the thickness of the thinner plate with a maximum of 3 mm.

c) Plates to be welded are to be suitably retained in position in order to limit deformation during welding. The arrangements are to be such as to avoid modification of the relative position of parts to be welded and misalignment, after welding, exceeding the limits indicated above.

d) Temporary welds for abutting are to be carried out so that there is no risk of damage to vessel shells. Such welds are to be carefully removed after welding of the vessel and before any heat treatment. Non-destructive testing of the corresponding zones of the shell may be required by the Surveyor if considered necessary.

e) Accessories such as doubling plates, brackets and stiffeners are to be suitable for the surface to which they are to be attached.

4.5 Tolerances after construction

4.5.1 General

The sizes and shape of vessels are to be checked after welding for compliance with the design taking into account the tolerances given below. The Society reserves the right to stipulate smaller values for these tolerances for vessels subjected to special loads.

Any defect in shape is to be gradual and there is to be no flat area in way of welded joints.

Measurements are to be taken on the surface of the parent plate and not on the weld or other raised part.

4.5.2 Straightness

The straightness of cylindrical shells is to be such that their deviation from the straight line does not exceed 0,6% of their length, with a maximum of 15 mm for each 5 m of length.

4.5.3 Out-of-roundness

a) Out-of-roundness of cylindrical shells is to be measured either when set up on end or when laid flat on their sides; in the second case, measures of diameters are to be repeated after turning the shell through 90° about its axis and out-of-roundness is to be calculated from the average of the two measures of each diameter.

b) For any transverse section, the difference between the maximum and minimum diameters is not to exceed 1% of the nominal diameter D with a maximum of:

   (D + 1250) / 200, D being expressed in mm.

   For large pressure vessels, this limit may be increased by a maximum of 0,2% of the internal diameter of the vessel. Any possible out-of-roundness within the above limit is to be gradual and there are to be no localised deformations in way of the welded joints.

4.5.4 Irregularities

Irregularities in profile of cylindrical shells, checked by a 20° gauge, are not to exceed 5% of the thickness of the plate plus 3 mm. This value may be increased by 25% if the length of the irregularity does not exceed one quarter of the distance between two circumferential seams, with a maximum of 1 mm.

5 Design and construction - Control and monitoring

5.1 Boiler control and monitoring system

5.1.1 Local control and monitoring

Means to effectively operate, control and monitor the operation of oil fired boilers and their associated auxiliaries are to be provided locally. The functional condition of the fuel, feed water and steam systems and the boiler operational status are to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.1.2 Emergency shut-off

Means are to be provided to shut down boiler forced draft or induced draft fans and fuel oil service pumps from outside the space where they are located, in the event that a fire in that space makes their local shut-off impossible.

5.1.3 Water level indicators

a) Each boiler is to be fitted with at least two separate means for indicating the water level. One of these means is to be a level indicator with transparent element. The other may be either an additional level indicator with transparent element or an equivalent device. Level indicators are to be of an approved type.

b) The transparent element of level indicators is to be made of glass, mica or other appropriate material.

c) Level indicators are to be located so that the water level is readily visible at all times. The lower part of the transparent element is not to be below the safety water level defined by the builder.

d) Level indicators are to be fitted either with normally closed isolating cocks, operable from a position free from any danger in case of rupture of the transparent element or with self-closing valves restricting the steam release in case of rupture of this element.

5.1.4 Water level indicators - Special requirements for water tube boilers

a) For water tube boilers having an athwarships steam drum more than 4 m in length, a level indicator is to be fitted at each end of the drum.

b) Water tube boilers serving turbine propulsion machinery shall be fitted with a high-water-level audible and visual alarm (see also Tab 11).

5.1.5 Water level indicators - Special requirements for fire tube boilers (vertical and cylindrical boilers)

a) For cylindrical boilers, the two water level indicators mentioned in [5.1.3] are to be distributed at each end of the boiler; i.e. double front cylindrical boilers are to have two level indicators on each front.

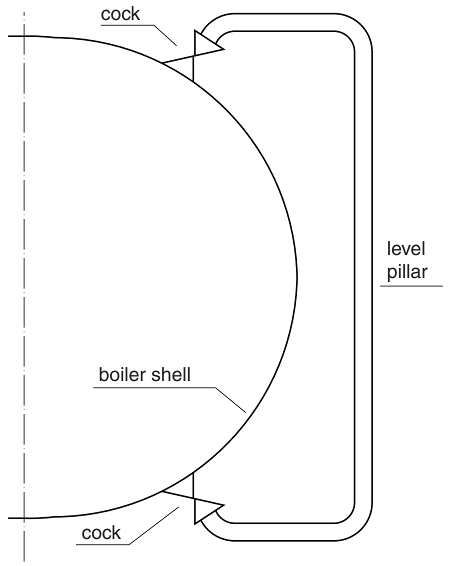
b) A system of at least two suitably located and remote controlled gauge-cocks may be considered as the equivalent device mentioned in [5.1.3] for cylindrical boilers having a design pressure lower than 1 MPa, for cylindrical boilers having a diameter lower than 2 m and for vertical boilers having height lower than 2,3 m. Gauge-cocks are to be fixed directly on the boiler shell.

c) Where level indicators are not fixed directly on the boiler shell, but on level pillars, the internal diameter of such pillars is not to be less than the value d_N given in Tab 10. Level pillars are to be either fixed directly on the boiler shell or connected to the boiler by pipes fitted with cocks secured directly to the boiler shell. The internal diameter of these pipes d_C is not to be less than the values given in Tab 10. The upper part of these pipes is to be arranged so that there is no bend where condense water can accumulate. These pipes are not to pass through smoke boxes or uptakes unless they are located inside metallic ducts having internal diameter exceeding by not less than 100 mm the external diameter of the pipes. Fig 3 shows the sketch of a level pillar arrangement.

Table 10 : Minimum internal diameters d_N and d_C

Internal diameter of the boiler	d_N (mm)	d_C (mm)
D > 3 m	60	38
2,30 m ≤ D ≤ 3 m	50	32
D < 2,30 m	45	26

Figure 3 : Level pillar arrangement



5.1.6 Pressure control devices

a) Each boiler is to be fitted with a steam pressure gauge so arranged that its indications are easily visible from the stokehold floor. A steam pressure gauge is also to be provided for superheaters which can be shut off from the boiler they serve.

b) Pressure gauges are to be graduated in units of effective pressure and are to include a prominent legible mark for the pressure that is not to be exceeded in normal service.

c) Each pressure gauge is to be fitted with an isolating cock.

d) Double front boilers are to have a steam pressure gauge arranged in each front.

5.1.7 Temperature control devices

Each boiler fitted with a superheater is to have an indicator or recorder for the steam temperature at the superheater outlet.

5.1.8 Automatic shut-off of oil fired propulsion and auxiliary boilers

a) Each burner is to be fitted with a flame scanner designed to automatically shut off the fuel supply to the burner in the event of flame failure. In the case of failure of the flame scanner, the fuel to the burner is to be shut off automatically.

b) A low water condition is to automatically shut off the fuel supply to the burners. The shut-off is to operate before the water level reaches a level so low as to affect the safety of the boiler and no longer be visible in the gauge glass. Means are to be provided to minimise the risk of shut-off provoked by the effect of roll and pitch and/or transients. This shut-off system need not be installed in auxiliary boilers which are under local supervision and are not intended for automatic operation.

c) Forced draft failure is to automatically shut off the fuel supply to the burners.

d) Loss of boiler control power is to automatically shut off the fuel supply to the burners.

5.1.9 Alarms

Any actuation of the fuel-oil shut-off listed in [5.1.8] is to operate a visual and audible alarm.

5.1.10 Additional requirements for boilers fitted with automatic control systems

a) The flame scanner required in [5.1.8] a) is to operate within 6 seconds from the flame failure.

b) A timed boiler purge with all air registers open is to be initiated manually or automatically when boilers are fitted with an automatic ignition system. The purge time is based on a minimum of 4 air changes of the combustion chamber and furnace passes. Forced draft fans are to be operating and air registers and dampers are to be open before the purge time commences.

c) Means are to be provided to bypass the flame scanner control system temporarily during a trial-for-ignition for a period of 15 seconds from the time the fuel reaches the burners. Except for this trial-for-ignition period, no means are to be provided to bypass one or more of the burner flame scanner systems unless the boiler is locally controlled.

d) Where boilers are fitted with an automatic ignition system, and where residual fuel oil is used, means are to be provided for lighting of burners with igniters lighting properly heated residual fuel oil. In the case of flame failure, the burner is to be brought back into automatic service only in the low-firing position.

e) An alarm is to be activated whenever a burner operates outside the limit conditions stated by the manufacturer.

f) Immediately after normal shutdown, an automatic purge of the boiler equal to the volume and duration of the pre-purge is to occur. Following automatic fuel valve shut-off, the air flow to the boiler is not to automatically increase; post-purge in such cases is to be carried out under manual control.

5.2 Pressure vessel instrumentation

5.2.1

a) Pressure vessels are to be fitted with the necessary devices for checking pressure, temperature and level, where it is deemed necessary.

b) In particular, each air pressure vessel is to be fitted with a local manometer.

5.3 Thermal oil heater control and monitoring

5.3.1 Local control and monitoring

Suitable means to effectively operate, control and monitor the operation of oil fired thermal oil heaters and their associated auxiliaries are to be provided locally. The functional condition of the fuel, thermal oil circulation, forced draft and flue gas systems is to be indicated by pressure gauges, temperature indicators, flow-meter, lights or other similar devices.

5.3.2 Flow control and monitoring

a) A flow indicator of the thermal oil is to be provided.

b) Oil fired or exhaust gas heaters are to be provided with a flow monitor limit-switch. If the flow rate falls below a minimum value the firing system is to be switched off and interlocked.

5.3.3 Manual control

At least the temperature control device on the oil side and flow monitoring are to remain operative in manual operation.

5.3.4 Leakage monitoring

Oil tanks are to be equipped with a leakage detector which, when actuated, shuts down and interlocks the thermal oil firing system. If the oil fired heater is on standby, the starting of the burner is to be blocked if the leakage detector is actuated.

5.4 Control and monitoring

5.4.1 Tab 11, Tab 12, Tab 13 and Tab 14 summarise the control and monitoring requirements for main propulsion boilers, auxiliary boilers, oil fired thermal oil heaters and exhaust gas thermal oil heaters and incinerators, respectively.

Note 1: Some departures from Tab 11, Tab 12, Tab 13 and Tab 14 may be accepted by the Society in the case of ships with a restricted navigation notation.

6 Arrangement and installation

6.1 Foundations

6.1.1 For boilers and pressure vessels bolting down to their foundations, see Sec 1, [3.3.1]. Where necessary, they are also to be secured to the adjacent hull structures by suitable ties.

Where chocks are required to be fitted between the boilers and their foundations, they are to be of cast iron or steel.

6.2 Boilers

6.2.1 Thermal expansion

Means are to be provided to compensate thermal expansion of boilers.

6.2.2 Minimum distance of boilers from vertical bulkheads and fuel tanks

a) The distance between boilers and vertical bulkheads is to be not less than the minimum distance necessary to provide access for inspection and maintenance of the structure adjacent to the boiler.

b) In addition to the requirement in a), the distance of boilers from fuel oil tanks is to be such as to prevent the possibility that the temperature of the tank bulkhead may approach the flash point of the oil.

c) In any event, the distance between a boiler and a vertical bulkhead is not to be less than 450 mm.

Table 11 : Main propulsion boilers

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Boiler			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil							
• Fuel oil delivery pressure or flow	L						
• Fuel oil temperature after heater or viscosity fault	L+H	local					
• Master fuel oil valve position (open / close)		local					
• Fuel oil input burner valve position (open / close)		local					
Combustion							
• Flame failure of each burner	X						
• Failure of atomizing fluid	X						
• Boiler casing and economizer outlet smoke temperature (in order to detect possible fire out-break)	H						
	HH			X			
Air							
• Air register position		local					
General steam							
• Superheated steam pressure	L+H	local					
					X		
• Superheated steam temperature	H	local					
• Lifting of safety valve (or equivalent: high pressure alarm for instance)	X						
• Water level inside the drum of each boiler	L+H	local **(1)**					
	LL			X			
					X		
(1) Duplication of level indicator is required							

Table 12 : Auxiliary boilers

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Boiler			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Stand by Start	Stop
Water level	L+H	local					
	LL			X			
Circulation stopped (when forced circulation boiler)	X			X			
Fuel oil temperature or viscosity **(2)**	L+H	local					
Flame failure	X			X			
Temperature in boiler casing (Fire)	H						
Steam pressure	H **(1)**	local		X			
(1) When the automatic control does not cover the entire load range from zero load **(2)** Where heavy fuel is used							

Table 13 : Thermal oil system

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Stand by Start	Stop
Thermal fluid temperature heater outlet	H	local		X			
Thermal fluid pressure pump discharge	H	local		X			
Thermal fluid flow through each heating element	L	local		X			
Expansion tank level	L	local		X **(1)**			
Expansion tank temperature	H						
Forced draft fan stopped	X			X			
Heavy fuel oil temperature or viscosity	H+L	local					
Burner flame failure	X			X			
Flue gas temperature heater inlet (When exhaust gas heater)	H			X **(2)**			

(1) Stop of burner and fluid flow
(2) Stop of the flue gas only

Table 14 : Incinerators

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Incinerator			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Stand by Start	Stop
Flame failure	X			X			
Furnace temperature	H			X			
Exhaust gas temperature	H						
Fuel oil pressure		local					
Fuel oil temperature or viscosity **(1)**	H+L	local					

(1) Where heavy fuel is used

6.2.3 Minimum distance of boilers from double bottom

a) Where double bottoms in way of boilers may be used to carry fuel oil, the distance between the top of the double bottom and the lower metal parts of the boilers is not to be less than:
   - 600 mm, for cylindrical boilers
   - 750 mm, for water tube boilers.

b) The minimum distance of vertical tube boilers from double bottoms not intended to carry oil may be 200 mm.

6.2.4 Minimum distance of boilers from ceilings

a) A space sufficient for adequate heat dissipation is to be provided on the top of boilers.

b) Oil tanks are not permitted to be installed in spaces above boilers.

6.2.5 Installation of boilers on engine room flats

Where boilers are installed on an engine room flat and are not separated from the remaining space by means of a watertight bulkhead, a coaming of at least 200 mm in height is to be provided on the flat. The area surrounded by the coaming may be drained into the bilge.

6.2.6 Drip trays and gutterways

Boilers are to be fitted with drip trays and gutterways in way of burners so arranged as to prevent spilling of oil into the bilge.

6.2.7 Hot surfaces

Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Ch 1, Sec 1, [3.7.1].

6.2.8 Registers fitted in the smoke stacks of oil fired boilers

Where registers are fitted in smoke stacks, they are not to obstruct more than two thirds of the cross-sectional area of gas passage when closed. In addition, they are to be provided with means for locking them in open position when the boiler is in operation and for indicating their position and degree of opening.

6.3 Pressure vessels

6.3.1 Safety devices on multiple pressure vessels

Where two or more pressure vessels are interconnected by a piping system of adequate size so that no branch of piping may be shut off, it is sufficient to provide them with one safety valve and one pressure gauge only.

6.4 Thermal oil heaters

6.4.1 In general, the requirements of [6.2] for boilers are also applicable to thermal oil heaters.

7 Material test, workshop inspection and testing, certification

7.1 Material testing

7.1.1 General

Materials, including welding consumables, for the constructions of boilers and pressure vessels are to be certified by the material manufacturer in accordance with the appropriate material specification.

7.1.2 Boilers, other steam generators, and oil fired and exhaust gas thermal oil heaters

In addition to the requirement in [7.1.1], testing of materials intended for the construction of pressure parts of boilers, other steam generators, oil fired thermal oil heaters and exhaust gas thermal oil heaters is to be witnessed by the Surveyor.

7.1.3 Class 1 pressure vessels and heat exchangers

In addition to the requirement in [7.1.1], testing of materials intended for the construction of pressure parts of class 1 pressure vessels and heat exchangers is to be witnessed by the Surveyor.

This requirement may be waived at the Society’s discretion for mass produced small pressure vessels (such as accumulators for valve controls, gas bottles, etc.).

7.2 Workshop inspections

7.2.1 Boilers and individually produced class 1 and 2 pressure vessels

The construction, fitting and testing of boilers and individually produced class 1 and 2 pressure vessels are to be attended by the Surveyor, at the builder's facility.

7.2.2 Mass produced pressure vessels

Construction of mass produced pressure vessels which are type approved by the Society need not be attended by the Surveyor.

7.3 Hydrostatic tests

7.3.1 General

Hydrostatic tests of all class 1, 2 and 3 pressure vessels are to be witnessed by the Surveyor with the exception of mass produced pressure vessels which are built under the conditions stated in [7.2.2].

7.3.2 Testing pressure

a) Upon completion, pressure parts of boilers and pressure vessels are to be subjected to a hydraulic test under a pressure p_t defined below as a function of the design pressure p:
   - p_t = 1,5 p where $p \le 4$ MPa
   - p_t = 1,4 p + 0,4 where 4 MPa $< p \le 25$ MPa
   - P_t = p + 10,4 where $p > 25$ MPa

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

c) If the design temperature exceeds 300°C, the test pressure p_t is to be as determined by the following formula:

$$p_t = 1{,}5 \cdot \frac{K_{100}}{K} \cdot p$$

where:

p : Design pressure, in MPa

K_{100} : Permissible stress at 100°C, in N/mm^2

K : Permissible stress at the design temperature, in N/mm^2

d) Consideration is to be given to the reduction of the test pressure below the values stated above where it is necessary to avoid excessive stress. In any event, the general membrane stress is not to exceed 90% of the yield stress at the test temperature.

e) Economisers which cannot be shut off from the boiler in any working condition are to be submitted to a hydraulic test under the same conditions as the boilers.

f) Economisers which can be shut off from the boiler are to be submitted to a hydraulic test at a pressure determined as a function of their actual design pressure p.

7.3.3 Hydraulic test of boiler and pressure vessel accessories

a) Boilers and pressure vessel accessories are to be tested at a pressure p_t which is not less than 1,5 times the design pressure p of the vessels to which they are attached.

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

7.3.4 Hydraulic test procedure

a) The hydraulic test specified in [7.3.1] is to be carried out after all openings have been cut out and after execution of all welding work and of the heat treatment, if any. The vessel to be tested is to be presented without lagging, paint or any other lining and the pressure is to be maintained long enough for the Surveyor to proceed with a complete examination.

b) Hydraulic tests of boilers are to be carried out either after installation on board, or at the manufacturer's plant. Where a boiler is hydrotested before installation on board, the Surveyor may, if deemed necessary, request to proceed with a second hydraulic test on board under a pressure at least equal to 1,1 p. For this test, the boiler may be fitted with its lagging. However, the Surveyor may require this lagging to be partially or entirely removed as necessary.

c) For water tube boilers, the hydraulic test may also be carried out separately for different parts of the boiler upon their completion and after heat treatment. For drums and headers, this test may be carried out before drilling the tube holes, but after welding of all appendices and heat treatment. When all parts of the boiler have been separately tested and following assembly the boiler is to undergo a hydraulic test under a pressure of 1,25 p.

7.3.5 Hydraulic tests of condensers

Condensers are to be subjected to a hydrostatic test at the following test pressures:

- Steam space: 0,1 MPa
- Water space: maximum pressure which may be developed by the pump with closed discharge valve increased by 0,07 MPa. However, the test pressure is not to be less than 0,2 MPa. When the characteristics of the pump are not known, the hydrostatic test is to be carried out at a pressure not less than 0,35 MPa.

7.4 Certification

7.4.1 Certification of boilers and individually produced pressure vessels

Boilers and individually produced pressure vessels of classes 1 and 2 are to be certified by the Society in accordance with the procedures stated in Part D.

7.4.2 Mass produced pressure vessels

Small mass produced pressure vessels of classes 1 and 2 may be accepted provided they are type approved by the Society in accordance with the procedures stated in Part A.

7.4.3 Pressure vessels not required to be certified

The Manufacturer's certificate, including detail of tests and inspections, is to be submitted to the Society for pressure vessels not required to be certified by the Society. The Society reserves the right to require confirmatory hydrostatic tests in the presence of the Surveyor on a case by case basis, based on the criticality and service of the pressure vessel.

SECTION 4 GEARING

1 General

1.1 Application

1.1.1 Unless otherwise specified, the requirements of this section apply to:

- reduction and/or reverse gears intended for propulsion plants with a transmitted power of 220 kW and above
- other reduction and step-up gears with a transmitted power of 110 kW and above, intended for essential service auxiliary machinery.

All other gears are to be designed and constructed according to sound marine practice and delivered with the relevant works' certificate (see Pt D, Ch 1, Sec 1, [4.2.3]).

The provisions of [2] apply only to cylindrical involute spur or helical gears with external or internal teeth.

Some departure from the requirements of this Section may be accepted by the Society in cases of gears fitted to ships having a restricted navigation notation.

Alternative calculations based on a recognized standard may be submitted by the manufacturer of the gears and will be given special consideration by the Society.

1.2 Documentation to be submitted

1.2.1 Documents

Before starting construction, all plans, specifications and calculations listed in Tab 1 are to be submitted to the Society.

Table 1 : Documents to be submitted for gearing

No.	I/A **(1)**	Document **(2)**
1	A	Constructional drawings of shafts and flanges
2	A	Constructional drawings of pinions and wheels, including: a) specification and details of hardening procedure: • core and surface mechanical characteristics • diagram of the depth of the hardened layer as a function of hardness values b) specification and details of the finishing procedure: • finishing method of tooth flanks (hobbing, shaving, lapping, grinding, shot-peening) • surface roughness for tooth flank and root fillet • tooth flank corrections (helix modification, crowning, tip-relief, end-relief), if any • grade of accuracy according to ISO 1328-1 1997
3	A	Shrinkage calculation for shrunk-on pinions, wheels rims and/or hubs with indication of the minimum and maximum shrinkage allowances
4	A	Calculation of load capacity of the gears
5	A / I **(3)**	Constructional drawings of casings
6	A	Functional diagram of the lubricating system, with indication of: • specified grade of lubricating oil • expected oil temperature in service • kinematic viscosity of the oil
7	A	Functional diagram of control, monitoring and safety systems
8	I	Longitudinal and transverse cross-sectional assembly of the gearing, with indication of the type of clutch

(1) A = to be submitted for approval, in four copies
I = to be submitted for information, in duplicate.
(2) Constructional drawings are to be accompanied by the specification of the materials employed including the chemical composition, heat treatment and mechanical properties and, where applicable, the welding details, welding procedure and stress relieving procedure.
(3) "A" for welded casing, "I" otherwise

1.2.2 Data

The data listed in Tab 2 are to be submitted with the documents required in [1.2.1].

Table 2 : Data to be submitted for gearing

No.	Description of the data
1	Type of driving and driven machines and, if provided, type of flexible coupling
2	Maximum power transmitted by each pinion in continuous running and corresponding rotational speed, for all operating conditions, including clutching-in
3	Modules of teeth for pinion and wheels
4	Pressure angle and helix angle
5	Tooth profiles of pinions and wheels together with tip diameters and fillet radii
6	Operating centre distance
7	Addendum of the cutting tool
8	Common face width, operating pitch diameter
9	Data related to the bearings: • type, characteristics and designed service life of roller bearings • materials and clearances of plain bearings • position of each gear in relation to its bearings
10	Torsional vibration data (inertia and stiffness)

2 Design of gears - Determination of the load capacity

2.1 Symbols, units, definitions

2.1.1 Symbols and units

The meaning of the main symbols used in this Section is specified below.

Other symbols introduced in connection with the definition of influence factors are defined in the appropriate articles.

- a : Operating centre distance, in mm
- b : Common face width (for double helix gear, width of one helix), in mm
- d : Reference diameter, in mm
- d_a : Tip diameter, in mm
- d_b : Base diameter, in mm
- d_f : Root diameter, in mm
- d_w : Working pitch diameter, in mm
- x : Addendum modification coefficient
- z : Number of teeth
- z_n : Virtual number of teeth
- n : Rotational speed, in rpm
- U : Reduction ratio
- m_n : Normal module, in mm
- h : Tooth depth, in mm
- α_{Fen} : Load direction angle, relevant to direction of application of load at the outer point of single pair tooth contact of virtual spur gear, in rad
- α_n : Normal pressure angle at reference cylinder, in rad
- α_t : Transverse pressure angle at reference cylinder, in rad
- α_{tw} : Transverse pressure angle at working pitch cylinder, in rad
- β : Helix angle at reference cylinder, in rad
- β_b : Base helix angle, in rad.
- ε_α : Transverse contact ratio
- ε_β : Overlap ratio
- ε_γ : Total contact ratio
- ρ_{ao} : Tip radius of the tool,
- ρ_F : Tooth root radius at the critical section, in mm
- h_{Fe} : Bending moment relevant to the load application at the outer point of single pair tooth contact, in mm
- h_{fp} : Basic rack dedendum, in mm
- s_{Fn} : Tooth root chord at critical section, in mm
- χ_B : Running-in factor (mesh misalignment)
- Q : Gearing quality class according to ISO 1328-1 1997
- HB : Brinell Hardness
- HV : Vickers hardness
- R : Minimum tensile strength of gear material, in N/mm^2
- $R_{z(f)}$: Mean flank peak-to-valley roughness, in µm
- $R_{z(r)}$: Mean root peak-to-valley roughness, in µm
- F_t : Nominal tangential load, in N
- σ_F : Tooth root bending stress, in N/mm^2
- σ_{FE} : Endurance limit for tooth root bending stress, in N/mm^2
- σ_{FP} : Permissible tooth root bending stress, in N/mm^2
- σ_H : Contact stress (Hertzian pressure), in N/mm^2
- $\sigma_{H,lim}$: Endurance limit for contact stress (Hertzian pressure), in N/mm^2
- σ_{HP} : Permissible contact stress (Hertzian pressure), in N/mm^2
- v : Linear speed at working pitch diameter, in m/s

Subscripts:

- 1 for pinion, i.e. the gear having the smaller number of teeth
- 2 for wheel.

2.1.2 Geometrical definitions

In the calculation of surface durability, b is the common face width on the working pitch diameter.

In tooth strength calculations, b_1, b_2 are the face widths at the respective tooth roots. In any case b_1 and b_2 are not to be taken as greater than b by more than one module (m_n) on either side

For internal gears, z_2 , a, d_2 , d_{a2} , d_{b2} and d_{w2} are to be taken negative.

$$u = \frac{z_2}{z_1}$$

Note 1: u > 0 for external gears, u < 0 for internal gears.

$$\tan\alpha_t = \frac{\tan\alpha_n}{\cos\beta}$$

$$d = \frac{z \cdot m_n}{\cos\beta}$$

$$d_b = d \cdot \cos\alpha_t$$

$$\cos\alpha_{tw} = \frac{d_{b1} + d_{b2}}{2a}$$

$$\tan\beta_b = \tan\beta \cdot \cos\alpha_t$$

$$\text{inv}\ \alpha = \tan\alpha - \alpha$$

for external gears:

$$\varepsilon_\alpha = \frac{0{,}5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} + 0{,}5 \cdot (d_{a2}^2 - d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\frac{\pi \cdot m_n \cdot \cos\alpha_t}{\cos\beta}}$$

for internal gears:

$$\varepsilon_\alpha = \frac{0{,}5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} - 0{,}5 \cdot (d_{a2}^2 + d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\frac{\pi \cdot m_n \cdot \cos\alpha_t}{\cos\beta}}$$

$$\varepsilon_\beta = \frac{b \cdot \sin\beta}{\pi \cdot m_n}$$

$$\varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta$$

2.2 Principle

2.2.1

a) The following requirements apply to cylindrical involute spur or helical gears with external or internal teeth, and provide a method for the calculation of the load capacity with regard to:

- the surface durability (contact stress), and
- the tooth root bending stress.

The relevant formulae are provided in [2.4] and [2.5].

The influence factors common to the formuale are given in [2.3].

b) Gears for which the conditions of validity of some factors or formulae are not satisfied will be given special consideration by the Society.

c) Other methods of determination of load capacity will be given special consideration by the Society.

d) Load capacity is to be calculated according to this Section. Calculation according to the standards ISO 6336, 9083 and 10300 may be considered.

2.3 General influence factors

2.3.1 General

General influence factors are defined in [2.3.2], [2.3.3], [2.3.4], [2.3.5], [2.3.6] and [2.3.7]. Alternative values may be used provided they are derived from appropriate measurements.

2.3.2 Application factor K_A

The application factor K_A accounts for dynamic overloads from sources external to the gearing.

The values of K_A are given in Tab 3.

Table 3 : Values of K_A

Type of installation			K_A
Main gears (propulsion)	Diesel engine	with hydraulic coupling	1,00
		with elastic coupling	1,30
		with other type of coupling	1,50
	Turbine		1,00
	Electric motor		1,00
Auxiliary gears	Diesel engine	with hydraulic coupling	1,00
		with elastic coupling	1,20
		with other type of coupling	1,40
	Electric motor		1,00

2.3.3 Load sharing factor K_γ

The load sharing factor K_γ accounts for the uneven sharing of load on multiple path transmissions, such as epicyclic gears or tandem gears.

The values of K_γ are given in Tab 4.

Table 4 : Values of K_γ

Type of gear		K_γ
Dual tandem gear	without quill shaft **(1)**	1,15
	with quill shaft **(1)**	1,10
Epicyclic gear	with 3 planetary gears and less	1,00
	with 4 planetary gears	1,20
	with 5 planetary gears	1,30
	with 6 planetary gears and more	1,40

(1) A quill shaft is a torsionally flexible shaft intended for improving the load distribution between the gears.

2.3.4 Dynamic factor K_V

The dynamic factor K_V accounts for the additional internal dynamic loads acting on the tooth flanks and due to the vibrations of pinion and wheel.

The values of K_V are given in Tab 5. They apply only to steel gears of heavy rim sections with:

$$\frac{F_t}{b} > 150$$

$$z_1 < 50$$

Table 5 : Values of K_V

<table>
<tr><td>Type of gear</td><td colspan="3">K_V</td><td>Limitations</td></tr>
<tr><td>Spur gear</td><td colspan="3">$K_V = K_{V2}$ with: $K_{V2} = 1 + K_1 \cdot \frac{v \cdot z_1}{100}$
where K_1 has the values specified in Tab 6</td><td>$\frac{v \cdot z_1}{100} < 10$</td></tr>
<tr><td rowspan="2">Helical gear</td><td>• if $\varepsilon_\beta \geq 1$:</td><td>$K_V = K_{V1}$ with:</td><td>$K_{V1} = 1 + K_1 \cdot \frac{v \cdot z_1}{100}$
where K_1 has the values specified inTab 6</td><td rowspan="2">$\frac{v \cdot z_1}{100} < 14$</td></tr>
<tr><td>• if $\varepsilon_\beta < 1$:</td><td colspan="2">$K_V = K_{V2} - \varepsilon_\beta \cdot (K_{V2} - K_{V1})$
where K_{V2} is calculated as if the gear were of spur type</td></tr>
</table>

Table 6 : Values of K_1

	ISO grade of accuracy **(1)**					
Type of gear	3	4	5	6	7	8
Spur gear	0,022	0,030	0,043	0,062	0,092	0,125
Helical gear	0,0125	0,0165	0,0230	0,0330	0,0480	0,0700

(1) ISO grade of accuracy according to ISO 1328-1 1997. In case of mating gears with different grades of accuracy, the grade corresponding to the lower accuracy is to be used.

For gears not complying with the above given limitations or with the limitations given in Tab 5 the value of K_V shall be submitted by the manufacturer of the gears and will be given special consideration by the Society.

2.3.5 Face load distribution factors $K_{H\beta}$ and $K_{F\beta}$

a) The face load distribution factors, $K_{H\beta}$ for contact stress and $K_{F\beta}$ for tooth root bending stress, account for the effects of non-uniform distribution of load across the face width.

b) The values of $K_{H\beta}$ and $K_{F\beta}$ are to be determined according to method C2 of ISO 6336-1 and apply only to gears having:

- wheel, case, wheel shaft and bearings of stiff construction
- pinion on a solid or hollow shaft with an inner to outer diameter ratio not exceeding 0,5, and located symmetrically between the bearings
- no external loads acting on the pinion shaft.

$$K_{H\beta} = 1 + (F_{\beta y} \cdot C_\gamma \cdot b)/(2 \cdot F_m) \quad \text{for} \quad K_{H\beta} \leq 2$$

$$K_{H\beta} = \sqrt{2 \cdot F_{\beta y} \cdot C_\gamma \cdot b/F_m} \quad \text{for} \quad K_{H\beta} > 2$$

where:

$F_{\beta y}$ effective equivalent misalignment after running in, in µm;

C_γ: mesh stiffness, see [2.3.7];

F_m : mean transverse tangential load at the reference circle relevant to mesh calculation,

$$F_m = F_t \cdot K_A \cdot K_V$$

Note 1: For gears for which the above given conditions are not satisfied the value of $K_{H\beta}$ shall be submitted by the manufacturer of the gears and will be special consideration by the Society.

c) $K_{F\beta}$ is to be determined using the following formula:

$$K_{F\beta} = K_{H\beta}^{\frac{1}{1 + h/b + (h/b)^2}}$$

where b/h is the smaller of b_1/h_1 and b_2/h_2 but is not to be taken greater than 3.

In case of end relief or crowing: $K_{F\beta} = K_{H\beta}$

2.3.6 Transverse load distribution factors $K_{H\alpha}$ and $K_{F\alpha}$

The transverse load distribution factors, $K_{H\alpha}$ for contact stress, and $K_{F\alpha}$ for tooth root bending stress, account for the effects of pitch and profile errors on the transversal load distribution between two or more pairs of teeth in mesh.

The values of $K_{H\alpha}$ and $K_{F\alpha}$ are given inTab 7, complying with method B of ISO 6336-1.

2.3.7 Mesh stiffness c_γ

The value of the mesh stiffness c_γ shall be submitted by the manufacturer of the gears and will be given special consideration by the Society. Alternatively it will be assumed:

$$c_\gamma = 20 N/(mm \cdot \mu m)$$

Table 7 : Values of $K_{H\alpha}$ and $K_{F\alpha}$

Total contact ratio ε_γ	Transverse load distribution factors $K_{H\alpha}$ and $K_{F\alpha}$	Limitations
$\varepsilon_\gamma \le 2$	$K_{H\alpha} = K_{F\alpha} = \frac{\varepsilon_\gamma}{2} \cdot \left(0,9 + 0,4 \cdot \frac{c_\gamma \cdot b \cdot (f_{pb} - y_\alpha)}{F_{tH}}\right)$	$K_{H\alpha} = K_{F\alpha} \ge 1$ **(1)** $K_{H\alpha} \le \frac{\varepsilon_\gamma}{\varepsilon_\alpha \cdot Z_\varepsilon^2}$ **(2)** $K_{F\alpha} \le \frac{\varepsilon_\gamma}{\varepsilon_\alpha \cdot Y_\varepsilon}$ **(3)**
$\varepsilon_\gamma > 2$	$K_{H\alpha} = K_{F\alpha} = 0,9 + 0,4 \cdot \sqrt{\frac{2 \cdot (\varepsilon_\gamma - 1)}{\varepsilon_\gamma}} \cdot \frac{c_\gamma \cdot b \cdot (f_{pb} - y_\alpha)}{F_{tH}}$	
where: c_γ : Mesh stiffness, as defined in [2.3.7] f_{pb} : Maximum base pitch deviation of the wheel, in µm **(4)** y_α : Running-in allowance, in µm F_{tH} : determinant tangent load in a transverse plane, $F_{tH} = F_t \cdot K_A \cdot K_V \cdot K_{H\beta}$		
(1) Where $K_{H\alpha} = K_{F\alpha} < 1$, then take $K_{H\alpha} = K_{F\alpha} = 1$ **(2)** Where $K_{H\alpha} > \varepsilon_\gamma / (\varepsilon_\alpha . Z^2_\varepsilon)$, then take $K_{H\alpha} = \varepsilon_\gamma / (\varepsilon_\alpha . Z_\varepsilon^2)$ **(3)** Where $K_{F\alpha} > \varepsilon_\gamma / (\varepsilon_\alpha . Y_\varepsilon)$, then take $K_{F\alpha} = \varepsilon_\gamma / (\varepsilon_\alpha . Y_\varepsilon)$ **(4)** In cases of optimum profile correction, f_{pb} is to be replaced by f_{pb} / 2		

2.4 Calculation of surface durability

2.4.1 General

The criterion for surface durability is based on the contact stress (Hertzian pressure) on the pitch point or at the inner point of single pair contact.

The contact stress σ_H is not to exceed the permissible contact stress σ_{HP}.

2.4.2 Contact stress σ_H

The contact stress σ_H is to be determined as follows:

- for the pinion

$$\sigma_H = Z_B \cdot \sigma_{H0} \sqrt{K_A \cdot K_\gamma \cdot K_V \cdot K_{H\beta} \cdot K_{H\alpha}}$$

- for the wheel

$$\sigma_H = Z_D \cdot \sigma_{H0} \sqrt{K_A \cdot K_\gamma \cdot K_V \cdot K_{H\beta} \cdot K_{H\alpha}}$$

where:

σ_{H0} : calculated from the following formulae:

for external gears:

$$\sigma_{H0} = Z_H \cdot Z_E \cdot Z_\varepsilon \cdot Z_\beta \sqrt{\frac{F_t}{d_1 \cdot b} \cdot \frac{u+1}{u}}$$

for internal gears:

$$\sigma_{H0} = Z_H \cdot Z_E \cdot Z_\varepsilon \cdot Z_\beta \sqrt{\frac{F_t}{d_1 \cdot b} \cdot \frac{u-1}{u}}$$

K_A : Application factor (see [2.3.2]),

K_γ : Load sharing factor (see [2.3.3]),

K_V : Dynamic factor (see [2.3.4]),

$K_{H\beta}$: Face load distribution factors (see [2.3.5]),

$K_{H\alpha}$: Transverse load distribution factors (see [2.3.6]),

Z_B : Single pair mesh factor for pinion (see [2.4.4]),

Z_D : Single pair mesh factor for wheel (see [2.4.4]),

Z_H : Zone factor (see [2.4.5]),

Z_E : Elasticity factor (see [2.4.6]),

Z_ε : Contact ratio factor (see [2.4.7]),

Z_β : Helix angle factor (see [2.4.8]).

2.4.3 Permissible contact stress σ_{HP}

The permissible contact stress σ_{HP} is to be determined separately for pinion and wheel using the following formula:

$$\sigma_{HP} = \frac{\sigma_{H,lim}}{S_H} \cdot Z_L \cdot Z_V \cdot Z_R \cdot Z_W \cdot Z_X \cdot Z_N$$

where:

Z_L : Lubricant factor (see [2.4.9]),

Z_V : Speed factor (see [2.4.9]),

Z_R : Roughness factor (see [2.4.9]),

Z_W : Hardness ratio factor (see [2.4.10]),

Z_X : Size factor for contact stress (see [2.4.11]),

Z_N : Life factor for contact stress, assumed equal to Z_{NT} according to method B of ISO 6336-2, or assumed to be 1,

S_H : Safety factor for contact stress (see [2.4.12]).

2.4.4 Single pair mesh factors Z_B and Z_D

The single pair mesh factors Z_B for pinion and Z_D for wheel account for the influence on contact stresses of the tooth flank curvature at the inner point of single pair contact in relation to Z_H. These factors transform the contact stress determined at the pitch point to contact stresses considering the flank curvature at the inner point of single pair contact.

Z_B and Z_D are to be determined as follows:

a) for spur gears ($\varepsilon_\beta = 0$):

- $Z_B = M_1$ or 1, whichever is the greater, where

$$M_1 = \frac{\tan\alpha_{tw}}{\sqrt{\left[\sqrt{\left(\frac{d_{a1}}{d_{b1}}\right)^2 - 1} - \frac{2\pi}{z_1}\right] \cdot \left[\sqrt{\left(\frac{d_{a2}}{d_{b2}}\right)^2 - 1} - (\varepsilon_\alpha - 1)\frac{2\pi}{z_2}\right]}}$$

- $Z_D = M_2$ or 1, whichever is the greater, where

$$M_2 = \frac{\tan\alpha_{tw}}{\sqrt{\left[\sqrt{\left(\frac{d_{a2}}{d_{b2}}\right)^2 - 1} - \frac{2\pi}{z_2}\right] \cdot \left[\sqrt{\left(\frac{d_{a1}}{d_{b1}}\right)^2 - 1} - (\varepsilon_\alpha - 1)\frac{2\pi}{z_1}\right]}}$$

b) for helical gears:

- with $\varepsilon_\beta \geq 1$: $Z_B = Z_D = 1$.
- with $\varepsilon_\beta < 1$: Z_B and Z_D are to be determined by linear interpolation between:
  - Z_B and Z_D for spur gears, and
  - Z_B and Z_D for helical gears with $\varepsilon_\beta \geq 1$,

  thus
  - $Z_B = M_1 - \varepsilon_\beta (M_1 - 1)$ and $Z_B \geq 1$
  - $Z_D = M_2 - \varepsilon_\beta (M_2 - 1)$ and $Z_D \geq 1$

2.4.5 Zone factor Z_H

The zone factor Z_H accounts for the influence on the Hertzian pressure of tooth flank curvature at the pitch point and transforms the tangential force at the reference cylinder to normal force at the pitch cylinder.

Z_H is to be determined as follows:

$$Z_H = \sqrt{\frac{2 \cdot \cos\beta_b \cdot \cos\alpha_{tw}}{(\cos\alpha_t)^2 \cdot \sin\alpha_{tw}}}$$

2.4.6 Elasticity factor Z_E

The elasticity factor Z_E accounts for the influence of the metal properties (module of elasticity E and Poisson's ratio ν) on the Hertzian pressure.

For steel gears, $Z_E = 189{,}8\ N^{1/2}/mm$.

2.4.7 Contact ratio factor Z_ε

The contact ratio factor Z_ε accounts for the influence of the transverse contact ratio and the overlap ratio on the specific surface load of gears.

Z_ε is to be determined as follows:

a) for spur gears:

$$Z_\varepsilon = \sqrt{\frac{4 - \varepsilon_\alpha}{3}}$$

b) for helical gears:

- for $\varepsilon_\beta < 1$

$$Z_\varepsilon = \sqrt{\frac{4 - \varepsilon_\alpha}{3} \cdot (1 - \varepsilon_\beta) + \frac{\varepsilon_\beta}{\varepsilon_\alpha}}$$

- for $\varepsilon_\beta \geq 1$

$$Z_\varepsilon = \sqrt{\frac{1}{\varepsilon_\alpha}}$$

2.4.8 Helix angle factor Z_β

The helix angle factor Z_β accounts for the influence of helix angle on surface durability, allowing for such variables as the distribution of load along the lines of contact.

Z_β is to be determined as follows:

$$Z_\beta = \sqrt{\cos\beta}$$

2.4.9 Lubrication, speed and roughness factors Z_L, Z_V and Z_R

The lubricant factor Z_L accounts for the influence of the type of the lubricant and of its viscosity, the speed factor Z_V accounts for the influence of the pitch line velocity, and the roughness factor Z_R accounts for the influence of the surface roughness on the surface endurance capacity.

These factors are to be determined as follows:

a) Lubricant factor Z_L

$$Z_L = C_{ZL} + \frac{4 \cdot (1{,}0 - C_{ZL})}{\left(1{,}2 + \frac{134}{\nu_{40}}\right)^2}$$

where:

ν_{40} : nominal kinematic viscosity of the oil at 40°C, mm^2/s

C_{ZL} :
- for $\sigma_{H,lim} < 850\ N/mm^2$

  $C_{ZL} = 0{,}83$
- for $850\ N/mm^2 \leq \sigma_{H,lim} \leq 1200\ N/mm^2$

  $$C_{ZL} = \frac{\sigma_{H,lim}}{4375} + 0{,}6357$$
- for $\sigma_{H,lim} > 1200\ N/mm^2$

  $C_{ZL} = 0{,}91$

b) Speed factor Z_V

$$Z_V = C_{ZV} + \frac{2 \cdot (1{,}0 - C_{ZV})}{\sqrt{0{,}8 + \frac{32}{v}}}$$

where:

- for $\sigma_{H,lim} < 850\ N/mm^2$

  $C_{ZV} = 0{,}85$
- for $850\ N/mm^2 \leq \sigma_{H,lim} \leq 1200\ N/mm^2$

  $$C_{ZV} = \frac{\sigma_{H,lim}}{4375} + 0{,}6557$$
- for $\sigma_{H,lim} > 1200\ N/mm^2$

  $C_{ZV} = 0{,}93$

c) Roughness factor Z_R

$$Z_R = \left(\frac{3}{R_{Z10(f)}}\right)^{C_{ZR}}$$

where:

$R_{Z10(f)}$: Mean relative flank peak-to-valley roughness for the gear pair

$$R_{Z10(f)} = R_{Z(f)} \sqrt[3]{\frac{10}{\rho_{red}}}$$

$R_{Z(f)}$: Mean flank peak-to-valley roughness of the gear pair,

$$R_{Z(f)} = \frac{R_{Z(f)1} + R_{Z(f)2}}{2}$$

ρ_{red} : Relative radius of curvature, equal to:

$$\rho_{red} = \frac{\rho_1 \cdot \rho_2}{\rho_1 + \rho_2} \quad \text{with:}$$

$\rho_1 = 0{,}5 \cdot d_{b1} \cdot \tan\alpha_{tw}$

$\rho_2 = 0{,}5 \cdot d_{b2} \cdot \tan\alpha_{tw}$

d_b being taken negative for internal gears,

C_{ZR} : Coefficient having the following values:

- for $\sigma_{H,lim} < 850$ N/mm²
  $C_{ZR} = 0{,}15$
- for 850 N/mm² $\leq \sigma_{H,lim} \leq$ 1200 N/mm²
  $$C_{ZR} = 0{,}32 - \frac{\sigma_{H,lim}}{5000}$$
- for $\sigma_{H,lim} > 1200$ N/mm²
  $C_{ZR} = 0{,}08$

2.4.10 Hardness ratio factor Z_W

The hardness ratio factor Z_W accounts for the increase of surface durability in the case of a through-hardened wheel meshing with a surface-hardened or significantly (≥200HV) harder pinion having a smooth tooth surface ($R_{Z(f)} \leq 6\mu m$). Z_W applies to the soft wheel only, and is to be determined as follows:

- for HB < 130
  $Z_W = 1{,}2$
- for 130 ≤ HB ≤ 470
  $$Z_W = 1{,}2 - \frac{HB - 130}{1700}$$
- for HB > 470
  $Z_W = 1{,}0$

where HB is the Brinell hardness of the soft wheel.

2.4.11 Size factor Z_X

The size factor Z_X accounts for the influence of tooth dimensions on permissible contact stress and reflects the non-uniformity of material properties.

Z_X is to be determined as follows:

- for through-hardened steel: $Z_X = 1$
- for nitrided or nitrocarburised steel:
  $Z_X = 1{,}08 - 0{,}011\ m_n$ with $0{,}75 \leq Z_X \leq 1$
- for case-hardened steels:
  $Z_X = 1{,}05 - 0{,}005\ m_n$ with $0{,}90 \leq Z_X \leq 1$

2.4.12 Safety factor for contact stress S_H

The values to be adopted for the safety factor for contact stress S_H are given in Table 8.

Table 8 : Safety factor for contact stress S_H

Type of installation		S_H
Main gears (propulsion)	single machinery	1,25
	duplicate machinery	1,20
Auxiliary gears		1,15

2.4.13 Endurance limit for contact stress $\sigma_{H,lim}$

The endurance limit for contact stress $\sigma_{H,lim}$ is the limit of repeated contact stress which can be permanently endured.

The values to be adopted for $\sigma_{H,lim}$ are given in Table 9 in relation to the type of steel employed and the heat treatment performed, unless otherwise documented according to recognised standards.

Table 9 : Endurance limit for contact stress $\sigma_{H,lim}$

Type of steel and heat treatment	$\sigma_{H,lim}$ in N/mm²
through-hardened carbon steels	0,26 R + 350
through-hardened alloy steels	0,42 R + 330
case-hardened alloy steels	1500
nitrided (nitriding steels)	1250
nitrided or induction-hardened (other steels)	1000

2.5 Calculation of tooth bending strength

2.5.1 General

The criterion for tooth bending strength is based on the local tensile stress at the tooth root in the direction of the tooth height.

The tooth root bending stress σ_F is not to exceed the permissible tooth root bending stress σ_{FP}.

2.5.2 Tooth root bending stress σ_F

The tooth root bending stress σ_F is to be determined as follows:

$$\sigma_F = \frac{F_t}{b \cdot m_n} \cdot Y_F \cdot Y_S \cdot Y_\beta \cdot K_A \cdot K_\gamma \cdot K_V \cdot K_{F\beta} \cdot K_{F\alpha}$$

where:

Y_F : Tooth form factor (see [2.5.4])

Y_S : Stress correction factor (see [2.5.5])

Y_β : Helix factor (see [2.5.6])

K_A : Application factor (see [2.3.2])

K_γ : Load sharing factor (see [2.3.3])

K_V : Dynamic factor (see [2.3.4])

$K_{F\beta}$: Face load distribution factor (see [2.3.5])

$K_{F\alpha}$: Transverse load distribution factor (see [2.3.6]).

2.5.3 Permissible tooth root bending stress σ_{FP}

The permissible tooth root bending stress σ_{FP} is to be determined separately for pinion and wheel using the following formula:

$$\sigma_{FP} = \frac{\sigma_{FE} \cdot Y_d \cdot Y_N}{S_F} \cdot (Y_{\delta relT} \cdot Y_{RrelT} \cdot Y_X)$$

where:

σ_{FE} : Endurance limit for tooth root bending stress (see [2.5.7])

Y_d : Design factor (see [2.5.8])

Y_N : Life factor for bending stress (see [2.5.9])

$Y_{\delta relT}$: Relative notch sensitive factor (see [2.5.10])

Y_{RrelT} : Relative surface factor (see [2.5.11])

Y_X : Size factor (see [2.5.12])

S_F : Safety factor for tooth root bending stress (see [2.5.13]).

2.5.4 Tooth form factor Y_F

The tooth form factor Y_F takes into account the effect of the tooth form on the nominal bending stress assuming the load applied at the outer point of a single pair tooth contact.

In the case of helical gears, the form factors are to be determined in the normal section, i.e. for the virtual spur gear with the virtual number of teeth z_n.

Y_F is to be determined separately for the pinion and the wheel using the following formula:

$$Y_F = \frac{6 \cdot \frac{h_{Fe}}{m_n} \cdot \cos\alpha_{Fen}}{\left(\frac{s_{Fn}}{m_n}\right)^2 \cdot \cos\alpha_n}$$

where h_{Fe}, α_{Fen} and s_{Fn} are shown in Fig 1.

The parameters required for the calculation of Y_F are to be determined according to Method B of ISO 6336-3.

2.5.5 Stress correction factor Y_S

The stress correction factor Y_S is used to convert the nominal bending stress to local tooth root stress, assuming the load applied at the outer point a single pair tooth contact. It takes into account the influence of:

- the bending moment
- the proximity of the load application to the critical section.

Y_S is to be determined as follows:

$$Y_S = (1,2 + 0,13L) \cdot q_s^{\left(\frac{1}{1,21 + (2,3/L)}\right)}$$

where:

- $L = \frac{s_{Fn}}{h_{Fe}}$

  s_{Fn} and h_{Fe} are taken from [2.5.4]
- the notch parameter q_S as defined in [2.5.10] is assumed to be within the range $1 \le q_s < 8$.

2.5.6 Helix angle factor Y_β

The helix angle factor Y_β converts the tooth root stress of a virtual spur gear to that of the corresponding helical gear, taking into account the oblique orientation of the lines of mesh contact.

Y_β is to be determined as follows:

- for $\varepsilon_\beta \le 1$: $Y_\beta = 1 - 0,477\, \varepsilon_\beta\, \beta$
- for $\varepsilon_\beta > 1$: $Y_\beta = 1 - 0,477\, \beta$

Where $\beta > 0,52$ rad, the value $\beta = 0,52$ rad is to be substituted for β in the above formulae.

2.5.7 Endurance limit for tooth root bending stress σ_{FE}

The endurance limit for tooth root bending stress σ_{FE} is the local tooth root bending stress which can be permanently endured.

The values to be adopted for σ_{FE} are given in Tab 10 in relation to the type of steel employed, unless otherwise documented according to recognised standards.

Figure 1 : Geometric elements of teeth

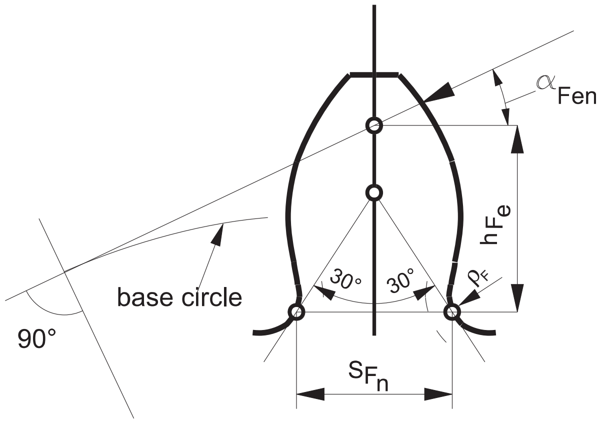


Table 10 : Values of endurance limit for tooth root bending stress σ_{FE}

Type of steel	σ_{FE}, in N/mm²
Through-hardened carbon steel	0,17 R + 300 (1)
Through-hardened alloy steel	0,22 R + 340 (1)
Surface-hardened by means of flame or induction hardening	0,66 HV + 270
Nitriding steel, surface-hardened by means of gas nitriding	740
Alloy steels, surface-hardened by means of bath or gas nitriding	640 (1)
Case-hardened steels	840 (1)

(1) In case of shot peened tooth root the given value can be increased up to 20% for case hardened steels and up to 10% for through hardened steels.

2.5.8 Design factor Y_d

The design factor Y_d takes into account the influence of load reversing and shrinkfit prestressing on the tooth root strength.

Y_d is to be determined as follows:

$$Y_d = Y_{dr} \cdot Y_{ds}$$

- for gears with occasional part load in reverse direction, such as main wheel in reverse gearboxes: $Y_{dr} = 0,9$
- for idler gears: $Y_{dr} = 0,7$
- otherwise $Y_{dr} = 1$
- for shrunk on pinions and wheel rims:

  $$Y_{ds} = 1 - \frac{\sigma_t}{\sigma_{FE}}$$

  where:

  σ_t : shrinkage induced tangential stress in way of the tooth root.
- otherwise: $Y_{ds} = 1$

2.5.9 Life factor for bending stress Y_N

The life factor for bending stress Y_N accounts for the higher tooth root bending stress permissible if a limited life (number of cycles) is required.

Y_N assumed equal to Y_{NT} according to method B ISO 6336-3 or assumed to be as follows:

- for gears intended for ahead running: $Y_N = 1$
- for gear intended for astern running only: $Y_N = 1,25$
- for other intermittent running, Y_N will be specially considered by the Society.

2.5.10 Relative notch sensitivity factor $Y_{\delta rel\ T}$

The relative notch sensitivity factor $Y_{\delta rel\ T}$ indicates the extent to which the theorically concentrated stress lies above the fatigue endurance limit.

$Y_{\delta rel\ T}$ is to be determined as follows:

- for notch parameter values included in the range

  $1,5 < q_s < 4$: $Y_{\delta rel\ T} = 1$
- for notch parameters values outside this range, $Y_{\delta rel\ T}$ will be specially considered by the Society.

The notch parameter q_s is defined as follows:

$$q_s = \frac{s_{Fn}}{2 \cdot \rho_F}$$

where s_{Fn} and ρ_F are taken from [2.5.4].

2.5.11 Relative surface factor $Y_{Rrel\ T}$

The relative surface factor $Y_{Rrel\ T}$ takes into account the dependence of the root strength on the surface condition on the tooth root fillet (roughness).

The values to be adopted for $Y_{Rrel\ T}$ are given in Tab 11 in relation to the type of steel employed. They are valid only when scratches or similar defects deeper than 2 $R_{Z(r)}$ are not present.

Table 11 : Values of relative surface factor $Y_{Rrel\ T}$

Type of steel	$R_{Z(r)} < 1$	$1 \le R_{Z(r)} \le 40$
Normalised steels	1,070	$5,3 - 4,2\ (R_{Z(r)}+1)^{0,01}$
Case-hardened or through-hardened steels	1,120	$1,675 - 0,53\ (R_{Z(r)}+1)^{0,1}$
Nitrided steels	1,025	$4,3 - 3,26\ (R_{Z(r)}+1)^{0,005}$

2.5.12 Size factor Y_X

The size factor Y_X takes into account the decrease of the strength with increasing size.

The values to be adopted for Y_X are given in Tab 12 in relation to the type of steel employed and the value of the normal module m_n.

Table 12 : Values of size factor Y_X

Type of steel	Normal module	Value of Y_X
All types of steel	$m_n \le 5$	1
Normalised through-hardened	$5 < m_n < 30$	$1,03 - 0,006\ m_n$
	$m_n \ge 30$	0,85
Surface-hardened steels	$5 < m_n < 25$	$1,05 - 0,01\ m_n$
	$m_n \ge 25$	0,80

2.5.13 Safety factor for tooth root bending stress S_F

The values to be adopted for the safety factor for tooth root bending stress S_F are given in Tab 13.

Table 13 : Values of safety factor for tooth root bending stress S_F

Type of installation		S_F
Main gears (propulsion)	single machinery	1,55
	duplicate machinery	1,4
Auxiliary gears	single machinery	1,4
	duplicate machinery	1,3

3 Design and construction - except tooth load capacity

3.1 Materials

3.1.1 General

a) Forged, rolled and cast materials used in the manufacturing of shafts, couplings, pinions and wheels are to comply with the requirements of Part D.

b) Materials other than steels will be given special consideration by the Society.

3.1.2 Steels for pinions and wheel rims

a) Steels intended for pinions and wheels are to be selected considering their compatibility in service. In particular, for through-hardened pinion / wheel pairs, the hardness of the pinion teeth is to exceed that of the corresponding wheel. For this purpose, the minimum tensile strength of the pinion material is to exceed that of the wheel by at least 15 %.

b) The minimum tensile strength of the core is not to be less than:

- 750 N/mm² for case-hardened teeth
- 800 N/mm² for induction-hardened or nitrided teeth

3.2 Teeth

3.2.1 Manufacturing accuracy

a) The standard of accuracy of teeth of propulsion machinery gearing transmitting a power of 1000 kW and above is to correspond to that of quality class 4 as defined by ISO 1328-1.

b) The standard of accuracy of teeth of propulsion machinery gearing transmitting a power lower than 1000 kW is to correspond to that of quality class 6 as defined by ISO 1328-1.

c) A lower standard of accuracy (i.e. higher ISO quality classes) may be accepted for auxiliary machinery gearing and for particular cases of propulsion machinery gearing, subject to special consideration.

d) Mean roughness (peak-to-valley) of shaved or ground teeth is not to exceed 4 µm.

e) Wheels are to be cut by cutters with a method suitable for the expected type and quality. Whenever necessary, the cutting is to be carried out in a temperature-controlled environment.

3.2.2 Tooth root

Teeth are to be well faired and rounded at the root. The fillet radius at the root of the teeth, within a plane normal to the teeth, is to be not less than 0,25 m_n.

Profile-grinding of gear teeth is to be performed in such a way that no notches are left in the fillet.

3.2.3 Tooth tips and ends

a) All sharp edges on the tips and ends of gear teeth are to be removed after cutting and finishing of teeth.

b) Where the ratio b/d exceeds 0,3, the ends of pinion and wheel are to be chamfered to an angle between 45 and 60 degrees. The chamfering depth is to be at least equal to 1,5 m_n.

3.2.4 Surface treatment

a) The hardened layer on surface-hardened gear teeth is to be uniform and extended over the whole tooth flank and fillet.

b) Where the pinions and the toothed portions of the wheels are case-hardened and tempered, the teeth flanks are to be ground while the bottom lands of the teeth remain only case-hardened. The superficial hardness of the case-hardened zone is to be at least equal to 56 C Rockwell units.

c) Where the pinions and the toothed portions of the wheels are nitrided, the hardened layer is to comply with Tab 14.

d) The use of other processes of superficial hardening of the teeth, such as flame hardening, will be given special consideration, in particular as regards the values to be adopted for $\sigma_{H,lim}$ and σ_{FE}.

Table 14 : Characteristics of the hardened layer for nitrided gears

Type of steel	Minimum thickness of hardened layer (mm) **(1)**	Minimum hardness (HV)
Nitriding steel	0,6	500 (at 0,25 mm depth)
Other steels	0,3	450 (surface)

(1) Depth of the hardened layer to core hardness. When the grinding of nitrided teeth is performed, the depth of the hardened layer to be taken into account is the depth after grinding.

3.3 Wheels and pinions

3.3.1 General

Wheel bodies are to be so designed that radial deflexions and distorsions under load are prevented, so as to ensure a satisfactory meshing of teeth.

3.3.2 Welding

a) Where welding is employed for the construction of wheels, the welding procedure is to be submitted to the Society for approval. Welding processes and their qualification are to comply with Part D.

b) Stress relieving treatment is to be performed after welding.

c) Examination of the welded joints is to be performed by means of magnetic particle or dye penetrant tests to the satisfaction of the Surveyor. Suitable arrangements are to be made to permit the examination of the internal side of the welded joints.

3.3.3 Shrink-fits

The shrink assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 5.

3.3.4 Bolting

The bolting assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 5.

The nuts are to be suitably locked by means other than welding.

3.4 Shafts and bearings

3.4.1 General

Shafts and their connections, in particular flange couplings and shrink-fits connections, are to comply with the provisions of Sec 5.

3.4.2 Pinion and wheel shafts

The minimum diameter of pinion and gear wheel shafts is not to be less than the value d_S, in mm, given by the following formula:

$$d_S = \left\{\left[\left(10,2 + \frac{28000}{R_{S,min}}\right)T\right]^2 + \left[\frac{170000}{412 + R_{s,min}}M\right]^2\right\}^{\frac{1}{6}} \left(\frac{1}{1 - K_d^{\,4}}\right)^{\frac{1}{3}}$$

where:

- $R_{S,min}$: minimum yield strength of the shaft material, in N/mm²
- T : nominal torque transmitted by the shaft, in Nm
- M : bending moment on the shaft, in Nm
- K_d : coefficient having the following values:
  - for solid shafts: $K_d = 0$
  - for hollow shafts, K_d is equal to the ratio of the hole diameter to the outer shaft diameter.

    Where $K_d \leq 0{,}3$: $K_d = 0$ may be taken.

Note 1: The values of d_S, T and M refer to the cross-section of the shaft concerned.

Note 2: In correspondence of keyways d_S shall be increased by 10%.

As an alternative to the above given formula, the Society may accept direct strength calculations showing that the equivalent stress represented in a diagram alternate stress/average stress falls below the lines defined by the points having coordinates:

$(R_m;0)$, $(0;\sigma_{fa}/1,5)$

and

$(0,8R_s;0)$, $(0;0,8R_s)$

where σ_{fa} is the pure alternate bending fatigue limit for a survival probability not less than 80%.

3.4.3 Quill shafts

The minimum diameter of quill shafts subject to torque only is not to be less than the value d_{QS}, in mm, given by the following formula:

$$d_{QS} = \left[\left(7,65 + \frac{27000}{R_{S,min}}\right) \cdot \frac{T}{1 - K_d^{\,4}}\right]^{\frac{1}{3}}$$

$R_{S,min}$ and K_d being defined in [3.4.2].

3.4.4 Bearings

a) Thrust bearings and their supports are to be so designed as to avoid detrimental deflexions under load.

b) Life duration of bearings L_{10h} calculed according to ISO 281-1, is not be less than 40000 hours. Shorter durations may be accepted on the basis of the actual load time distribution, and subject to the agreement of the owner.

3.5 Casings

3.5.1 General

Gear casings are to be of sufficient stiffness such that misalignment, external loads and thermal effects in all service conditions do not adversely affect the overall tooth contact.

3.5.2 Welded casings

a) Carbon content of steels used for the construction of welded casings is to comply with the provisions of Part D.

b) The welded joints are to be so arranged that welding and inspection can be performed satisfactorily. They are to be of the full penetration type.

c) Welded casings are to be stress-relieved after welding.

3.5.3 Openings

Access or inspection openings of sufficient size are to be provided to permit the examination of the teeth and the structure of the wheels.

3.6 Lubrication and clutch control

3.6.1 General

a) Manufacturers are to take care of the following points :
   - reliable lubrication of gear meshes and bearings is ensured :
     - over the whole speed range, including starting, stopping and, where applicable, manoeuvring
     - for all angles stated in Sec 1, [2.4]
   - in multi-propellers plants not fitted with shaft brakes, provision is to be made to ensure lubrication of gears likely to be affected by windmilling.

b) Lubrication by means other than oil circulation under pressure will be given special consideration.

3.6.2 Pumps

a) Gears intended for propulsion or other essential services are to be provided with:
   1) one main lubricating pump, capable of maintaining a sufficient lubrication of the gearbox in the whole speed range
   2) and one standby pump independently driven of at least the same capacity.
   3) an additional standby pump to the one required above, in case the failure of any pump prevents the propulsion from starting.

b) In the case of:
   1) gears having a transmitted power not exceeding 375 kW
   2) or multi-engines plants,

   one of the pumps mentioned in a) may be a spare pump ready to be connected to the reduction gear lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

c) The requirements in a) 1), a) 2) and b) 1), b) 2) also apply to clutch control oil supply pumps.

   With reference to the requirements in a) 1) and a) 2), in case the failure of any pump prevents the operation of the clutch, an additional stand-by pump is to be fitted.

3.6.3 Filtration

a) Forced lubrication systems are to be fitted with a device which efficiently filters the oil in the circuit.

b) When fitted to gears intended for propulsion machinery or machinery driving electric propulsion generators, such filters are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

3.7 Control and monitoring

3.7.1 Gears are to be provided with the alarms and safeguards listed in Tab 15.

Note 1: Some departures from Tab 15 may be accepted by the Society in the case of ships with a restricted navigation notation.

4 Installation

4.1 General

4.1.1 Manufacturers and shipyards are to take care directly that stiffness of gear seating and alignment conditions of gears are such as not to adversely affect the overall tooth contact and the bearing loads under all operating conditions of the ship.

4.2 Fitting of gears

4.2.1 Means such as stoppers or fitted bolts are to be arranged in the case of gears subject to propeller thrust. However, where the thrust is transmitted by friction and the relevant safety factor is not less than 2, such means may be omitted.

5 Certification, inspection and testing

5.1 General

5.1.1

a) Inspection and testing of shafts and their connections (flange couplings, hubs, bolts, pins) are to be carried out in accordance with the provisions of Sec 5.

b) For inspection of welded joints of wheels, refer to [3.3.2].

5.2 Workshop inspection and testing

5.2.1 Testing of materials

Chemical composition and mechanical properties are to be tested in accordance with the applicable requirements of Pt D, Ch 2, Sec 3 for the following items:

- pinions and wheel bodies
- rims
- plates and other elements intended for propulsion gear casings of welded construction.

5.2.2 Testing of pinion and wheel forgings

a) Mechanical tests of pinions and wheels are to be carried out in accordance with:
   - Pt D, Ch 2, Sec 3, [5.6] for normalised and tempered or quenched and tempered forgings
   - Pt D, Ch 2, Sec 3, [5.7] for surface-hardened forgings.

b) Non-destructive examination of pinion and wheel forgings is to be performed in accordance with Pt D, Ch 2, Sec 3, [5.8].

5.2.3 Balancing test

Rotating components, in particular gear wheel and pinion shaft assemblies with the coupling part attached, are to undergo a static balancing test.

Where $n^2.d \geq 1,5.10^9$, gear wheel and pinion shaft assemblies are also to undergo a dynamic balancing test.

5.2.4 Verification of cutting accuracy

Examination of the accuracy of tooth cutting is to be performed in the presence of the Surveyor. Records of measurements of errors, tolerances and clearances of teeth are to be submitted at the request of the Surveyor.

5.2.5 Meshing test

a) A tooth meshing test is to be performed in the presence of the Surveyor. This test is to be carried out at a load sufficient to ensure tooth contact, with the journals located in the bearings according to the normal running conditions. Before the test, the tooth surface is to be coated with a thin layer of suitable coloured compound.

b) The results of such test are to demonstrate that the tooth contact is adequately distributed on the length of the teeth. Strong contact marks at the end of the teeth are not acceptable.

c) A permanent record of the tooth contact is to be made for the purpose of subsequent checking of alignment following installation on board.

5.2.6 Hydrostatic tests

a) Hydraulic or pneumatic clutches are to be hydrostatically tested before assembly to 1,5 times the maximum working pressure of the pumps.

b) Pressure piping, pumps casings, valves and other fittings are to be hydrostatically tested in accordance with the requirements of Sec 8, [16].

Table 15 : Reduction gears / reversing gears and clutch monitoring

Symbol convention H = High, HH = High High, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Stand by Start	Stop
Lubricating oil temperature		local					
Lubricating oil pressure		local					
	L						
Oil tank level		local					
Clutch control oil pressure	L						

SECTION 5 MAIN PROPULSION SHAFTING

1 General

1.1 Application

1.1.1 This Section applies to shafts, couplings, clutches and other shafting components transmitting power for main propulsion.

For shafting components in engines, gears and thrusters, see Sec 2, Sec 4 and Sec 10, respectively; for propellers, see Sec 6.

For vibrations, see Sec 7.

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to the Society for approval the documents listed in Tab 1.

Plans of power-transmitting parts and shaft liners listed in Tab 1 are to include the relevant material specifications.

2 Design and construction

2.1 Materials

2.1.1 General

The use of other materials or steels having values of tensile strength exceeding the limits given in [2.1.2], [2.1.3] and [2.1.4] will be considered by the Society in each case

2.1.2 Shaft materials

In general, shafts are to be of forged steel having tensile strength, R_m, between 400 and 800 N/mm^2.

Where shafts may experience vibratory stresses close (i.e. higher than 80%) to the permissible stresses for transient operation, the materials are to have a specified minimum ultimate tensile strength (R_m) of 500 N/mm^2. Otherwise, materials having a specified minimum ultimate tensile strength (R_m) of 400 N/mm^2 may be used.

Table 1 : Documentation to be submitted

No.	Document (drawings, calculations, etc.)
1	Shafting arrangement **(1)**
2	Thrust shaft
3	Intermediate shafts
4	Propeller shaft
5	Shaft liners, relevant manufacture and welding procedures, if any
6	Couplings and coupling bolts
7	Flexible couplings **(2)**
8	Sterntube
9	Details of sterntube glands

(1) This drawing is to show the entire shafting, from the main engine coupling flange to the propeller. The location of the thrust block, and the location and number of shafting bearings (type of material and length) are also to be shown.

(2) The Manufacturer of the elastic coupling is also to submit the following data:
- allowable mean transmitted torque (static) for continuous operation
- maximum allowable shock torque
- maximum allowable speed of rotation
- maximum allowable values for radial, axial and angular misalignment

In addition, when the torsional vibration calculation of main propulsion system is required (see Sec 9), the following data are also to be submitted:
- allowable alternating torque amplitude and power loss for continuous operation, as a function of frequency and/or mean transmitted torque
- static and dynamic stiffness, as a function of frequency and/or mean transmitted torque
- moments of inertia of the primary and secondary halves of the coupling
- damping coefficient or damping capability
- properties of rubber components
- for steel springs of couplings: chemical composition and mechanical properties of steel employed.

2.1.3 Couplings, flexible couplings, hydraulic couplings

Non-solid-forged couplings and stiff parts of elastic couplings subjected to torque are to be of forged or cast steel, or nodular cast iron.

Rotating parts of hydraulic couplings may be of grey cast iron, provided that the peripheral speed does not exceed 40m/s.

2.1.4 Coupling bolts

Coupling bolts are to be of forged, rolled or drawn steel.

In general, the value of the tensile strength of the bolt material R_{mB} is to comply with the following requirements:

- $R_m \leq R_{mB} \leq 1,7\ R_m$
- $R_{mB} \leq 1000$ N/mm².

2.1.5 Shaft liners

Liners are to be of metallic corrosion resistant material complying with the applicable requirements of Part D and with the approved specification, if any; in the case of liners fabricated in welded lengths, the material is to be recognised as suitable for welding.

In general, they are to be manufactured from castings.

For small shafts, the use of liners manufactured from pipes instead of castings may be considered.

Where shafts are protected against contact with seawater not by metal liners but by other protective coatings, the coating procedure is to be approved by the Society.

2.1.6 Sterntubes

Sterntubes are to comply with the "Rules for the Classification of Ships".

2.2 Shafts - Scantling

2.2.1 General

For the check of the scantling, the methods given in [2.2.2] and [2.2.3] apply for intermediate shafts and propeller shafts, respectively. As an alternative, the direct stress calculation method as per [2.2.4] may be applied.

Transitions of diameters are to be designed with either a smooth taper or a blending radius. For guidance, a blending radius equal to the change in diameter is recommended.

2.2.2 Intermediate and thrust shafts

The minimum diameter of intermediate and thrust shafts is not to be less than the value d, in mm, given by the following formula:

$$d = F \cdot k \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/3}$$

where:

Q : • in the case of solid shafts: Q = 0
- in the case of hollow shafts: Q = ratio of the hole diameter to the outer shaft diameter in the section concerned.

  where Q ≤ 0,4, Q = 0 is to be taken.

  Hollow shafts whose longitudinal axis does not coincide with the longitudinal hole axis will be specially considered by the Society in each case.

F : • 95 for main propulsion systems powered by diesel engines fitted with slip type coupling, by turbines or by electric motors;
- 100 for main propulsion systems powered by diesel engines fitted with other type of couplings.

k : Factor whose value is given in Tab 2 depending upon the different design features of the shafts.

For shaft design features other than those given in the Table, the value of k will be specially considered by the Society in each case.

n : Speed of rotation of the shaft, in r.p.m., corresponding to power P

P : Maximum continuous power of the propulsion machinery for which the classification is requested, in kW.

R_m : Value of the minimum tensile strength of the shaft material, in N/mm². Whenever the use of a steel having R_m in excess of 800 N/mm² is allowed in accordance with [2.1], the value of R_m to be introduced in the above formula is not to exceed the following:

- for carbon and carbon manganese steels, a minimum specified tensile strength not exceeding 760 N/mm²
- for alloy steels, a minimum specified tensile strength not exceeding 800 N/mm².

Where materials with greater specified or actual tensile strengths than the limitations given above are used, reduced shaft dimensions are not acceptable when derived from the formula in this item [2.2.2].

In cases of stainless steels and in other particular cases, at the discretion of the Society, the value of R_m to be introduced in the above formula will be specially considered.

The scantlings of intermediate shafts inside tubes or sterntubes will be subject to special consideration by the Society. Where intermediate shafts inside sterntubes are water lubricated, the requirements of [2.4.7] are to be applied.

2.2.3 Propeller shafts

For propeller shafts in general a minimum specified tensile strength R_m to be introduced in the following formula not exceeding 600 N/mm² is to be taken for carbon, carbon manganese and alloy steel.

Where materials with greater specified or actual tensile strengths than the limitations given above are used, reduced shaft dimensions are not acceptable when derived from the formula in this item [2.2.3].

The minimum diameter of the propeller shaft is not to be less than the value d_P, in mm, given by the following formula:

$$d_P = 100 \cdot k_P \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/3}$$

where:

k_p : Factor whose value, depending on the different constructional features of shafts, is given below.

The other symbols have the same meaning as in [2.2.2].

In cases of stainless steels and in other particular cases, at the discretion of the Society, the value of R_m to be introduced in the above formula will be specially considered. In general, the diameter of the part of the propeller shaft located forward of the forward sterntube seal may be gradually reduced to the diameter of the intermediate shaft.

The values of factor k_P to be introduced in the above formula are to be taken as follows:

k_P : k_P = 1,26, for propeller shafts where:

- the propeller is keyed on to the shaft taper in compliance with the requirements of [2.5.5]

k_P = 1,22, for propeller shafts where:

- the propeller is keyless fitted on to the shaft taper by a shrinkage method in compliance with Sec 8, [3.1.2], or the propeller boss is attached to an integral propeller shaft flange in compliance with [2.5.1]
- the sterntube of the propeller shaft is oil lubricated and provided with oil sealing glands approved by the Society or when the sterntube is water lubricated and the propeller shaft is fitted with a continuous liner.

The above values of k_P apply to the portion of propeller shaft between the forward edge of the aftermost shaft bearing and the forward face of the propeller boss or the forward face of the integral propeller shaft flange for the connection to the propeller boss. In no case is the length of this portion of propeller shaft to be less than 2,5 times the rule diameter d_P obtained with the above formula.

The determination of factor k_P for shaft design features other than those given above will be specially considered by the Society in each case.

For the length of the propeller shaft between the forward edge of the aftermost shaft bearing and the forward edge of the forward sterntube seal:

- k_P = 1,15 is to be taken in any event.

2.2.4 Direct stress calculation method

Alternative calculation methods may be considered by the Society. Any alternative calculation method is to include all relevant loads on the complete dynamic shafting system under all permissible operating conditions. Consideration is to be given to the dimensions and arrangements of all shaft connections.

Moreover, an alternative calculation method is to take into account design criteria for continuous and transient operating loads (dimensioning for fatigue strength) and for peak operating loads (dimensioning for yield strength). The fatigue strength analysis may be carried out separately according to different criteria corresponding to different load assumptions, for example the following:

- low cycle fatigue criterion (typically lower than 10^4), i.e. the primary cycles represented by zero to full load and back to zero, including reversing torque if applicable
- high cycle fatigue criterion (typically much higher than 10^7), i.e. torsional vibration stresses permitted for continuous operation, reverse bending stresses and operation passing through a barred speed range or any other transient condition.

Table 2 : Values of factor k

For intermediate shafts with					For thrust shafts external to engines	
integral coupling flange and straight sections	shrink fit coupling	keyways, tapered or cylindrical connection	radial hole	longitudinal slot	on both sides of thrust collar	in way of axial bearing, where a roller bearing is used as a thrust bearing
1,00 **(1)**	1,00 **(2)**	1,10 **(3)** **(4)**	1,10 **(5)**	1,20 **(6)**	1,10 **(1)**	1,10

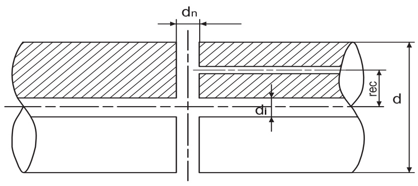
(1) Value applicable in the case of fillet radii in accordance with the provisions of [2.5.1].

(2) k refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2 % and a blending radius as described in [2.2.1].

(3) Keyways are, in general, not to be used in installations with a barred speed range.

(4) At a distance of not less than 0,2 d from the end of the keyway, the shaft diameter may be reduced to the diameter calculated using k = 1,0. Fillet radii in the transverse section of the bottom of the keyway are to be not less than 0,0125 d, d being the diameter as calculated above using k = 1,0.

(5) Value applicable in the case of diameter of radial bore d_h not exceeding 0,3 d, d being as defined in **(4)**.
Cases foreseeing intersection between a radial and an eccentric (r_{ec}) axial bore (see figure below) are specially considered by the Society.



(6) Subject to limitations: slot length (l)/outside diameter < 0,8, inner diameter (d_i)/outside diameter < 0,8 and slot width (e)/outside diameter > 0,10. The end rounding of the slot is not to be less than e/2. An edge rounding is preferably to be avoided as this increases the stress concentration slightly.The k values are valid for 1, 2 and 3 slots, i.e. with slots at, respectively, 360, 180 and 120 degrees apart.

Note 1: Explanation of k and C_K (for C_K see Sec 9, Tab 1)

The factors k (for low cycle fatigue) and C_K (for high cycle fatigue) take into account the influence of:

- the stress concentration factors (scf) relative to the stress concentration for a flange with fillet radius of 0,08 d (geometric stress concentration of approximately 1,45)

  $$C_K = \frac{1,45}{scf} \quad \text{and} \quad k = \left(\frac{scf}{1,45}\right)^x$$

  where the exponent x considers low cycle notch sensitivity.
- the notch sensitivity. The chosen values are mainly representative for soft steels (R_m < 600), while the influence of steep stress gradients in combination with high strength steels may be underestimated.
- the fact that that the size factor c_D being a function of diameter only does not purely represent a statistical size influence, but rather a combination of this statistical influence and the notch sensitivity.

The actual values for k and C_K are rounded off.

Note 2: Stress concentration factor of slots

The stress concentration factor (scf) at the end of slots can be determined by means of the following empirical formulae using the symbols in **(4)**

$$scf = \alpha_{t(hole)} + 0,57 \cdot \frac{(l-e)/d}{\sqrt{\left(1-\frac{d_i}{d}\right) \cdot \frac{e}{d}}}$$

This formula applies to:

- slots at 120 or 180 or 360 degrees apart.
- slots with semicircular ends. A multi-radii slot end can reduce the local stresses, but this is not included in this empirical formula.
- slots with no edge rounding (except chamfering), as any edge rounding increases the scf slightly.

$\alpha_{t(hole)}$ represents the stress concentration of radial holes (in this context e = hole diameter) and can be determined as :

$$\alpha_{t(hole)} = 2,3 - 3 \cdot \frac{e}{d} + 15 \cdot \left(\frac{e}{d}\right)^2 + 10 \cdot \left(\frac{e}{d}\right)^2 \cdot \left(\frac{d_i}{d}\right)^2$$

or simplified to $\alpha_{t(hole)} = 2,3$.

Note 3: The determination of k factors for shafts other than those provided in this table will be given special consideration by the Society.

2.3 Liners

2.3.1 General

Metal liners or other protective coatings approved by the Society are required where propeller shafts are not made of corrosion-resistant material.

Metal liners are generally to be continuous; however, discontinuous liners, i.e. liners consisting of two or more separate lengths, may be accepted by the Society on a case by case basis, provided that:

- they are fitted in way of all supports
- the shaft portion between liners, likely to come into contact with sea water, is protected with a coating of suitable material with characteristics, fitting method and thickness approved by the Society.

2.3.2 Scantling

The thickness of metal liners fitted on propeller shafts or on intermediate shafts inside sterntubes is to be not less than the value t, in mm, given by the following formula:

$$t = \frac{d + 230}{32}$$

where:

d : Actual diameter of the shaft, in mm.

Between the sternbushes, the above thickness t may be reduced by 25%.

2.4 Stern tube bearings

2.4.1 Oil lubricated aft bearings of antifriction metal

a) The length of bearings lined with white metal or other antifriction metal and with oil glands of a type approved by the Society is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above, provided the nominal bearing pressure is not more than 0,8 N/mm^2, as determined by static bearing reaction calculations taking into account shaft and propeller weight, as exerting solely on the aft bearing, divided by the projected area of the shaft.

However, the minimum bearing length is to be not less than 1,5 times its actual inner diameter.

2.4.2 Oil lubricated aft bearings of synthetic rubber, reinforced resin or plastics material

a) For bearings of synthetic rubber, reinforced resin or plastics material which are approved by the Society for use as oil lubricated sternbush bearings, the length of the bearing is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above provided the nominal bearing pressure is not more than 0,6 N/mm^2, as determined according to [2.4.1] b).

However, the minimum length of the bearing is to be not less than 1,5 times its actual inner diameter.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

2.4.3 Water lubricated aft bearings of lignum vitae or antifriction metal

Where the bearing comprises staves of wood (known as "lignum vitae") or is lined with antifriction metal, the length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.4 Water lubricated aft bearings of synthetic materials

a) Where the bearing is constructed of synthetic materials which are approved by the Society for use as water lubricated sternbush bearings, such as rubber or plastics, the length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

b) For a bearing design substantiated by experimental data to the satisfaction of the Society, consideration may be given to a bearing length less than 4 times, but in no case less than 2 times, the rule diameter of the shaft in way of the bearing.

2.4.5 Grease lubricated aft bearings

The length of grease lubricated bearings is generally to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.6 Oil or grease lubrication system

a) For oil lubricated bearings, provision for oil cooling is to be made.

A gravity tank is to be fitted to supply lubricating oil to the sterntube; the tank is to be located above the full load waterline.

Oil sealing glands are to be suitable for the various sea water temperatures which may be encountered in service.

b) Grease lubricated bearings will be specially considered by the Society.

2.4.7 Water circulation system

For water lubricated bearings, means are to be provided to ensure efficient water circulation. In the case of bearings lined with "lignum vitae" of more than 400 mm in diameter and bearings lined with synthetic materials, means for forced water circulation are to be provided. In the case of bearings of synthetic materials, water flow indicators or pump outlet pressure indicators are to be provided.

The water grooves on the bearings are to be of ample section such as to ensure efficient water circulation and be scarcely affected by wear-down, particularly for bearings of the plastic type.

The shut-off valve or cock controlling the water supply is to be fitted direct to the stuffing box bulkhead or in way of the water inlet to the sterntube, when this is fitted forward of such bulkhead.

2.5 Couplings

2.5.1 Flange couplings

a) Flange couplings of intermediate and thrust shafts and the flange of the forward coupling of the propeller shaft are to have a thickness not less than 0,2 times the rule diameter of the solid intermediate shaft and not less than the coupling bolt diameter calculated for a tensile strength equal to that of the corresponding shaft.

The fillet radius at the base of solid forged flanges is to be not less than 0,08 times the actual shaft diameter.

The fillet may be formed of multi-radii in such a way that the stress concentration factor will not be greater than that for a circular fillet with radius 0,08 times the actual shaft diameter.

For non-solid forged flange couplings, the above fillet radius is not to cause a stress in the fillet higher than that caused in the solid forged flange as above.

Fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

b) Where the propeller is connected to an integral propeller shaft flange, the thickness of the flange is to be not less than 0,25 times the rule diameter of the aft part of the propeller shaft. The fillet radius at the base of the flange is to be not less than 0,125 times the actual diameter.

The strength of coupling bolts of the propeller boss to the flange is to be equivalent to that of the aft part of the propeller shaft.

c) Non-solid forged flange couplings and associated keys are to be of a strength equivalent to that of the shaft.

They are to be carefully fitted and shrunk on to the shafts, and the connection is to be such as to reliably resist the vibratory torque and astern pull.

d) For couplings of intermediate and thrust shafts and for the forward coupling of the propeller shaft having all fitted coupling bolts, the coupling bolt diameter in way of the joining faces of flanges is not to be less than the value d_B, in mm, given by the following formula:

$$d_B = 0,65 \cdot \left[\frac{d^3 \cdot (R_m + 160)}{n_B \cdot D_C \cdot R_{mB}}\right]^{0,5}$$

where:

- d : Rule diameter of solid intermediate shaft, in mm, taking into account the ice strengthening requirements of Pt F, Ch 9, Sec 3, where applicable
- n_B : Number of fitted coupling bolts
- D_C : Pitch circle diameter of coupling bolts, in mm
- R_m : Value of the minimum tensile strength of intermediate shaft material taken for calculation of d, in N/mm²
- R_{mB} : Value of the minimum tensile strength of coupling bolt material, in N/mm². Where, in compliance with [2.1.1], the use of a steel having R_{mB} in excess of the limits specified in [2.1.4] is allowed for coupling bolts, the value of R_{mB} to be introduced in the formula is not exceed the above limits.

e) Flange couplings with non-fitted coupling bolts may be accepted on the basis of the calculation of bolt tightening, bolt stress due to tightening, and assembly instructions.

To this end, the torque based on friction between the mating surfaces of flanges is not to be less than 2,8 times the transmitted torque, assuming a friction coefficient for steel on steel of 0,18. In addition, the bolt stress due to tightening in way of the minimum cross-section is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2 proof stress ($R_{p\,0,2}$), of the bolt material.

Transmitted torque has the following meanings:

- For main propulsion systems powered by diesel engines fitted with slip type or high elasticity couplings, by turbines or by electric motors: the mean transmitted torque corresponding to the maximum continuous power P and the relevant speed of rotation n, as defined under [2.2.2].
- For main propulsion systems powered by diesel engines fitted with couplings other than those mentioned in (a): the mean torque above increased by 20% or by the torque due to torsional vibrations, whichever is the greater.

The value 2,8 above may be reduced to 2,5 in the following cases:

- ships having two or more main propulsion shafts
- when the transmitted torque is obtained, for the whole functioning rotational speed range, as the sum of the nominal torque and the alternate torque due to the torsional vibrations, calculated as required in Sec 9.

2.5.2 Shrunk couplings

Non-integral couplings which are shrunk on the shaft by means of the oil pressure injection method or by other means may be accepted on the basis of the calculation of shrinking and induced stresses, and assembly instructions.

To this end, the force due to friction between the mating surfaces is not to be less than 2,8 times the total force due to the transmitted torque and thrust.

The value 2,8 above may be reduced to 2,5 in the cases specified under item e) of [2.5.1].

The values of 0,14 and 0,18 will be taken for the friction coefficient in the case of shrinking under oil pressure and dry shrink fitting, respectively.

In addition, the equivalent stress due to shrinkage determined by means of the von Mises-Hencky criterion in the points of maximum stress of the coupling is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the material of the part concerned.

The transmitted torque is that defined under item e) of [2.5.1].

For the determination of the thrust, see Sec 6, [3.1.2].

2.5.3 Other couplings

Types of couplings other than those mentioned in [2.5.1] and [2.5.2] above will be specially considered by the Society.

2.5.4 Flexible couplings

a) The scantlings of stiff parts of flexible couplings subjected to torque are to be in compliance with the requirements of Article [2].

b) For flexible components, the limits specified by the Manufacturer relevant to static and dynamic torque, speed of rotation and dissipated power are not to be exceeded.

c) Where all the engine power is transmitted through one flexible component only (ships with one propulsion engine and one shafting only), the flexible coupling is to be fitted with a torsional limit device or other suitable means to lock the coupling should the flexible component break.

In stiff transmission conditions with the above locking device, a sufficiently wide speed range is to be provided, free from excessive torsional vibrations, such as to enable safe navigation and steering of the ship. As an alternative, a spare flexible element is to be provided on board.

2.5.5 Propeller shaft keys and keyways

a) Keyways on the propeller shaft cone are to have well rounded corners, with the forward end faired and preferably spooned, so as to minimize notch effects and stress concentrations.

When these constructional features are intended to obtain an extension of the interval between surveys of the propeller shaft in accordance with the relevant provisions of Pt A, Ch 2, Sec 2, [5.5], they are to be in compliance with Fig 1.

Different scantlings may be accepted, provided that at least the same reduction in stress concentration is ensured.

The fillet radius at the bottom of the keyway is to be not less than 1,25% of the actual propeller shaft diameter at the large end of the cone.

The edges of the key are to be rounded.

The distance from the large end of the propeller shaft cone to the forward end of the key is to be not less than 20% of the actual propeller shaft diameter in way of the large end of the cone.

Key securing screws are not to be located within the first one-third of the cone length from its large end; the edges of the holes are to be carefully faired.

b) The sectional area of the key subject to shear stress is to be not less than the value A, in mm², given by the following formula:

$$A = 0{,}4 \cdot \frac{d^3}{d_{PM}}$$

where:

d : Rule diameter, in mm, of the intermediate shaft calculated in compliance with the requirements of [2.2.2], assuming:

$R_m = 400$ N/mm²

d_{PM} : Actual diameter of propeller shaft at mid-length of the key, in mm.

2.6 Control and monitoring

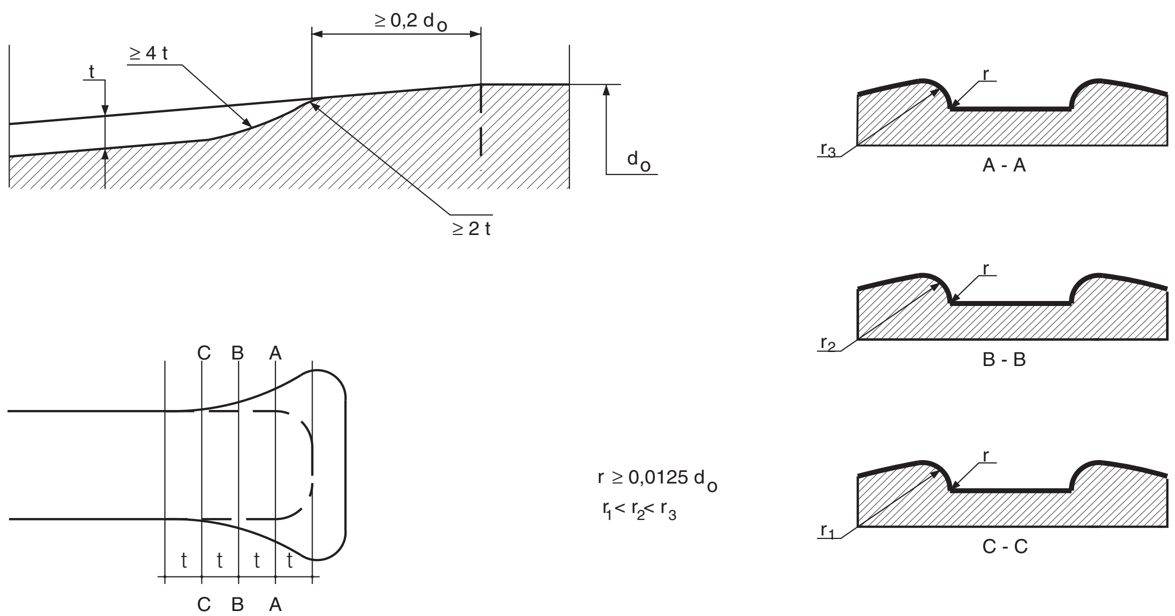
2.6.1 Indicators

The local indicators for main propulsion shafting to be installed on ships of 500 gross tonnage and upwards without automation notations are given in Tab 3. For monitoring of engines, gears, controllable pitch propellers and thrusters, see Sec 2, Sec 4, Sec 6 and Sec 10, respectively.

The indicators listed in Tab 3 are to be fitted at a normally attended position.

Note 1: Some departures from Tab 3 may be accepted by the Society in the case of ships with a restricted navigation notation

Figure 1 : Details of forward end of propeller shaft keyway



3 Arrangement and installation

3.1 General

3.1.1 The installation is to be carried out according to the instructions of the component Manufacturer or approved documents, when required.

3.1.2 The installation of sterntubes and/or associated non-shrunk bearings is subject to approval of procedures and materials used.

3.1.3 The joints between liner parts are not to be located in way of supports and sealing glands.

Metal liners are to be shrunk on to the shafts by pre-heating or forced on by hydraulic pressure with adequate interference; dowels, screws or other means of securing the liners to the shafts are not acceptable.

3.2 Protection of propeller shaft against corrosion

3.2.1 The propeller shaft surface between the propeller and the sterntube, and in way of propeller nut, is to be suitably protected in order to prevent any entry of sea water, unless the shaft is made of austenitic stainless steel.

4 Material tests, workshop inspection and testing, certification

4.1 Material and non-destructive tests, workshop inspections and testing

4.1.1 Material tests

Shafting components are to be tested in accordance with Tab 4 and in compliance with the requirements of Part D.

Magnetic particle or liquid penetrant tests are required for the parts listed in Tab 4 and are to be effected in positions mutually agreed upon by the Manufacturer and the Surveyor, where experience shows defects are most likely to occur.

4.1.2 Hydrostatic tests

Parts of hydraulic couplings, clutches of hydraulic reverse gears and control units, hubs and hydraulic cylinders of controllable pitch propellers, including piping systems and associated fittings, are to be hydrostatically tested to1,5 times the maximum working pressure.

Sterntubes, when machine-finished, and propeller shaft liners, when machine-finished on the inside and with an overthickness not exceeding 3 mm on the outside, are to be hydrostatically tested to 0,2 MPa.

4.2 Certification

4.2.1 Testing certification

Society's certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests of components in items 1 to 5 of Tab 4.

Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for hydrostatic tests of components indicated in [4.1.2] and for material and non-destructive tests of components in items of Tab 4 other than those for which Society's certificates (C) are required.

Table 3 : Shafting of propulsion machinery

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Temperature of each shaft thrust bearing (non applicable for ball or roller bearings)	H		X				
Stern tube bush oil gravity tank level	L						

Table 4 : Material and non-destructive tests

Shafting component	Material tests (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic
1) Coupling (separate from shafts)	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
2) Propeller shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
3) Intermediate shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
4) Thrust shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
5) Cardan shafts (flanges, crosses, shafts, yokes)	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
6) Sterntubes	all	-	-
7) Sterntube bushes and other shaft bearings	all	-	-
8) Propeller shaft liners	all	-	-
9) Coupling bolts or studs	all	-	-
10) Flexible couplings (metallic parts only)	all	-	-
11) Thrust sliding-blocks (frame only)	all	-	-

SECTION 6 PROPELLERS

1 General

1.1 Application

1.1.1 Propulsion propellers

The requirements of this Section apply to propellers of any size and type intended for propulsion. They comprise fixed and controllable pitch propellers, including those ducted in fixed nozzles.

1.1.2 Manoeuvring thruster propellers

For manoeuvring thruster propellers see Sec 10.

1.2 Definitions

1.2.1 Solid propeller

A solid propeller is a propeller (including hub and blades) cast in one piece.

1.2.2 Built-up propeller

A built-up propeller is a propeller cast in more than one piece. In general, built up propellers have the blades cast separately and fixed to the hub by a system of bolts and studs.

1.2.3 Controllable pitch propellers

Controllable pitch propellers are built-up propellers which include in the hub a mechanism to rotate the blades in order to have the possibility of controlling the propeller pitch in different service conditions.

1.2.4 Nozzle

A nozzle is a circular structural casing enclosing the propeller.

1.2.5 Ducted propeller

A ducted propeller is a propeller installed in a nozzle.

1.2.6 Skewed propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

1.2.7 Highly skewed propellers and very highly skewed propellers

Highly skewed propellers are propellers having blades with skew angle between 25° and 50°. Very highly skewed propellers are propellers having blades with skew angle exceeding 50°.

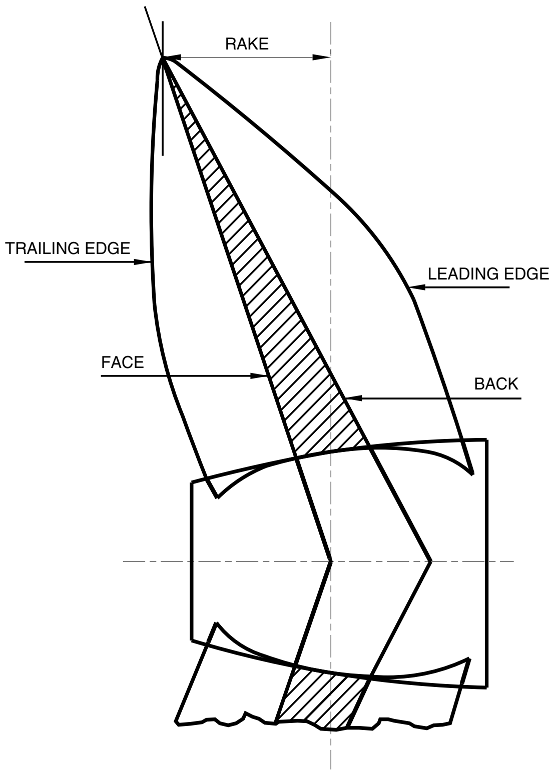
1.2.8 Leading edge

The leading edge of a propeller blade is the edge of the blade at side entering the water while the propeller rotates (see Fig 1).

1.2.9 Trailing edge

The trailing edge of a propeller blade is the edge of the blade opposite the leading edge (see Fig 1).

Figure 1 : Rake



1.2.10 Developed area ratio

Developed area ratio is the ratio of the total blade developed area to the area of the ring included between the propeller diameter and the hub diameter.

1.3 Documentation to be submitted

1.3.1 Solid propellers

The documents listed in Tab 1 are to be submitted for solid propellers intended for propulsion.

All listed plans are to be constructional plans complete with all dimensions and are to contain full indication of types of materials employed.

Table 1 : Documents to be submitted for solid propellers

No.	A/I **(1)**	ITEM
1	A	Sectional assembly
2	A	Blade and hub details
3	I	Rating (power, rpm, etc.)
4	A	Data and procedures for fitting propeller to the shaft
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.3.2 Built-up and controllable pitch propellers

The documents listed in Tab 2, as applicable, are to be submitted for built-up and controllable pitch propellers intended for propulsion.

Table 2 : Documents to be submitted for built-up and controllable pitch propellers

No.	A/I **(1)**	ITEM
1	A/I	Same documents requested for solid propellers
2	A	Blade bolts and pre-tensioning procedures
3	I	Pitch corresponding to maximum propeller thrust and to normal service condition
4	A	Pitch control mechanism
5	A	Pitch control hydraulic system
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.3.3 Very highly skewed propellers and propellers of unusual design

For very highly skewed propellers and propellers of unusual design, in addition to the documents listed in Tab 1 and Tab 2, as applicable, a detailed hydrodynamic load and stress analysis is to be submitted (see [2.4.2]).

2 Design and construction

2.1 Materials

2.1.1 Normally used materials for propeller hubs and blades

a) Tab 3 indicates the minimum tensile strength R_m (in N/mm²), the density δ (in kg/dm³) and the material factor f of normally used materials.

b) Common bronze, special types of bronze and cast steel used for the construction of propeller hubs and blades are to have a minimum tensile strength of 400 N/mm².

c) Other materials are subject of special consideration by the Society following submission of full material specification.

Table 3 : Normally used materials for propeller blades and hub

Material	R_m	δ	f
Common brass	400	8,3	7,6
Manganese brass (Cu1)	440	8,3	7,6
Nickel-manganese brass (Cu2)	440	8,3	7,9
Aluminium bronze (Cu3 and Cu4)	590	7,6	8,3
Steel	440	7,9	9,0

2.1.2 Materials for studs

In general, steel (preferably nickel-steel) is to be used for manufacturing the studs connecting steel blades to the hub of built-up or controllable pitch propellers, and high tensile brass or stainless steel is to be used for studs connecting bronze blades.

2.2 Solid propellers - Blade thickness

2.2.1

a) The maximum thickness $t_{0.25}$, in mm, of the solid propeller blade at the section at 0,25 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,25} = 3,2\left[f\cdot\frac{1,5.10^6.\rho.M_T + 51.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l\cdot z\cdot R_m}\right]^{0,5}$$

where:

- f : Material factor as indicated in Tab 3
- ρ : D/H
- H : Mean pitch of propeller, in m. When H is not known, the pitch $H_{0.7}$ at 0,7 radius from the propeller axis, may be used instead of H.
- D : Propeller diameter, in m
- M_T : Continuous transmitted torque, in kN.m; where not indicated, the value given by the following formula may be assumed for M_T :

$$M_T = 9,55\cdot\left(\frac{P}{N}\right)$$

- P : Maximum continuous power of propulsion machinery, in kW
- N : Rotational speed of the propeller, in rev/min
- δ : Density of blade material, in kg/dm³, as indicated in Tab 3
- B : Expanded area ratio
- h : Rake, in mm
- l : Developed width of blade section at 0,25 radius from propeller axis, in mm
- z : Number of blades
- R_m : Minimum tensile strength of blade material, in N/mm².

b) The maximum thickness $t_{0,6}$, in mm, of the solid propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,6} = 1,9\left[f\frac{1,5.10^6.\rho_{0,6}.M_T + 18,4.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l_{0,6}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,6}$: $D/H_{0.6}$

$H_{0.6}$: Pitch at 0,6 radius from the propeller axis, in m

$l_{0.6}$: Developed width of blade section at 0,6 radius from propeller axis, in mm.

c) The radius at the blade root is to be at least ¾ of the required minimum thickness $t_{0,25}$. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account. If the propeller hub extends over 0,25 radius, the thickness calculated by the formula in a) is to be compared with the thickness obtained by linear interpolation of the actual blade thickness up to 0,25 radius.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller material R_m.

2.3 Built-up propellers and controllable pitch propellers

2.3.1 Blade thickness

a) The maximum thickness $t_{0,35}$, in mm, of the blade at the section at 0,35 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,35} = 2,7\left[f\frac{1,5.10^6.\rho_{0,7}.M_T + 41.\delta\left(\frac{D}{100}\right)^3 B.l_{0,35}.N^2 h}{l_{0,35}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,7}$: $D/H_{0.7}$

$H_{0.7}$: Pitch at 0,7 radius from the propeller axis, in m. The pitch to be used in the formula is the actual pitch of the propeller when the propeller develops the maximum thrust.

$l_{0.35}$: Developed width of blade section at 0,35 radius from propeller axis, in mm.

b) The maximum thickness $t_{0,6}$, in mm, of the propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the formula in [2.2.1], item b, using the value of $l_{0,35}$ in lieu of l.

c) The radius at the blade root is to be at least ¾ of the required minimum thickness $t_{0,35}$. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller blade material R_m.

2.3.2 Flanges for connection of blades to hubs

a) The diameter D_F, in mm, of the flange for connection to the propeller hub is not to be less than that obtained from the following formula:

$$D_F = D_C + 1,8 d_{PR}$$

where:

D_C : Stud pitch circle diameter, in mm

d_{PR} : Diameter of studs.

b) The thickness of the flange is not to be less than 1/10 of the diameter D_F.

2.3.3 Connecting studs

a) The diameter d_{PR}, in mm, at the bottom of the thread of the studs is not to be less than that obtained from the following formula:

$$d_{PR} = \left(\frac{4,6.10^7.\rho_{0,7}.M_T + 0,88.\delta.\left(\frac{D}{10}\right)^3.B.l_{0,35}.N^2.h_1}{n_{PR}\cdot z\cdot D_C\cdot R_{m,PR}}\right)^{0,5}$$

where:

h_1 : $h + 1,125\ D_C$

n_{PR} : Total number of studs in each blade,

$R_{m,PR}$: Minimum tensile strength of stud material, in N/mm^2.

b) The studs are to be tightened in a controlled manner such that the tension on the studs is approximately 60-70 % of their yield strength.

c) The shank of studs may be designed with a minimum diameter equal to 0,9 times the root diameter of the thread.

d) The studs are to be properly secured against unintentional loosening.

2.4 Skewed propellers

2.4.1 Skewed propellers

The thickness of skewed propeller blades may be obtained by the formulae in [2.2] and [2.3.1], as applicable, provided the skew angle is less than 25°.

2.4.2 Highly skewed propellers

a) For solid and controllable pitch propellers having skew angles between 25° and 50°, the blade thickness, in mm, is not to be less than that obtained from the following formulae:

1) For solid propellers

$$t_{S-0,25} = t_{0,25} \cdot (0,92 + 0,0032\vartheta)$$

2) For built-up and controllable pitch propellers

$$t_{S-0,35} = t_{0,35} \cdot (0,9 + 0,004\vartheta)$$

3) For all propellers

$$t_{S-0,6} = t_{0,6} \cdot (0,74 + 0,0129\vartheta - 0,0001\vartheta^2)$$
$$t_{S-0,9} = t_{0,6} \cdot (0,35 + 0,0015\vartheta)$$

where:

- $t_{S-0,25}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,25 radius from the propeller axis
- $t_{0,25}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,25 radius from the propeller axis, obtained by the formula in [2.2.1]
- $t_{S-0,35}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,35 radius from the propeller axis
- $t_{0,35}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,35 radius from the propeller axis, obtained by the formula in [2.3.1]
- $t_{S-0,6}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,6 radius from the propeller axis
- $t_{0,6}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,6 radius from the propeller axis, obtained by the formula in [2.2.1]
- $t_{S-0,9}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,9 radius from the propeller axis
- ϑ : Skew angle.

b) As an alternative, highly skewed propellers may be accepted on the basis of a stress analysis, as stated in [2.4.3] for very highly skewed propellers.

2.4.3 Very highly skewed propellers

For very highly skewed propellers, the blade thickness is to be obtained by a stress analysis according to a calculation criteria accepted by the Society. The safety factor to be used in this direct analysis is not to be less than 9 with respect to the ultimate tensile strength of the propeller blade material, R_m.

2.5 Ducted propellers

2.5.1 The minimum blade thickness of propellers with wide tip blades running in nozzles is not to be less than the values obtained by the applicable formula in [2.2] or [2.3.1], increased by 10%.

2.6 Features

2.6.1 Blades and hubs

a) All parts of propellers are to be free of defects and are to be built and installed with clearances and tolerances in accordance with sound marine practice.

b) Particular care is to be taken with the surface finish of the blades.

2.6.2 Controllable pitch propellers pitch control system

a) The general requirements given in Sec 8, [12] apply.

b) Separate oil systems intended for the control of controllable pitch propellers are to include at least two power pumps, of such a capacity as to maintain normal control with any one pump out of action.

c) In the case of propulsion plants comprising:

- more than one shaft line with the propellers fitted with their own control system,
- or one engine with an output not exceeding 375 kW,

one of the pumps mentioned in b) may be a spare pump ready to be connected to the oil control system, provided disassembling and reassembling operations can be carried out on board in a short time.

d) However, when the propulsion plant comprises one or more engines, each with an output not exceeding 375 kW, the standby or spare pump may be omitted for the controllable pitch propellers provided that they are so designed as to be fixed mechanically in the "forward" position and that the capacity of the starting means ensures the numbers of starts required in such conditions.

e) Pitch control systems are to be provided with an engine room indicator showing the actual setting of the blades. Further blade position indicators are to be mounted on the bridge and in the engine control room, if any.

f) Suitable devices are to be fitted to ensure that an alteration of the blade setting cannot overload the propulsion plant or cause it to stall.

g) Steps are to be taken to ensure that, in the event of failure of the control system, the setting of the blades

- does not change, or
- assumes a final position slowly enough to allow the emergency control system to be put into operation.

h) Controllable pitch propeller systems are to be equipped with means of emergency control enabling the controllable pitch propeller to operate should the remote control system fail. This requirement may be complied with by means of a device which locks the propeller blades in the "ahead" setting.

i) Tab 4 indicates the monitoring requirements to be displayed at the control console.

3 Arrangement and installation

3.1 Fitting of propeller on the propeller shaft

3.1.1 General

a) Screw propeller hubs are to be properly adjusted and fitted on the propeller shaft cone.

b) The forward end of the hole in the hub is to have the edge rounded to a radius of approximately 6 mm.

c) In order to prevent any entry of sea water under the liner and onto the end of the propeller shaft, the arrangement of Fig 2 is generally to be adopted for assembling the liner and propeller boss.

d) The external stuffing gland is to be provided with a seawater resistant rubber ring preferably without joints. The clearance between the liner and the internal air space of the boss is to be as small as possible. The internal air space is to be filled with an appropriate protective material which is insoluble in sea water and non-corrodible or fitted with a rubber ring.

e) All free spaces between the propeller shaft cone, propeller boss, nut and propeller cap are to be filled with a material which is insoluble in sea water and non-corrodible. Arrangements are to be made to allow any air present in these spaces to withdraw at the moment of filling. It is recommended that these spaces be tested under a pressure at least equal to that corresponding to the immersion of the propeller in order to check the tightness obtained after filling.

f) For propeller keys and key area, see Sec 5, [2.5.5].

3.1.2 Shrinkage of keyless propellers

In the case of keyless shrinking of propellers, the following requirements apply:

a) The meaning of the symbols used in the subparagraphs below is as follows:

A : 100% theoretical contact area between propeller boss and shaft, as read from plans and disregarding oil grooves, in mm²

d_{PM} : Diameter of propeller shaft at the mid-point of the taper in the axial direction, in mm

d_H : Mean outer diameter of propeller hub at the axial position corresponding to d_{PM}, in mm

K : $K = d_H/d_{PM}$

F : Tangential force at interface, in N

M_T : Continuous torque transmitted; in N.m, where not indicated, M_T may be assumed as indicated in [2.2.1]

C :
- C = 1 for turbines, geared diesel engines, electrical drives and direct-drive reciprocating internal combustion engines with a hydraulic, electromagnetic or high elasticity coupling,
- C = 1,2 for diesel engines having couplings other than those specified above.

The Society reserves the right to increase the value of C if the shrinkage needs to absorb an extremely high pulsating torque,

T : Temperature of hub and propeller shaft material, in °C, assumed for calculation of pull-up length and push-up load

V : Ship speed at P power, in knots

S : Continuous thrust developed for free running ship, in N

s_F : Safety factor against friction slip at 35°C

θ : Half taper of propeller shaft (for instance: taper = 1/15, θ =1/30)

μ : Coefficient of friction between mating surfaces

p_{35} : Surface pressure between mating surfaces, in N/mm², at 35°C

p_T : Surface pressure, in N/mm², between mating surfaces at temperature T

p_0 : Surface pressure between mating surfaces, in N/mm², at 0°C

p_{MAX} : Maximum permissible surface pressure, in N/mm², at 0°C

d_{35} : Push-up length, in mm, at 35°C

d_T : Push-up length, in mm, at temperature T

d_{MAX} : Maximum permissible pull-up length, in mm, at 0°C

W_T : Push-up load, in N, at temperature T

σ_{ID} : Equivalent uni-axial stress in the boss according to the von Mises-Hencky criterion, in N/mm²

α_P : Coefficient of linear expansion of shaft material, in mm/(mm°C)

α_M : Coefficient of linear expansion of boss material, in mm/(mm°C)

E_P : Value of the modulus of elasticity of shaft material, in N/ mm²

E_M : Value of the modulus of elasticity of boss material, in N/ mm²

ν_P : Poisson's ratio for shaft material

ν_M : Poisson's ratio for boss material

$R_{S,MIN}$: Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\,0,2}$), of propeller boss material, in N/mm².

For other symbols not defined above, see [2.2].

b) The manufacturer is to submit together with the required constructional plans specifications containing all elements necessary for verifying the shrinkage. Tests and checks deemed necessary for verifying the characteristics and integrity of the propeller material are also to be specified.

c) The formulae and other provisions below do not apply to propellers where a sleeve is introduced between shaft and boss or in the case of hollow propeller shafts. In such cases, a direct shrinkage calculation is to be submitted to the Society.

d) The taper of the propeller shaft cone is not to exceed 1/15.

e) Prior to final pull-up, the contact area between the mating surfaces is to be checked and is not to be less than

70% of the theoretical contact area (100%). Non-contact bands extending circumferentially around the boss or over the full length of the boss are not acceptable.

f) After final push-up, the propeller is to be secured by a nut on the propeller shaft. The nut is to be secured to the shaft.

g) The safety factor s_F against friction slip at 35°C is not to be less than 2,8, under the combined action of torque and propeller thrust, based on the maximum continuous power P for which classification is requested at the corresponding speed of rotation N of the propeller, plus pulsating torque due to torsionals.

h) For the oil injection method, the coefficient of friction μ is to be 0,13 in the case of bosses made of copper-based alloy and steel. For other methods, the coefficient of friction will be considered in each case by the Society.

i) The maximum equivalent uni-axial stress in the boss at 0°C, based on the von Mises-Hencky criterion, is not to exceed 70% of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the propeller material, based on the test piece value. For cast iron, the value of the above stress is not to exceed 30% of the nominal tensile strength.

j) For the formulae given below, the material properties indicated in the following items are to be assumed:
   - Modulus of elasticity, in N/mm²:
     Cast and forged steel: E = 206000
     Cast iron: E = 98000
     Type Cu1 and Cu2 brass: E = 108000
     Type Cu3 and Cu4 brass: E = 118000
   - Poisson's ratio:
     Cast and forged steel: ν = 0,29
     Cast iron: ν = 0,26
     All copper based alloys: ν = 0,33
   - Coefficient of linear expansion in mm/(mm°C)
     Cast and forged steel and cast iron: $\alpha = 12{,}0\ 10^{-6}$
     All copper based alloys: $\alpha = 17{,}5\ 10^{-6}$

k) For shrinkage calculation the formulae in the following items, which are valid for the ahead condition, are to be applied. They will also provide a sufficient margin of safety in the astern condition.
   - Minimum required surface pressure at 35°C:

$$p_{35} = \frac{s_F S}{AB} \cdot \left[-s_F\theta + \left(\mu^2 + B \cdot \frac{F^2}{S^2}\right)^{0,5} \right]$$

     where:
     $B = \mu^2 - s_F^2\theta^2$
   - Corresponding minimum pull-up length at 35°C:

$$d_{35} = \frac{p_{35} d_{PM}}{2\theta} \cdot \left[\frac{1}{E_M} \cdot \left(\frac{K^2+1}{K^2-1} + \nu_M \right) + \frac{1-\nu_P}{E_P} \right]$$

   - Minimum pull-up length at temperature T (T<35°C):

$$d_T = d_{35} + \frac{d_{PM}}{2\theta} \cdot (\alpha_M - \alpha_P) \cdot (35 - T)$$

   - Corresponding minimum surface pressure at temperature T:

$$p_T = p_{35} \cdot \frac{d_T}{d_{35}}$$

   - Minimum push-up load temperature T:

$$W_T = Ap_T \cdot (\mu + \theta)$$

   - Maximum permissible surface pressure at 0°C:

$$p_{MAX} = \frac{0{,}7 R_{S,MIN} \cdot (K^2 - 1)}{(3K^4 + 1)^{0,5}}$$

   - Corresponding maximum permissible pull-up length at 0°C:

$$d_{MAX} = d_{35} \cdot \frac{p_{MAX}}{p_{35}}$$

   - Tangential force at interface:

$$F = \frac{2000 C M_T}{d_{PM}}$$

   - Continuous thrust developed for free running ship; if the actual value is not given, the value, in N, calculated by one of the following formulae may be considered:

$$S = 1760 \cdot \frac{P}{V}$$

$$S = 57{,}3 \cdot 10^3 \cdot \frac{P}{H \cdot N}$$

3.1.3 Circulating currents

Means are to be provided to prevent circulating electric currents from developing between the propeller and the hull. A description of the type of protection provided and its maintenance is to be kept on board.

4 Testing and certification

4.1 Material tests

4.1.1 Solid propellers

Material used for the construction of solid propellers is to be tested in accordance with the requirements of Part D of the Rules in the presence of the Surveyor.

4.1.2 Built-up propellers and controllable pitch propellers

In addition to the requirement in [4.1.1], materials for studs and for all other parts of the mechanism transmitting torque are to be tested in the presence of the Surveyor.

4.2 Testing and inspection

4.2.1 Inspection of finished propeller

Finished propellers are to be inspected at the manufacturer's plant by the Surveyor. At least the following checks are to be carried out:

- visual examination of the entire surface of the propeller blades
- conformity to approved plans of blade profile
- liquid penetrant examination of suspected and critical parts of the propeller blade, to the satisfaction of the Surveyor.

4.2.2 Controllable pitch propellers

The complete hydraulic system for the control of the controllable pitch propeller mechanism is to be hydrotested at a pressure equal to 1,5 times the design pressure. The proper operation of the safety valve is to be tested in the presence of the Surveyor.

4.2.3 Balancing

Finished propellers are to be statically balanced. For built-up and controllable pitch propellers, the required static balancing of the complete propeller may be replaced by an individual check of blade weight and gravity centre position.

4.3 Certification

4.3.1 Certification of propellers

Propellers having the characteristics indicated in [1.1.1] are to be individually tested and certified by the Society.

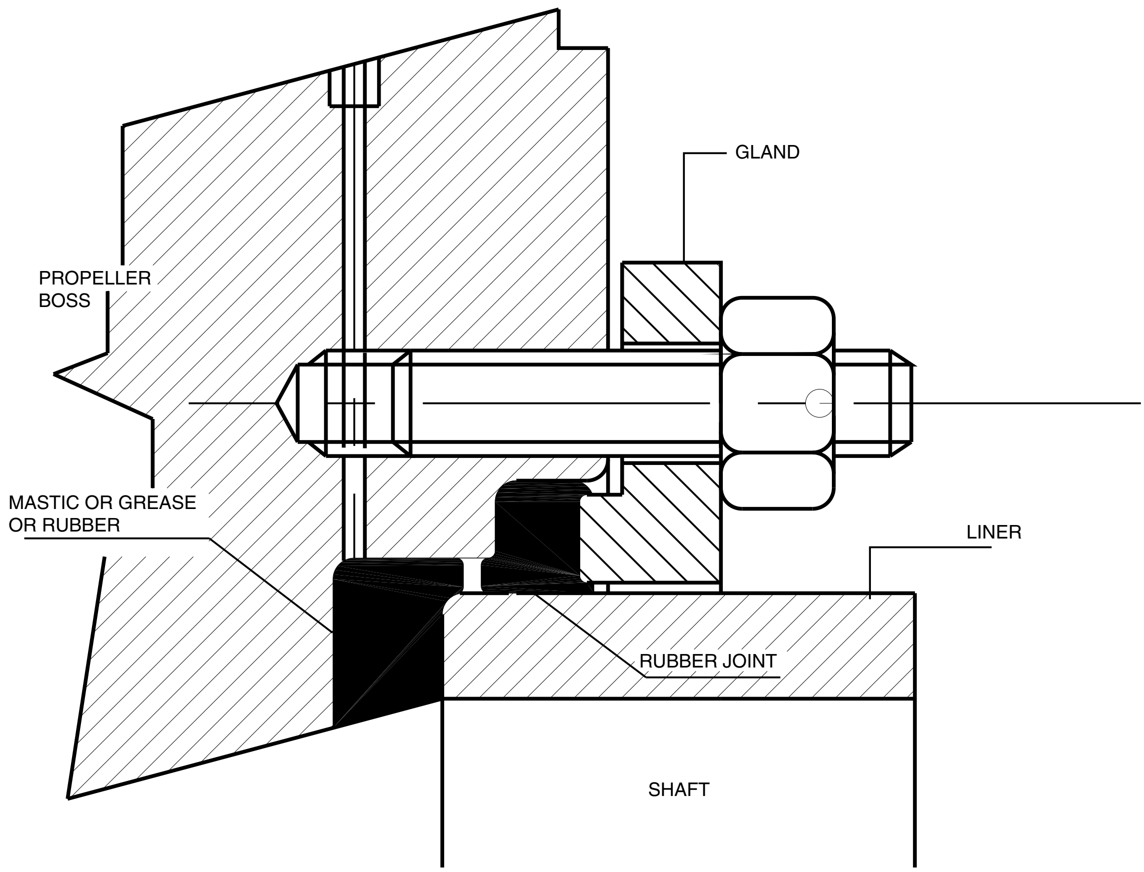
4.3.2 Mass produced propellers

Mass produced propellers may be accepted within the framework of the type approval program of the Society.

Table 4 : Controllable pitch propeller monitoring

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Pump pressure	L						
Oil tank level	L						

Figure 2 : Example of sealing arrangement



SECTION 7 SHAFT VIBRATIONS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the shafting of the following installations:

- propulsion systems with prime movers developing 220 kW or more
- other systems with internal combustion engines developing 110 kW or more and driving auxiliary machinery intended for essential services.

1.1.2 Exemptions

The requirements of this Section may be waived at the Society's discretion in cases where satisfactory service operation of similar installations is demonstrated.

1.2 Submission of documentation

1.2.1 As the analysis of the vibration behaviour of systems is part of their design, the relevant documentation, as listed in [3.2], is to be promptly submitted for approval.

2 Design of systems in respect of vibrations

2.1 Principle

2.1.1 General

Calculations are to be carried out for all the configurations of the system likely to have any influence on the torsional vibrations (i.e. normal operations, misfiring).

2.1.2 Vibration levels

Systems are to have torsional vibrations both in continuous and in transient running acceptable to the Manufacturers, and in accordance with the requirements of this Section.

Where vibrations are found to exceed the limits stated in this Section, the Designer or the builder of the plant is to propose corrective actions, such as:

- operating restrictions, provided that the Owner is informed, or
- modification of the plant.

2.1.3 Condition of components

Systems are to be designed considering essential components in a non-ideal condition. In particular, the following conditions are to be considered:

- propulsion engine: cylinder malfunction,
- flexible coupling: possible variation of the stiffness or damping characteristics due to heating or ageing,
- vibration damper: possible variation of the damping coefficient.

2.2 Modifications of existing plants

2.2.1 Where substantial modifications of existing plants, such as:

- change of the running speed or power of the engine,
- replacement of an essential component of the system (propeller, flexible coupling, damper) by one of different characteristics, or
- connection of a new component,

are carried out, new vibration analysis is to be submitted for approval.

3 Torsional vibrations

3.1 General

3.1.1 The torsional vibration torques (or stresses) calculated in the various components of the installation are additional to those resulting from the mean power transmitted by such components. Where the scantling formulae given in Sec 7 and App 1 are applied, the vibratory torques are not to be taken into account unless otherwise stated.

3.2 Documentation to be submitted

3.2.1 Calculations

Torsional vibration calculations are to be submitted for the various configurations of the plants, showing:

- the equivalent dynamic system used for the modelling of the plant, with indication of:
  - inertia and stiffness values for all the components of the system
  - diameter and material properties of the shafts
- the natural frequencies
- the values of the vibratory torques or stresses in the components of the system for the most significant critical speeds and their analysis in respect of the Rules and other acceptance criteria
- the possible restrictions of operation of the plant.

3.2.2 Particulars to be submitted

The following particulars are to be submitted with the torsional vibration calculations:

a) for installations with controllable pitch propellers, the power/rotational speed values resulting from the combinator operation

b) for prime movers, the service speed range and the minimum speed at no load

c) for internal combustion engines:
   - Manufacturer and type
   - nominal output and rotational speed
   - mean indicated pressure
   - number of cylinders
   - "V" angle
   - firing angles
   - bore and stroke
   - excitation data, such as the polynomial law of harmonic components of excitations
   - nominal alternating torsional stress considered for crankpin and journal

Note 1: The nominal alternating torsional stress is part of the basic data to be considered for the assessment of the crankshaft. It is defined in App 1.

d) for reduction or step-up gears, the speed ratio for each step
e) for flexible couplings, the data required in Sec 5, [2.1.3]
f) for torsional vibration dampers:
   - the Manufacturer and type
   - the permissible heat dissipation
   - the damping coefficient
   - the inertial and stiffness properties, as applicable
g) for propellers:
   - the number of blades
   - the excitation and damping data, if available
h) for electric motors, generators and pumps, the drawing of the rotating parts, with their mass moment of inertia and main dimensions.

3.3 Definitions, symbols and units

3.3.1 Definitions

a) Torsional vibration stresses referred to in this Article are the stresses resulting from the alternating torque corresponding to the synthesis of the harmonic orders concerned.
b) The misfiring condition of an engine is the malfunction of one cylinder due to the absence of fuel injection (which results in a pure compression or expansion in the cylinder).

3.3.2 Symbols, units

The main symbols used in this Article are defined as follows:

τ : Torsional vibration stress, as defined in [3.3.1], in N/mm^2

τ_1 : Permissible stress due to torsional vibrations for continuous operation, in N/mm^2

τ_2 : Permissible stress due to torsional vibrations for transient running, in N/mm^2

R_m : Tensile strength of the shaft material, in N/mm^2

C_R : Material factor, equal to:

$$\frac{R + 160}{18}$$

d : Minimum diameter of the shaft, in mm

C_D : Size factor of the shaft, equal to:

$$0,35 + 0,93\ d^{-0,2}$$

N : Speed of the shaft for which the check is carried out, in rev/min

N_n : Nominal speed of the shaft, in rev/min

N_c : Critical speed, in rev/min

λ : Speed ratio, equal to N/N_n

C_λ : Speed ratio factor, equal to:
   - $3 - 2\,\lambda^2$ for $\lambda < 0,9$
   - $1,38$ for $0,9 \leq \lambda \leq 1,05$

C_k : Factor depending on the shaft design features given in Tab 1.

3.4 Calculation principles

3.4.1 Method

a) Torsional vibration calculations are to be carried out using a recognised method.
b) Where the calculation method does not include harmonic synthesis, attention is to be paid to the possible superimposition of two or more harmonic orders of different vibration modes which may be present in some restricted ranges.

Table 1 : Values of C_K factors

Intermediate shafts						Thrust shafts external to engines		Propeller shafts	
with integral coupling flanges and straight sections	with shrink-fit couplings	with keyways, tapered connection	with keyways, cylindrical connection	with radial holes	with longitudinal slots	on both sides of thrust collar	in way of axial bearing where a roller bearing is used as a thrust bearing	for which **(5)** k = 1,22 or k = 1,26	for which **(5)** k = 1,15
1,00 **(1)**	1,00 **(2)**	0,60 **(3)**	0,45 **(3)**	0,50	0,30 **(4)**	0,85	0,85	0,55	0,80

(1) Value applicable in the case of fillet radii in accordance with the provisions of Sec 5, [2.5.1].

(2) C_K refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2 % and a blending radius as described inof Sec 5, [2.2.1].

(3) Keyways are, in general, not to be used in installations with a barred speed range.

(4) C_K = 0,3 is a safe approximation within the limitations in (6) of Sec 5, Tab 2. If the slot dimensions are outside of the above limitations, or if the use of another C_K is desired, the actual stress concentration factor (scf) is to be documented or determined from the criteria of accumulated fatigue. In which case:

C_K = 1,45/scf

Note that the scf is defined as the ratio between the maximum local principal stress and $3^{0,5}$ times the nominal torsional stress (determined for the bored shaft without slots).

(5) k is defined in Sec 5.

Note 1: For explanation of c_K and stress concentration factor of slots, seeof Sec 5, Tab 2.

Note 2: The determination of C_K factors for shafts other than those given in this table will be given special consideration by the Society.

3.4.2 Scope of the calculations

a) Torsional vibration calculations are to be carried out considering:
   - normal firing of all cylinders, and
   - misfiring of one cylinder.

b) Where the torsional dynamic stiffness of the coupling depends on the transmitted torque, two calculations are to be carried out:
   - one at full load
   - one at the minimum load expected in service.

c) For installations with controllable pitch propellers, two calculations are to be carried out:
   - one for full pitch condition
   - one for zero pitch condition.

d) The calculations are to take into account all possible sources of excitation. Electrical sources of excitations, such as static frequency converters, are to be detailed.

e) The natural frequencies are to be considered up to a value corresponding to 15 times the maximum service speed. Therefore, the excitations are to include harmonic orders up to the fifteenth.

3.4.3 Criteria for acceptance of the torsional vibration loads under normal firing conditions

a) Torsional vibration stresses in the various shafts are not to exceed the limits defined in [3.5]. Higher limits calculated by an alternative method may be considered, subject to special examination by the Society.

   The limit for continuous running τ_1 may be exceeded only in the case of transient running in restricted speed ranges, which are defined in [3.5.5]. In no case are the torsional vibration stresses to exceed the limit for transient running τ_2.

   Propulsion systems are to be capable of running continuously without restrictions at least within the speed range between 0,8 N_n and 1,05 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,8$.

   Auxiliary machinery is to be capable of running continuously without restrictions at least within the range between 0,95 N_n and 1,1 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,95$.

b) Torsional vibration levels in other components are to comply with the provisions of [3.6].

3.4.4 Criteria for acceptance of torsional vibration loads under misfiring conditions

a) The provisions of [3.4.3] related to normal firing conditions also apply to misfiring conditions except that restricted speed ranges are also acceptable for $\lambda > 0,8$.

   The restricted speed ranges in one-cylinder misfiring condition of single propulsion engine ships are to enable safe navigation.

b) Where calculations show that the limits imposed for certain components may be exceeded under misfiring conditions, a suitable device is to be fitted to indicate the occurence of such conditions.

3.5 Permissible limits for torsional vibration stresses in crankshaft, propulsion shafting and other transmission shafting

3.5.1 General

a) The limits provided below apply to steel shafts. For shafts made of other material, the permissible limits for torsional vibration stresses will be determined by the Society after examination of the results of fatigue tests carried out on the material concerned.

b) These limits apply to the torsional vibration stresses as defined in [3.3.1]. They relate to the shaft minimum section, without taking account of the possible stress concentrations.

3.5.2 Crankshaft

a) Where the crankshaft has been designed in accordance with App 1, the torsional vibration stresses in any point of the crankshaft are not exceed the following limits:
   - $\tau_1 = \tau_N$ for continuous running
   - $\tau_2 = 1,7\ \tau_N$ for transient running,

   where τ_N is the nominal alternating torsional stress on which the crankshaft scantling is based (see [3.2.2], Note 1).

b) Where the crankshaft has not been designed in accordance with App 1, the torsional vibration stresses in any point of the crankshaft are not to exceed the following limits:
   - $\tau_1 = 0,55 \,.\, C_R \,.\, C_D \,.\, C_\lambda$ for continuous running
   - $\tau_2 = 2,3\ \tau_1$ for transient running.

3.5.3 Intermediate shafts, thrust shafts and propeller shafts

The torsional vibration stresses in any intermediate, thrust and propeller shafts are not to exceed the following limits:

- $\tau_1 = C_R \,.\, C_k \,.\, C_D \,.\, C_\lambda$ for continuous running
- $\tau_2 = 1,7\ \tau_1 \,.\, C_k^{-0,5}$ for steady state conditions within barred speed range.

Note 1: For intermediate, thrust and propeller shafts, the material factor C_R is not to be taken as greater than 42,2.

3.5.4 Transmission shafting for generating sets and other auxiliary machinery

The torsional vibration stresses in the transmission shafting for generating sets and other auxiliary machinery, such as pumps or compressors, are not to exceed the following limits:

- $\tau_1 = 0,90 \,.\, C_R \,.\, C_D$ for continuous running
- $\tau_2 = 5,4\ \tau_1$ for transient running.

3.5.5 Restricted speed ranges

a) Where the stress amplitudes exceed the limiting values of τ_1 for continuous operation, including one cylinder misfiring conditions, restricted speed ranges are to be imposed which are to be passed through rapidly;

b) restricted speed ranges in one cylinder misfiring conditions of single propulsion engine ships are to enable safe navigation;

c) the barred speed range is to cover all speeds where the acceptance limits (τ_1) are exceeded. For controllable pitch propellers with the possibility of individual pitch and speed control, both full and zero pitch conditions are to be considered.

   Additionally, the tachometer tolerance is to be added. At each end of the barred speed range the engine is to be stable in operation;

d) the limits of the restricted speed range related to a critical speed N_c are to be calculated in accordance with the following formula:

$$\frac{16 \cdot N_c}{18 - \lambda} \leq N \leq \frac{(18 - \lambda) \cdot N_c}{16}$$

e) where the resonance curve of a critical speed is obtained from torsional vibration measurements, the restricted speed range may be established considering the speeds for which the stress limit for continuous running τ_1 is exceeded;

f) where restricted speed ranges are imposed, they are to be crossed out on the tachometers and an instruction plate is to be fitted at the control stations indicating that:
   - the continuous operation of the engine within the considered speed range is not permitted
   - this speed range is to be passed through rapidly.

3.6 Permissible vibration levels in components other than shafts

3.6.1 Gears

a) The torsional vibration torque in any gear step is not to exceed 30% of the torque corresponding to the approved rating throughout the service speed range.

   Where the torque transmitted at nominal speed is less than that corresponding to the approved rating, higher torsional vibration torques may be accepted, subject to special consideration by the Society.

b) Gear hammering induced by torsional vibration torque reversal is not permitted throughout the service speed range, except during transient running at speed ratios $\lambda \leq 0,3$.

   Where calculations show the existence of torsional vibration torque reversals for speed ratios $\lambda > 0,3$, the corresponding speed ranges are to be identified by appropriate investigations during sea trials and considered as restricted speed ranges in accordance with [3.5.5].

3.6.2 Generators

a) In the case of alternating current generators, the torsional vibration amplitude at the rotor is not to exceed ±2,5 electrical degrees at service rotational speed under full load working conditions.

b) Vibratory inertia torques due to torsional vibrations and imposed on the rotating parts of the generator are not to exceed the values M_A, in N.m, calculated by the following formulae, as appropriate:
   - for $0,95 \leq \lambda \leq 1,1$: $M_A = \pm\ 2,5\ M_T$
   - for $\lambda \leq 0,95$: $M_A = \pm\ 6\ M_T$,

where:

M_T : Mean torque transmitted by the engine under full load running conditions, in N.m

Note 1: In the case of two or more generators driven by the same engine, the portion of M_T transmitted to each generator is to be considered.

λ : Speed ratio defined in [3.3.2].

3.6.3 Flexible couplings

a) Flexible couplings are to be capable of withstanding the mean transmitted torque and the torsional vibration torque throughout the service speed range, without exceeding the limits for continuous operation imposed by the Manufacturer (permissible vibratory torque and power loss).

Where such limits are exceeded under misfiring conditions, appropriate restrictions of power or speed are to be established.

b) Flexible couplings fitted in generating sets are also to be capable of withstanding the torques and twist angles arising from transient criticals and short-circuit currents.

3.6.4 Dampers

a) Torsional vibration dampers are to be such that the permissible power loss recommended by the Manufacturer is not exceeded throughout the service speed range.

b) Dampers for which a failure may lead to a significant vibration overload of the installation will be the subject of special consideration.

3.7 Torsional vibration measurements

3.7.1 General

a) The Society may require torsional vibration measurements to be carried out under its supervision in the following cases:
   - where the calculations indicate the possibility of dangerous critical speeds in the operating speed range,
   - where doubts arise as to the actual stress amplitudes or critical speed location, or
   - where restricted speed ranges need to be verified.

b) Where measurements are required, a comprehensive report including the analysis of the results is to be submitted to the Society.

3.7.2 Torsional vibration measurement

The Society may require torsional measurement after consideration of calculation results. After conversion or major alteration of the main propulsion plan, torsional vibration measurements may be required.

SECTION 8 PIPING SYSTEMS

1 General

1.1 Application

1.1.1

a) General requirements applying to all piping systems are contained in:
- [2] for their design and construction
- [3] for the welding of steel pipes
- [4] for the bending of pipes
- [5] for their arrangement and installation
- [20] for their certification, inspection and testing.

b) Specific requirements for ship piping systems and machinery piping systems are given in Articles [6] to [19].

1.2 Documentation to be submitted

1.2.1 Documents

The documents listed in Tab 1 are to be submitted.

1.2.2 Additional information

The information listed in Tab 2 is also to be submitted.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document **(2)**
1	A	Diagram of the bilge and ballast systems (in and outside machinery spaces)
2	I	Diagram of the drinking water and sewage system
3	A	Diagram of the air, sounding and overflow systems
4	A	Diagram of cooling systems (sea water and fresh water)
5	A	Diagram of fuel oil system
6	A	Diagram of the lubricating oil system
7	A	Diagram of the thermal oil system
8	A	Diagram of steam system, including safety valve exhaust and drain pipes
9	A	Diagram of the boiler feed water and condensate system
10	A	Diagram of the compressed air system
11	A	Diagram of systems for remotely controlled valves

(1) A = to be submitted for approval, in four copies;
I = to be submitted for information, in duplicate.
(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

Table 2 : Information to be submitted

No.	I/A **(1)**	Document
1	I	Nature, service temperature and pressure of the fluids
2	I	Material, external diameter and wall thickness of the pipes
3	I	Type of the connections between pipe lengths, including details of the weldings, where provided
4	I	Material, type and size of the accessories
5	A	Capacity, prime mover and, when requested, location of the pumps
6	I	Hose and compensator: material and, when requested, type approval information
7	A	For plastic pipes: • the chemical composition • the physical and mechanical characteristics in function of temperature • the characteristics of inflammability and fire resistance • the resistance to the products intended to be conveyed

(1) A = to be submitted for approval, in four copies;
I = to be submitted for information, in duplicate.

1.3 Definitions

1.3.1 Piping and piping systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include boilers, turbines, internal combustion engines and reduction gears.

Note 1: The equipment other than piping is to be designed in accordance with the relevant Sections of Chapter 1.

1.3.2 Design pressure

a) The design pressure of a piping system is the pressure considered by the manufacturer to determine the scantling of the system components. It is not to be taken less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

b) The design pressure of a boiler feed system is not to be less than 1,25 times the design pressure of the boiler or the maximum pressure expected in the feed piping, whichever is the greater.

c) The design pressure of steam piping located upstream of pressure reducing valves (high pressure side) is not to be less than the setting pressure of the boiler or superheater safety valves.

d) The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

e) The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than the setting pressure of the safety valve for displacement pumps or the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps, whichever is the greater.

1.3.3 Design temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

1.3.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils (having flashpoint lower than 150°C).

1.4 Symbols and units

1.4.1 The following symbols and related units are commonly used in this Section. Additional symbols, related to some formulae indicated in this Section, are listed wherever it is necessary.

p : Design pressure, in MPa

T : Design temperature, in °C

t : Rule required minimum thickness, in mm

D : Pipe external diameter, in mm.

1.5 Class of piping systems

1.5.1 Purpose of the classes of piping systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.5.2 Definitions of the classes of piping systems

a) Classes I, II and III are defined in Tab 3

b) The following systems are not covered by Tab 3:
- cargo piping for oil tankers, gas tankers and chemical tankers, and
- fluids for refrigerating plants.

2 General requirements for design and construction

2.1 Materials

2.1.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended.

2.1.2 Use of metallic materials

a) Metallic materials are to be used in accordance with Tab 4.

b) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of Part D.

c) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

d) Mechanical characteristics required for metallic materials are specified in Part D.

2.1.3 Use of plastics

a) Plastics may be used for piping systems belonging to class III in accordance with App 3. The use of plastics for other systems or in other conditions will be given special consideration.

b) Plastics intended for piping systems dealt with in this Section are to be of a type approved by the Society.

2.2 Thickness of pressure piping

2.2.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 5 to Tab 8.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

t_0 : Coefficient, in mm, equal to

$$t_0 = \frac{p \cdot D}{2Ke + p}$$

with:

p and D : as defined in [1.4.1],

K : Permissible stress defined in [2.2.2],

e : Weld efficiency factor to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society,
- specially considered by the Society for other welded pipes, depending on the service and the manufacture procedure.

b : Thickness reduction due to bending defined in [2.2.3], in mm

c : Corrosion allowance defined in [2.2.4], in mm

a : Negative manufacturing tolerance percentage:

- equal to 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society,
- equal to 12,5 for hot laminated seamless steel pipes,
- subject to special consideration by the Society in other cases.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

Table 3 : Class of piping systems

Media conveyed by the piping system	CLASS I	CLASS II	CLASS III
Fuel oil **(1)**	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Thermal oil	p > 1,6 or T > 300	other **(2)**	p ≤ 0,7 and T ≤ 150
Flammable Hydraulic oil without special safeguards **(3)**	p>1,6 or T>150	other **(2)**	p ≤ 0,7 and T≤60
Lubricating oil	p> 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Other flammable media: • heated above flashpoint, or • having flashpoint <60°C and liquefied gas	without special safeguards **(3)**	with special safeguards **(3)**	
Oxyacetylene	irrespective of p		
Toxic media	irrespective of p, T		
Corrosive media	without special safeguards **(3)**	with special safeguards **(3)**	
Steam	p > 1,6 or T > 300	other **(2)**	p ≤ 0,7 and T ≤ 170
Air, gases, water, non-flammable hydraulic oil **(4)**	p > 4 or T > 300	other **(2)**	p ≤ 1,6 and T ≤ 200
Open-ended pipes (drains, overflows, vents, exhaust gas lines, boiler escape pipes)			irrespective of T

(1) Valves under static pressure on fuel oil tanks belong to class II.
(2) Pressure and temperature conditions other than those required for class I and class III.
(3) Safeguards for reducing the possibility of leakage and limiting its consequences, e.g. pipes led in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas which may include the use of pipe ducts, shielding, screening, etc.
(4) Valves and fittings fitted on the ship side and collision bulkhead belong to class II.
Note 1: p : Design pressure, as defined in [1.3.2], in MPa.
Note 2: T : Design temperature, as defined in [1.3.3], in °C.

Table 4 : Conditions of use of metallic materials in piping systems

Material	Allowable classes	Maximum design temperature (°C) **(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II, I	400 **(2)**	Class I and II pipes are to be seamless drawn pipes **(3)**
Copper and aluminium brass	III, II, I	200	**(4)**
Copper-nickel	III, II, I	300	
Special high temperature resistant bronze	III, II, I	260	
Stainless steel	III, II, I	300	Austenitic stainless steel is not recommended for sea water systems
Spheroidal graphite cast iron	III, II	350	• Spheroidal cast iron of the ferritic type according to the material rules of the Society may be accepted for bilge, ballast and cargo oil piping • The use of this material for pipes, valves and fittings for other services, in principle Classes II and III, will be subject to special consideration • Minimum elongation is not to be less than 12% on a gauge length of $5,65.S^{0,5}$, where S is the actual cross-sectional area of the test piece • Not to be used for boiler blow-down valves and pieces for connection to the shell plating
Grey cast iron	III II **(5)**	220	Grey cast iron is not to be used for the following systems: • boiler blow-down systems and other piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the freeboard deck or for passengers ships below the bulkhead deck • ship side valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems • thermal oil systems
Aluminium and aluminium alloys	III, II **(6)**	200	Aluminium and aluminium alloys are not to be used on the following systems: • flammable oil systems • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • bilge system in boiler or machinery spaces or in spaces containing fuel oil tanks or pumping units • scuppers and overboard discharges except for pipes led to the bottoms or to the shell above the freeboard deck or fitted at their upper end with closing means operated from a position above the freeboard deck • boiler blow-down valves and pieces for connection to the shell plating.

(1) Maximum design temperature is not to exceed that assigned to the class of piping.
(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel Manufacturer.
(3) Pipes fabricated by a welding procedure approved by the Society may also be used.
(4) Pipes made of copper and copper alloys are to be seamless.
(5) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.
(6) Accessories of aluminium or aluminium alloys intended for flammable oil systems may be accepted subject to the satisfactory result of an endurance flame test to be carried out according to the "Rules for the type approval of flexible hoses and expansion joints" issued by the Society.
Note 1: On board oil tankers and chemical tankers aluminised pipes may be permitted in ballast tanks, in inerted cargo tanks and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

Table 5 : Minimum wall thickness for steel pipes

External diameter (mm)	Minimum nominal wall thickness (mm)		Minimum reinforced wall thickness (mm) **(2)**	Minimum extra-reinforced wall thickness (mm) **(3)**
	Sea water pipes, bilge and ballast systems **(1)**	Other piping systems **(1)**		
10,2 - 12,0	-	1,6	-	-
13,5 - 19,3	-	1,8	-	-
20,0	-	2,0	-	-
21,3 - 25,0	3,2	2,0	-	-
26,9 - 33,7	3,2	2,0	-	-
38,0 - 44,5	3,6	2,0	6,3	7,6
48,3	3,6	2,3	6,3	7,6
51,0 - 63,5	4,0	2,3	6,3	7,6
70,0	4,0	2,6	6,3	7,6
76,1 - 82,5	4,5	2,6	6,3	7,6
88,9 - 108,0	4,5	2,9	7,1	7,8
114,3 - 127,0	4,5	3,2	8,0	8,8
133,0 - 139,7	4,5	3,6	8,0	9,5
152,4 - 168,3	4,5	4,0	8,8	11,0
177,8	5,0	4,5	8,8	12,7
193,7	5,4	4,5	8,8	12,7
219,1	5,9	4,5	8,8	12,7
244,5 - 273,0	6,3	5,0	8,8	12,7
298,5 - 368,0	6,3	5,6	8,8	12,7
406,4 - 457,2	6,3	6,3	8,8	12,7

(1) Attention is drawn to the special requirements regarding:
- bilge and ballast systems
- scupper and discharge pipes
- sounding, air and overflow pipes
- ventilation systems
- oxyacetylene welding systems
- CO_2 fire-extinguishing systems (see Ch 4, Sec 1)
- cargo lines (see Pt E, Ch 10, Sec 3).

(2) Reinforced wall thickness applies to bilge, ballast, vent, overflow and sounding pipes passing through fuel tank and bilge, vent, overflow, sounding and fuel pipes passing through ballast tanks.

(3) Extra-reinforced wall thickness applies to pipes connected to the shell.

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Note 2: Where pipes and any integral pipe joints are protected against corrosion by means coating, lining, etc. at the discretion of the Society, thickness may be reduced by not more than 1 mm.

Note 3: The thickness of threaded pipes is to be measured at the bottom of the thread.

Note 4: The minimum thickness listed in this table is the nominal wall thickness and no allowance is required for negative tolerance or reduction in thickness due to bending.

Note 5: The minimum wall thickness for pipes larger than 450 mm nominal size is to be in accordance with a national or international standard and in any case not less than the minimum wall thickness of the appropriate column indicated for 450 mm pipe size.

Table 6 : Minimum wall thickness for copper and copper alloy pipes

External diameter (mm)	Minimum wall thickness (mm)	
	Copper	Copper alloy
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193,7 - 267	3,5	3,0
273 - 457,2	4,0	3,5
470	4,0	3,5
508	4,5	4,0

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Table 7 : Minimum wall thickness for stainless steel pipes

External diameter (mm)	Minimum wall thickness (mm)
up to 17,2	1,0
up to 48,3	1,6
up to 88,9	2,0
up to 168,3	2,3
up to 219,1	2,6
up to 273,0	2,9
up to 406,4	3,6
over 406,4	4

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Table 8 : Minimum wall thickness for aluminium and aluminium alloy pipes

External diameter (mm)	Minimum wall thickness (mm)
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Note 2: For sea water pipes, the minimum thickness is not to be less than 5 mm.

2.2.2 Permissible stress

a) The permissible stress K is given:
- in Tab 9 for carbon and carbon-manganese steel pipes,
- in Tab 10 for alloy steel pipes, and
- in Tab 11 for copper and copper alloy pipes,

as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of the permissible stress K is not given in Tab 9 or Tab 10, it is to be taken equal to the lowest of the following values:

$$\frac{R_{m,20}}{2,7} \quad \frac{R_e}{A} \quad \frac{S_R}{A} \quad S$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm^2

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm^2

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm^2

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm^2

A : Safety factor to be taken equal to:
- 1,6 when R_e and S_R values result from tests attended by the Society,
- 1,8 otherwise.

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by the Society.

2.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{D t_0}{2,5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

D : as defined in [1.4.1]

t_0 : as defined in [2.2.1].

b) When the bending radius is not given, the thickness reduction is to be taken equal to:

$$\frac{t_0}{10}$$

c) For straight pipes, the thickness reduction is to be taken equal to 0.

2.2.4 Corrosion allowance

The values of corrosion allowance c are given for steel pipes in Tab 12 and for non-ferrous metallic pipes in Tab 13.

Table 9 : Permissible stresses for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm²)	Design temperature (°C)												
	≤50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 10 : Permissible stresses for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	42
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr1/2Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 1/4Cr1Mo normalised and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr1Mo normalised and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
1/2Cr 1/2Mo 1/4V	460	101	99	97	94	82	72	62	53	45	37

Table 11 : Permissible stresses for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength (N/mm²)	Design temperature (°C)										
		≤50	75	100	125	150	175	200	225	250	275	300
Copper	215	41	41	40	40	34	27,5	18,5				
Aluminium brass	325	78	78	78	78	78	51	24,5				
Copper-nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59	56	52	48	44
Copper-nickel 70/30	365	81	79	77	75	73	71	69	67	65,5	64	62

Table 12 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance (mm)
Superheated steam	0,3
Saturated steam	0,8
Steam coils in cargo tanks and liquid fuel tanks	2,0
Feed water for boilers in open circuit systems	1,5
Feed water for boilers in closed circuit systems	0,5
Blow-down systems for boilers	1,5
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Thermal oil	1,0
Fresh water	0,8
Sea water	3,0
Refrigerants referred to in Section 13	0,3
Cargo systems for oil tankers	2,0
Cargo systems for ships carrying liquefied gases	0,3

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.
Note 2: The corrosion allowance may be reduced where pipes and any integral pipe joints are protected against corrosion by means of coating, lining, etc.
Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

Table 13 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance (mm) **(2)**
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper-nickel alloys with less than 10% of Ni	0,8
Copper-nickel alloys with at least 10% of Ni	0,5
Aluminium and aluminium alloys	0,5

(1) The corrosion allowance for other materials will be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded.
(2) In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.

2.2.5 Tees

As well as complying with the provisions of [2.2.1] to [2.2.4] above, the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = \left(1 + \frac{D_1}{D}\right) \cdot t_0$$

where:

D_1 : External diameter of the branch pipe

D : as defined in [1.4.1]

t_0 : as defined in [2.2.1]

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.3 Calculation of high temperature pipes

2.3.1 General

For main steam piping having a design temperature exceeding 400°C, calculations are to be submitted to the Society concerning the stresses due to internal pressure, piping weight and any other external load, and to thermal expansion, for all cases of actual operation and for all lengths of piping.

The calculations are to include, in particular:

- the components, along the three principal axes, of the forces and moments acting on each branch of piping
- the components of the displacements and rotations causing the above forces and moments
- all parameters necessary for the computation of forces, moments and stresses.

In way of bends, the calculations are to be carried out taking into account, where necessary, the pipe ovalisation and its effects on flexibility and stress increase.

A certain amount of cold springing, calculated on the basis of expected thermal expansion, is to be applied to the piping during installation. Such springing is to be neglected in stress calculations; it may, however, be taken into account in terms of its effect on thrusts on turbines and other parts.

2.3.2 Thermal stress

The combined stress σ_{ID}, in N/mm², due to thermal expansion, calculated by the following formula:

$$\sigma_{ID} = (\sigma^2 + 4\tau^2)^{0,5}$$

is to be such as to satisfy the following equation:

$$\sigma_{ID} \leq 0{,}75 K_{20} + 0{,}25 K_T$$

where:

σ : Value of the longitudinal stress due to bending moments caused by thermal expansion, increased, if necessary, by adequate factors for bends, in N/mm²; in general it is not necessary to take account of the effect of axial force

τ : Value of the tangential stress due to torque caused by thermal expansion, in N/mm²; in general it is not necessary to take account of the effect of shear force

K_{20} : Value of the permissible stress for the material employed, calculated according to [2.2.2], for a temperature of 20°C, in N/mm²

K_T : Value of the permissible stress for the material employed, calculated according to [2.2.2], for the design temperature T, in N/mm².

2.3.3 Longitudinal stresses

The sum of longitudinal stresses σ_L, in N/mm², due to pressure, piping weight and any other external loads is to be such as to satisfy the following equation:

$\sigma_L \leq K_T$

where K_T is defined in [2.3.2].

2.3.4 Alternative limits for permissible stresses

Alternative limits for permissible stresses may be considered by the Society in special cases or when calculations have been carried out following a procedure based on hypotheses other than those considered above.

2.4 Junction of pipes

2.4.1 General

a) The number of joints in flammable oil piping systems is to be kept to the minimum necessary for mounting and dismantling purposes.

b) Direct connections of pipe lengths may be made by direct welding, flanges, threaded joints or mechanical joints, and are to be to a recognised standard or of a design proven to be suitable for the intended purpose and acceptable to the Society.

   The expression "mechanical joints" means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in [2.4.2], [2.4.3] and [2.4.4] below.

c) The gaskets and packings used for the joints are to suit the design pressure, the design temperature and the nature of the fluids conveyed.

d) The junction between plastic pipes is to comply with App 3.

2.4.2 Welded connections

a) Welding and non destructive testing of welds are to be carried out in accordance with [3]. Welded joints are to be used in accordance with Tab 15.

b) Butt-welded joints are to be of full penetration type with or without special provision for a high quality of root side.

   The expression "special provision for a high quality of root side" means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

   Butt welded joints with special provision for a high quality of root side may be used for piping of any Class and any outside diameter.

c) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions conforming to a standard recognised by the Society.

2.4.3 Flange connections

a) The dimensions and configuration of flanges and bolts are to be chosen in accordance with a Standard recognised by the Society. This standard is to cover the design pressure and design temperature of the piping system.

b) For non-standard flanges the dimensions of flanges and bolts are subject to special consideration by the Society.

c) Flange material is to be suitable for the nature and temperature of the fluid, as well as for the material of the pipe on which the flange is to be attached.

d) Flanges are to be attached to the pipes by welding or screwing in accordance with one of the designs shown in Fig 1.

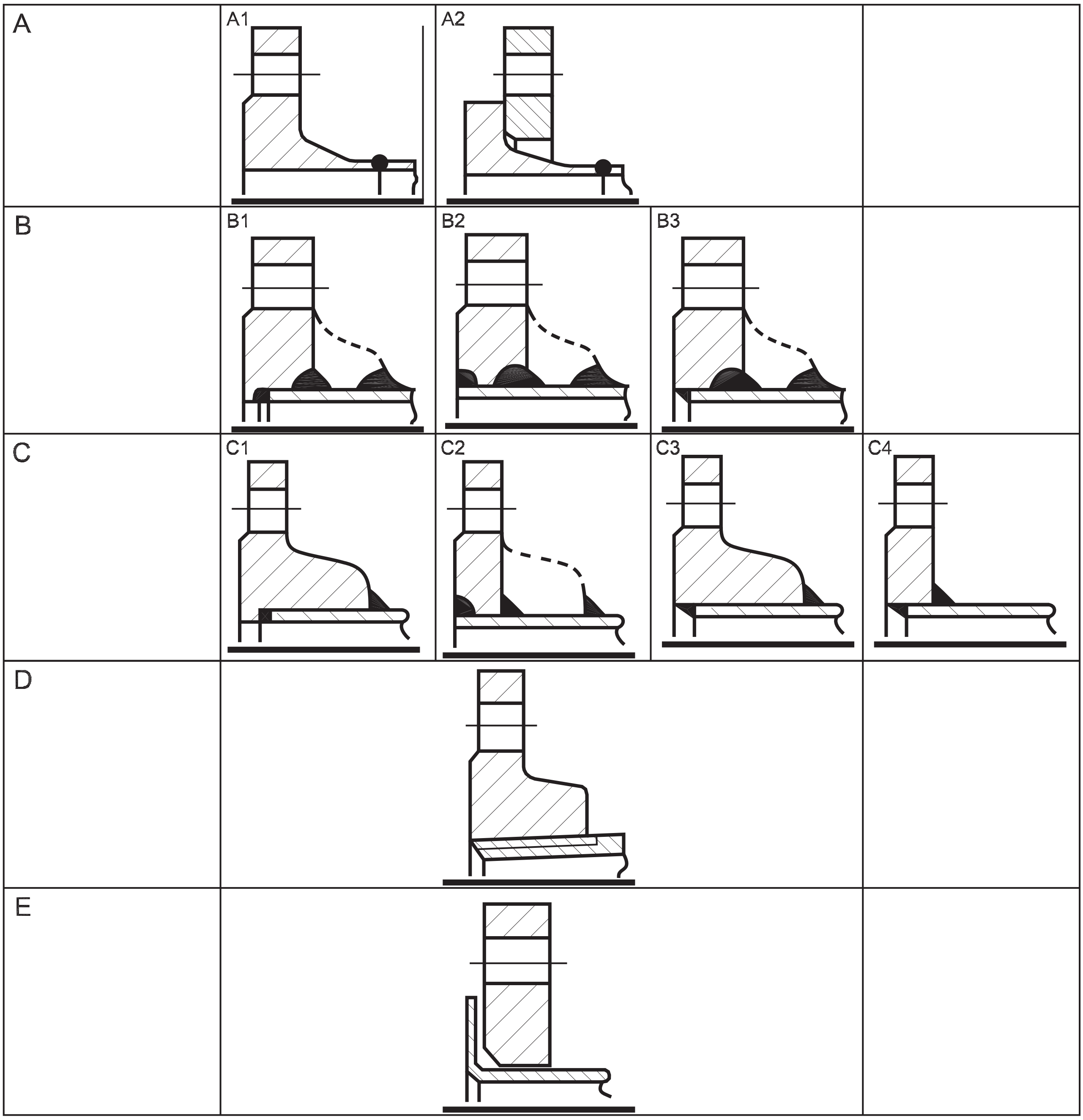
   Permitted applications are indicated in Tab 14. However the Society may accept flange attachments in accordance with national or international standards that are applicable to the piping system and recognise the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

2.4.4 Slip-on threaded joints

Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads, are to comply with requirements of a recognised national or international standard.

Slip-on threaded joints are to be used according to Tab 15.

Figure 1 : Types of metallic flange connections



Note 1: For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Note 2: For connections (C1), (C2), (C3) and (C4) the leg length of the fillet weld is to be in general equal to 1,5 times the pipe thickness but in no case is to be less than 6 mm.

Note 3: For connections (B1), (B2), (B3) and (C2) the dimension of the groove penetration in the flange is to be in general equal to the pipe thickness but in no case is to be less than 5 mm.

Table 14 : Types of flange connections required in relation to the class of piping and the type of media conveyed (1)

Class of piping → Type of media conveyed ↓	Class I	Class II	Class III
Toxic or corrosive media, flammable liquid media or liquefied gases	(A1)-(A2)-(B1)-(B2)-(B3) **(2) (3) (4)**	(A1)-(A2)-(B1)-(B2)-(B3)-(C1)-(C2)-(C3) **(2) (4)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3) **(2) (4)**
Lubricating and fuel oil	(A1)-(A2)-(B1)-(B2)-(B3)	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)- (C2)-(C3)-(C4) **(5)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3)-(C4)
Steam and thermal oil	(A1)-(A2)-(B1)-(B2)-(B3) **(3) (6)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)- (C2)-(C3)-(C4)-(D) **(7)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3)-(C4)-(D)
Other media, including water, air, gases, refrigerants, non flammable hydraulic oil **(8)**	(A1)-(A2)-(B1)-(B2)-(B3) **(6)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)- (C2)-(C3)-(C4)-(D) **(7)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3)-(C4)-(D)-(E) **(9)**

(1) The types of flange connections given in the Table are those shown in Fig 1.
(2) Only type (A1) and (A2) flange connections are to be adopted for piping conveying flammable, toxic or corrosive liquid media or liquefied gases having a design pressure **p** (see item [1.3.2]) higher than 1 N/mm².
(3) For piping having a nominal diameter equal to or greater than 150 mm, only type (A1) and (A2) flange connections are to be adopted.
(4) For the cargo piping of chemical carriers the provisions of IBC Code Ch. 5, 5.3 apply. For the cargo piping of gas carriers, the provisions of IGC Code Ch. 5, 5.4 apply.
(5) Flange connections of type (C4) are only acceptable for piping having a design pressure **p** less than 1,6 N/mm² and design temperature **T** (see item [1.3.3]) less than 150°C.
(6) Only type (A1) and (A2) flange connections are to be adopted for piping having a design temperature **T** higher than 400°C.
(7) Flange connections of types (D) and (C4) are not acceptable for piping having a design temperature **T** exceeding 250°C.
(8) For piping of hydraulic power plants of steering gears, only flange connections of types required for Class I piping are to be used.
(9) Flange connections of type (E) are only acceptable for water piping and open ended lines (e.g. drain, overflow, air vent piping, etc.).

Table 15 : Use of welded and threaded metallic joints in piping systems

	Permitted classes of piping	Restrictions of use
Butt-welded joint **(1)**	III, II, I	no restrictions
Slip-on sleeve joint **(2)**	III	no restrictions
Sleeve threaded joint (tapered thread) **(3)**	I	not allowed for: • pipes with outside diameter of more than 33,7 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
	II, III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
Sleeve threaded joint (parallel thread) **(3)**	III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

(1) Welded butt-joints without special provisions for root side may be used for Classes II and III, any outside diameter.
(2) In particular cases, slip- on sleeve and socket welded joints may be allowed by the Society for piping systems of Class I and II having outside diameter ≤ 88,9 mm except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
(3) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if in compliance with a recognised national and/or international standard.

2.4.5 Mechanical joints

Due to the great variations in design and configuration of mechanical joints, no specific recommendation regarding the method for theoretical strength calculations is given in these requirements. The mechanical joints are to be type approved by the Society according to the "Rules for the type approval of mechanical joints".

These requirements are applicable to pipe unions, compression couplings and slip-on joints as shown in Fig 2. Similar joints complying with these requirements may be acceptable.

The application and pressure ratings of different mechanical joints are to be approved by the Society.

Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the service conditions and the intended application.

Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

Material of mechanical joints is to be compatible with the piping material and internal and external media.

Mechanical joints are to be tested where applicable, to a burst pressure of 4 times the design pressure.

For design pressures above 20 MPa the required burst pressure will be specially considered by the Society.

In general, mechanical joints are to be of fire-resistant type as required by Tab 16.

Mechanical joints which in the event of damage could cause fire or flooding are not to be used in piping sections directly connected to sea openings or tanks containing flammable fluids.

Mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

The number of mechanical joints in oil systems is to be kept to a minimum. In general, flanged joints conforming to recognised standards are to be used.

Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

Slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible, unless approved by the Society.

The application of these joints inside tanks may be permitted only for the same media that is in the tanks.

Unrestrained slip-on joints are to be used only in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

Application of mechanical joints and their acceptable use for each service are indicated in Tab 16; dependence upon the Class of piping, pipe dimensions, working pressure and temperature are indicated in Tab 17.

In particular, Tab 16 indicates systems where the various kinds of joints may be accepted. However, in all cases, acceptance of the joint type is to be subject to approval of the intended application, and subject to conditions of the approval and applicable requirements.

In particular cases, sizes in excess of those mentioned above may be accepted if in compliance with a national and/or international standard recognised by the Society.

Mechanical joints are to be tested in accordance with a program approved by the Society, which is to include at least the following:

a) leakage test
b) vacuum test (where necessary)
c) vibration (fatigue) test
d) fire endurance test (where necessary)
e) burst pressure test
f) pressure pulsation test (where necessary)
g) assembly test (where necessary)
h) pull out test (where necessary).

The installation of mechanical joints is to be in accordance with the Manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be supplied by the Manufacturer.

Figure 2 : Examples of mechanical joints

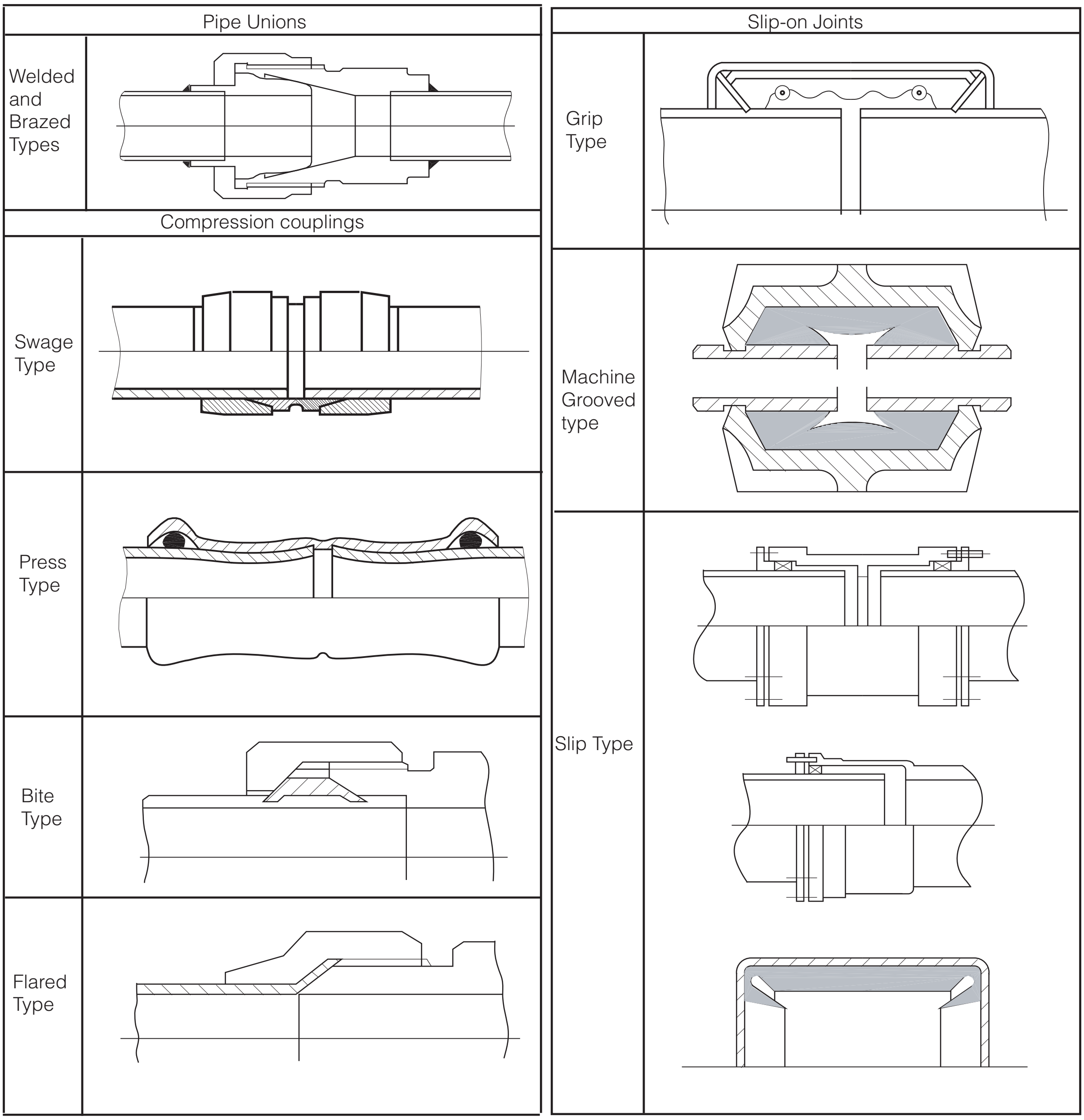


Table 16 : Application of mechanical joints

System		Kind of connections		
		Pipe Unions	Compression Couplings **(6)**	Slip-on Joints
Flammable fluids (Flash point ≤ 60°)				
1	Cargo oil lines	yes	yes	yes **(5)**
2	Crude oil washing lines	yes	yes	yes **(5)**
3	Vent lines	yes	yes	yes **(3)**
Inert gas				
4	Water seal effluent lines	yes	yes	yes
5	Scrubber effluent lines	yes	yes	yes
6	Main lines	yes	yes	yes **(2)** **(5)**
7	Distributions lines	yes	yes	yes **(5)**
Flammable fluids (Flash point > 60°)				
8	Cargo oil lines	yes	yes	yes **(5)**
9	Fuel oil lines	yes	yes	yes **(3)** **(2)**
10	Lubricating oil lines	yes	yes	yes **(2)** **(3)**
11	Hydraulic oil	yes	yes	yes **(2)** **(3)**
12	Thermal oil	yes	yes	yes **(2)** **(3)**
Sea Water				
13	Bilge lines	yes	yes	yes **(1)**
14	Fire main and water spray	yes	yes	yes **(3)**
15	Foam system	yes	yes	yes **(3)**
16	Sprinkler system	yes	yes	yes **(3)**
17	Ballast system	yes	yes	yes **(1)**
18	Cooling water system	yes	yes	yes **(1)**
19	Tank cleaning services	yes	yes	yes
20	Non-essential systems	yes	yes	yes
Fresh water				
21	Cooling water system	yes	yes	yes **(1)**
22	Condensate return	yes	yes	yes **(1)**
23	Non-essential system	yes	yes	yes
Sanitary/Drains/Scuppers				
24	Deck drains (internal)	yes	yes	yes **(4)**
25	Sanitary drains	yes	yes	yes
26	Scuppers and discharge (overboard)	yes	yes	not
Sounding/Vent				
27	Water tanks/Dry spaces	yes	yes	yes
28	Oil tanks (f.p.> 60°C)	yes	yes	yes **(2)** **(3)**
Miscellaneous				
29	Starting/Control air **(1)**	yes	yes	not
30	Service air (non-essential)	yes	yes	yes
31	Brine	yes	yes	yes
32	CO_2 system **(1)**	yes	yes	not
33	Steam	yes	yes	yes **(7)**

yes means application is allowed

not means application is not allowed

(1) Inside machinery spaces of category A - only approved fire resistant types

(2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.

(3) Approved fire resistant types

(4) Above free board deck only

(5) In pump rooms and open decks - only approved fire resistant types

(6) If Compression Couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for Slip-on joints.

(7) Provided that they are restrained on the pipes, they may be used for pipes on deck with a design pressure of 1,0 MPa or less

Table 17 : Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed type	yes (outside diameter ≤ 60.3mm)	yes (outside diameter ≤ 60.3mm)	yes
Compression Couplings			
Swage type	yes	yes	yes
Bite type Flared type	yes (outside diameter ≤ 60.3mm) yes (outside diameter ≤ 60.3mm)	yes (outside diameter ≤ 60.3mm) yes (outside diameter ≤ 60.3mm)	yes yes
Press type	not	not	yes
Slip-on joints			
Machine grooved type	yes	yes	yes
Grip type	not	yes	yes
Slip type	not	yes	yes
yes means application is allowed not means application is not allowed			

2.5 Protection against overpressure

2.5.1 General

a) These requirements deal with the protection of piping systems against overpressure, with the exception of heat exchangers and pressure vessels, which are dealt with in Sec 3, [2.4].

b) Safety valves are to be sealed after setting.

2.5.2 Protection of flammable oil systems

Provisions shall be made to prevent overpressure in any flammable oil tank or in any part of the flammable oil systems, including the filling pipes served by pumps on board.

2.5.3 Protection of pump and compressor discharges

a) Provisions are to be made so that the discharge pressure of pumps and compressors cannot exceed the pressure for which the pipes located on the discharge of these pumps and compressors are designed.

b) When provided on the pump discharge for this purpose, safety valves are to lead back to the pump suction or to any other suitable place.

c) The discharge capacity of the safety valves installed on pumps and compressors is to be such that the pressure at the discharge side cannot exceed by more than 10% the design pressure of the discharge pipe in the event of operation with closed discharge.

2.5.4 Protection of pipes

a) Pipes likely to be subjected to a pressure exceeding their normal working pressure are to be provided with safety valves or equivalent overpressure protecting devices.

b) In particular, pipes located on the low pressure side of pressure reducing valves are to be provided with safety valves unless they are designed for the maximum pressure on the high pressure side of the pressure reducing valve. See also [1.3.2] and [2.9.1].

c) The discharge capacity of the devices fitted on pipes for preventing overpressure is to be such that the pressure in these pipes cannot exceed the design pressure by more than 10%.

2.6 Flexible hoses and expansion joints

2.6.1 General

a) The Society may permit the use of flexible hose assemblies (short lengths of hose normally with prefabricated end fittings ready for installation), for permanent connection between a fixed piping system and items of machinery, and expansion joints, both in metallic and non-metallic materials, provided they are approved for the intended service.

b) Flexible hoses and expansion joints are to be of a type approved by the Society, designed in accordance with [2.6.2] and tested in accordance with [16.2.1].

c) These requirements may also be applied to temporary connected flexible hoses or hoses of portable equipment, and media not indicated in d).

d) Flexible hose assemblies as defined in a) may be accepted for use in fuel oil, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems, and Class III steam systems. Flexible hoses in high pressure fuel oil injection systems are not accepted.

e) Flexible hoses and expansion joints are to be installed in accordance with the requirements stated in [5.9.3].

f) These requirements for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire-extinguishing systems.

g) Specific requirements are given in:

- Part E, Chapter 7 for flexible hoses and expansion joints intended for cargo pipe lines of oil tankers
- Part E, Chapter 8 for flexible hoses and expansion joints intended for cargo pipe lines of chemical tankers
- Part E, Chapter 9 for flexible hoses and expansion joints intended for cargo pipe lines of liquefied gas carriers.

h) Flexible hoses and expansion joints intended for piping systems with a design temperature below the ambient temperature will be given special consideration by the Society.

i) The position of flexible hoses and expansion joints is to be clearly shown on the piping drawings submitted to the Society.

2.6.2 Design of flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be made of materials resistant to the marine environment and to the fluid they are to convey. Metallic materials are to comply with [2.1].

b) Flexible hoses are to be designed and constructed in accordance with recognised national or international standards acceptable to the Society.

c) Flexible hoses constructed of rubber materials and intended for use in bilge, ballast, compressed air, fuel oil, lubricating, hydraulic and thermal oil systems are to incorporate a single, double or more closely woven integral wire braid or other suitable material reinforcement.

Flexible hoses of plastics materials for the same purposes, such as Teflon or nylon, which are unable to be reinforced by incorporating closely woven integral wire braid are to have suitable material reinforcement as far as practicable.

d) Where rubber or plastic material hoses are to be used in fuel oil and lubricating oil systems, the hoses are to have external wire braid protection in addition to the reinforcement mentioned above.

e) Flexible hoses for use in steam systems are to be of metallic construction.

f) Flexible hoses are to be complete with approved end fittings in accordance with the Manufacturer's specification. End connections that do not have a flange are to comply with [2.4.5] as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

g) The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 0,5 MPa and provided there are double clamps at each end connection.

h) Flexible hoses and expansion joints are to be so designed as to withstand the bursting pressure requested by the "Rules for the type approval of flexible hoses and expansion joints".

i) Flexible hose assemblies and expansion joints intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required in [16.2.1] are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

j) Flexible hose assemblies and expansion joints constructed of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding are to be of fire-resistant type, according to ISO 15540 and 15541.

k) Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the Manufacturer's instructions.

2.6.3 Conditions of use of expansion joints in sea water systems and within duct keels and tanks

a) The use of non-metallic expansion joints on pipes connected to sea inlets and overboard discharges will be given special consideration by the Society. As a rule, the fitting of such joints between the ship side and the valves mentioned in [2.8.3] is not permitted. Furthermore, unless the above-mentioned valves are fitted with remote controls operable from places located above the freeboard deck, the expansion joints are to be arranged with guards which effectively enclose, but do not interfere with, the action of the expansion joints and reduce to the minimum practicable any flow of water into the machinery spaces in the event of failure of the flexible elements.

b) Use of expansion joints in water lines for other services, including ballast lines in machinery spaces, in duct keels and inside double bottom water ballast tanks, and bilge lines inside double bottom tanks and deep tanks, will be given special consideration by the Society.

2.7 Valves and accessories

2.7.1 General

a) Valves and accessories are normally to be built in accordance with a recognised standard.

Valves and fittings in piping systems are to be compatible with the pipes to which they are attached in respect of their strength (see [1.3.2] for design pressure) and are to be suitable for effective operation at the maximum working pressure they will experience in service.

Failing this, they are to be approved by the Society when they are fitted:

- in a class I piping system, or
- in a class II piping system with a diameter exceeding 100 mm, or
- on the ship side, on the collision bulkhead or on fuel tanks under static pressure.

b) Shut-off valves are to be provided where necessary to isolate pumps, heat exchangers, pressure vessels, etc., from the rest of the piping system when necessary, and in particular:

- to allow the isolation of duplicate components without interrupting the fluid circulation
- for survey or repair purposes.

2.7.2 Design of valves and accessories

a) Materials of valve and accessory bodies are to comply with the provisions of [2.1].

b) Connections of valves and accessories with pipes are to comply with the provisions of [2.4].

c) All valves and accessories are to be so designed as to prevent the loosening of covers and glands when they are operated.

d) Valves are to be so designed as to shut with a right-hand (clockwise) motion of the wheels.

e) Valves are to be provided with local indicators showing whether they are open or shut, unless this is readily apparent.

2.7.3 Valves with remote control

a) All valves which are provided with remote control are also to be designed for local manual operation.

b) The remote control system and means of local operation are to be independent. In this respect, arrangement of the local operation by means of a fixed hand pump will be specially considered by the Society.

c) In the case of valves which are to be provided with remote control in accordance with the Rules, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

d) Power failure of the remote control system is not to cause an undesired change of the valve position.

2.8 Sea inlets and overboard discharges

2.8.1 General

Except where expressly stated in Article [8], the requirements of this sub-article do not apply to scuppers and sanitary discharges.

2.8.2 Design of sea inlets and overboard discharges

a) All inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the ship.

b) Sea inlets and overboard discharges are to be fitted with valves complying with [2.7] and [2.8.3].

c) Machinery space main and auxiliary sea inlets and discharges in connection with the operation of machinery are to be fitted with readily accessible valves between the pipes and the shell plating or between the pipes and fabricated boxes attached to the shell plating. The valves may be controlled locally and are to be provided with indicators showing whether they are open or closed.

d) Sea inlets are to be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the ship.

e) Sea inlets are to be fitted with gratings complying with [2.8.4].

f) Provisions are to be made for clearing sea inlet gratings.

g) Sea chests are to be suitably protected against corrosion.

2.8.3 Valves

a) Sea inlet and overboard discharge valves are to be secured:

- directly on the shell plating, or
- on sea chests built on the shell plating, with scantlings in compliance with Part B, or
- on extra-reinforced and short distance pieces attached to the shell (see Tab 5).

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings, if any.

c) Valves are to be secured by means of:

- bolts screwed through the plating with a countersunk head, or
- studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

d) The use of butterfly valves will be specially considered by the Society. In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provisions are made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

e) The materials of the valve bodies and connecting pieces are to comply with [2.1.2] and Tab 4.

f) Ship side valves serving piping systems made of plastics are to comply with Pt C, Ch 1, App 3, [3.7.1] of the Rules for Classification of Ships.

2.8.4 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

e) When gratings are cleared by use of compressed air or steam devices, the chests, distance pieces and valves of sea inlets and outlets thus arranged are to be so constructed as to withstand the maximum pressure to which they may be subjected when such devices are operating.

2.8.5 Ship side connections for blow-down of boilers

a) Blow-down pipes of boilers are to be provided with cocks or valves placed as near the end of the pipes as possible, while remaining readily accessible and located above the engine room floor.

b) Blow-down valves are to be so designed that it is easy to ascertain whether they are open or shut. Where cocks are used, the control keys are to be such that they cannot be taken off unless the cocks are shut. Where valves are used, the control-wheels are to be permanently fixed to the spindle.

c) A protection ring is to be fitted on the shell plating, outside, at the end of the blow-down pipes. The spigot of the valve referred to in [2.8.3], item b), is to pass through this ring.

2.9 Control and monitoring

2.9.1 General

a) Local indicators are to be provided for at least the following parameters:
   - pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
   - temperatures, in tanks and vessels, at heat exchanger inlet and outlet
   - levels, in tanks and vessels containing liquids.

b) Safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter.

c) Automatic controls are to be provided where it is necessary to maintain parameters related to piping systems at a pre-set value.

2.9.2 Level gauges

Level gauges used in fuel oil systems, pressure lubricating oil systems and other flammable oil systems are to be of a type approved by the Society and are subject to the following conditions:

- in passenger ships, they are not to require penetration below the top of the tank and their failure or overfilling of the tanks is not to permit release of fuel
- in cargo ships, their failure or overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. The Society may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks. Their glasses are to be made of heat-resistant material and efficiently protected against shocks.

The above level gauges are to be maintained in the proper condition to ensure their continued accurate functioning in service.

Note 1: On cargo ships of less than 500 tons gross tonnage and non-propelled ships:
- cylindrical gauges may be used provided they are fitted with self-closing valves at their lower end as well as at their upper end if the latter is below the maximum liquid level.
- in the case of tanks not subject to filling by power pumps, with the exception of fuel oil service tanks, the valves need not be of the self-closing type. Such valves are, however, to be readily accessible and instruction plates are to be fitted adjacent to them specifying that they are to be kept closed.

3 Welding of steel piping

3.1 Application

3.1.1

a) The following requirements apply to welded joints belonging to class I or II piping systems.

   They may also be applied to class III piping systems, at the discretion of the Society.

b) This article does not apply to refrigerated cargo installation piping systems operating at temperatures lower than minus 40°C.

c) The requirements for qualification of welding procedures are given in Part D.

3.2 General

3.2.1 Welding processes

a) Welded joints of pipes are to be made by means of electric arc or oxyacetylene welding, or any other previously approved process.

b) When the design pressure exceeds 0,7 MPa, oxyacetylene welding is not permitted for pipes with an external diameter greater than 100 mm or a thickness exceeding 6 mm.

3.2.2 Location of joints

The location of welded joints is to be such that as many as possible can be made in a workshop. The location of welded joints to be made on board is to be so determined as to permit their joining and inspection in satisfactory conditions.

3.3 Design of welded joints

3.3.1 Types of joints

a) Except for the fixing of flanges on pipes in the cases mentioned in [2.4.4], Fig 1 and for the fixing of branch pipes, joints between pipes and between pipes and fittings are to be of the butt-welded type. However, for class I pipes with an internal diameter not exceeding 50 mm and for class II pipes, socket welded connections of approved types may be used.

b) For butt-welded joints between pipes or between pipes and flanges or other fittings, correctly adjusted backing rings may be used; such rings are to be either of the same grade of steel as the elements to be welded or of such a grade as not to adversely influence the weld; if the backing ring cannot be removed after welding, it is to be correctly profiled.

3.3.2 Assembly of pipes of unequal thickness

If the difference of thickness between pipes to be butt-welded exceeds 10% of the thickness of the thinner pipe plus 1 mm, subject to a maximum of 4 mm, the thicker pipe is to be thinned down to the thickness of the thinner pipe on a length at least equal to 4 times the offset, including the width of the weld if so desired.

3.3.3 Accessories

a) When accessories such as valves are connected by welding to pipes, they are to be provided with necks of sufficient length to prevent abnormal deformations during the execution of welding or heat treatment.

b) For the fixing by welding of branch pipes on pipes, it is necessary to provide either a thickness increase as indicated in [2.2.5] or a reinforcement by doubling plate or equivalent.

3.4 Preparation of elements to be welded and execution of welding

3.4.1 General

Attention is drawn to the provisions of Sec 3, which apply to the welding of pressure pipes.

3.4.2 Edge preparation for welded joints

The preparation of the edges is preferably to be carried out by mechanical means. When flame cutting is used, care is to be taken to remove the oxide scales and any notch due to irregular cutting by matching, grinding or chipping back to sound metal.

3.4.3 Abutting of parts to be welded

a) The elements to be welded are to be so abutted that surface misalignments are as small as possible.

b) As a general rule, for elements which are butt-welded without a backing ring the misalignment between internal walls is not to exceed the lesser of:

   - the value given in Tab 18 as a function of thickness t and internal diameter d of these elements, and
   - t/4.

   Where necessary, the pipe ends are to be bored or slightly expanded so as to comply with these values; the thickness obtained is not to be less than the Rule thickness.

c) In the case of welding with a backing ring, smaller values of misalignment are to be obtained so that the space between the backing ring and the internal walls of the two elements to be assembled is as small as possible; normally this space is not to exceed 0,5 mm.

d) The elements to be welded are to be adequately secured so as to prevent modifications of their relative position and deformations during welding.

e) Tack welds should be made with an electrode suitable for the base metal; tack welds which form part of the finished weld should be made using approved procedures.

   When welding materials requiring preheating are employed, the same preheating should be applied during tack welding.

Table 18 : Maximum value of misalignment

d (mm)	t (mm)		
	t ≤ 6	6 < t ≤ 10	10 < t
d < 150	1,0	1,0	1,0
150 ≤ d < 300	1,0	1,5	1,5
300 ≤ d	1,0	1,5	2,0

3.4.4 Protection against adverse weather conditions

a) Pressure pipes are to be welded, both on board and in the shop, away from draughts and sudden temperature variations.

b) Unless special justification is given, no welding is to be performed if the temperature of the base metal is lower than 0°C.

3.4.5 Preheating

a) Preheating is to be performed as indicated in Tab 19, depending on the type of steel, the chemical composition and the pipe thickness.

b) The temperatures given in Tab 19 are based on the use of low hydrogen processes. Where low hydrogen processes are not used, the Society reserves the right to require higher preheating temperatures.

3.5 Post-weld heat treatment

3.5.1 General

a) As far as practicable, the heat treatment is to be carried out in a furnace. Where this is impracticable, and more particularly in the case of welding on board, the treatment is to be performed locally by heating uniformly a circular strip, extending on at least 75 mm on both sides of the welded joint; all precautions are to be taken to permit accurate checking of the temperature and slow cooling after treatment.

b) For austenitic and austenitic ferritic steels, post-weld head treatment is generally not required.

Table 19 : Preheating temperature

Type of steel		Thickness of thicker part (mm)	Minimum preheating temperature (°C)
C and C-Mn steels	$C + \frac{Mn}{6} \leq 0,40$	t ≥ 20 **(2)**	50
	$C + \frac{Mn}{6} > 0,40$	t ≥ 20 **(2)**	100
0,3 Mo		t ≥ 13 **(2)**	100
1 Cr 0,5 Mo		t < 13 t ≥ 13	100 150
2,25 Cr 1 Mo **(1)**		t < 13 t ≥ 13	150 200
0,5 Cr 0,5 Mo 0,25 V **(1)**		t < 13 t ≥ 13	150 200

(1) For 2,25 Cr 1 Mo and 0,5 Cr 0,5 Mo 0,25 V grades with thicknesses up to 6 mm, preheating may be omitted if the results of hardness tests carried out on welding procedure qualification are considered acceptable by the Society.
(2) For welding in ambient temperature below 0°C, the minimum preheating temperature is required independent of the thickness unless specially approved by the Society.

Table 20 : Heat treatment temperature

Type of steel	Thickness of thicker part (mm)	Stress relief treatment temperature (°C)
C and C-Mn steels	t ≥ 15 **(1)** **(3)**	550 to 620
0,3 Mo	t ≥ 15 **(1)**	580 to 640
1 Cr 0,5 Mo	t ≥ 8	620 to 680
2,25 Cr 1 Mo 0,5 Cr 0,5 Mo 0,25 V	any **(2)**	650 to 720

(1) Where steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which post-weld heat treatment is to be applied may be increased, subject to the special agreement of the Society.
(2) For 2,25Cr 1Mo and 0,5Cr 0,5Mo 0,25 V grade steels, heat treatment may be omitted for pipes having thickness lower than 8 mm, diameter not exceeding 100 mm and service temperature not exceeding 450°C.
(3) For C and C-Mn steels, stress relieving heat treatment may be omitted up to 30 mm thickness, subject to the special agreement of the Society.

3.5.2 Heat treatment after welding other than oxyacetylene welding

a) Stress relieving heat treatment after welding other than oxyacetylene welding is to be performed as indicated in Tab 20, depending on the type of steel and thickness of the pipes.

b) The stress relieving heat treatment is to consist in heating slowly and uniformly to a temperature within the range indicated in the Table, soaking at this temperature for a suitable period, normally one hour per 25 mm of thickness with a minimum of half an hour, cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in still atmosphere.

c) In any event, the heat treatment temperature is not to be higher than $(T_T - 20)$°C, where T_T is the temperature of the final tempering treatment of the material

3.5.3 Heat treatment after oxyacetylene welding

Stress relieving heat treatment after oxyacetylene welding is to be performed as indicated in Tab 21, depending on the type of steel.

3.6 Inspection of welded joints

3.6.1 General

a) The inspection of pressure pipe welded joints is to be performed at the various stages of the fabrication further to the qualifications defined in [3.1.1], item c).

b) The examination mainly concerns those parts to be welded further to their preparation, the welded joints once they have been made and the conditions for carrying out possible heat treatments.

c) The required examinations are to be carried out by qualified operators in accordance with procedures and techniques to the Surveyor's satisfaction.

Table 21 : Heat treatment after oxyacetylene welding

Type of steel	Heat treatment and temperature (°C)
C and C-Mn	Normalising 880 to 940
0,3 Mo	Normalising 900 to 940
1Cr-0,5Mo	Normalising 900 to 960 Tempering 640 to 720
2,25Cr-1Mo	Normalising 900 to 960 Tempering 650 to 780
0,5Cr-0,5Mo-0,25V	Normalising 930 to 980 Tempering 670 to 720

3.6.2 Visual examination

Welded joints, including the inside wherever possible, are to be visually examined.

3.6.3 Non-destructive examinations

a) Non-destructive tests for class I pipes are to be performed as follows:
   - butt-welded joints of pipes with an external diameter exceeding 75 mm are to be subjected to full radiographic examination or equivalent
   - welded joints other than butt-welded joints and which cannot be radiographed are to be examined by magnetic particle or liquid penetrant tests
   - fillet welds of flange connections are to be examined by magnetic particle tests or by other appropriate non-destructive tests.

b) Non-destructive tests for class II pipes are to be performed as follows:
   - butt-welded joints of pipes with an external diameter exceeding 100 mm are to be subjected to at least 10% random radiographic examination or equivalent
   - welded joints other than butt-welded joints are to be examined by magnetic particle tests or by other appropriate non-destructive tests
   - fillet welds of flange connections may be required to be examined by magnetic particle tests or by other appropriate non-destructive tests, at the discretion of the Surveyor.

3.6.4 Defects and acceptance criteria

a) Joints for which non-destructive examinations reveal unacceptable defects are to be re-welded and subsequently to undergo a new non-destructive examination. The Surveyor may require that the number of joints to be subjected to non-destructive examination is larger than that resulting from the provisions of [3.6.3].

b) The acceptance criteria of defects are:
   - for class I pipes, those defined in the "Rules for carrying out not-destructive examinations of welding" for the special quality level,
   - for class II pipes, those defined in the "Rules for carrying out not-destructive examinations of welding" for the normal quality level.

4 Bending of pipes

4.1 Application

4.1.1 This Article applies to pipes made of:
- alloy or non-alloy steels,
- copper and copper alloys.

4.2 Bending process

4.2.1 General

The bending process is to be such as not to have a detrimental influence on the characteristics of the materials or on the strength of the pipes.

4.2.2 Bending radius

Unless otherwise justified, the bending radius measured on the centreline of the pipe is not to be less than:
- twice the external diameter for copper and copper alloy pipes,
- 3 times the external diameter for cold bent steel pipes.

4.2.3 Acceptance criteria

a) The pipes are to be bent in such a way that, in each transverse section, the difference between the maximum and minimum diameters after bending does not exceed 10% of the mean diameter; higher values, but not exceeding 15%, may be allowed in the case of pipes which are not subjected in service to appreciable bending stresses due to thermal expansion or contraction.

b) The bending is to be such that the depth of the corrugations is as small as possible and does not exceed 5% of their length.

4.2.4 Hot bending

a) In the case of hot bending, all arrangements are to be made to permit careful checking of the metal temperature and to prevent rapid cooling, especially for alloy steels.

b) Hot bending is to be generally carried out in the temperature range 850°C-1000°C for all steel grades; however, a decreased temperature down to 750°C may be accepted during the forming process.

4.3 Heat treatment after bending

4.3.1 Copper and copper alloy

Copper and copper alloy pipes are to be suitably annealed after cold bending if their external diameter exceeds 50 mm.

4.3.2 Steel

a) After hot bending carried out within the temperature range specified in [4.2.4], the following applies:
   - for C, C-Mn and C-Mo steels, no subsequent heat treatment is required,
   - for Cr-Mo and Cr-Mo-V steels, a subsequent stress relieving heat treatment in accordance with Tab 20 is required.

b) After hot bending performed outside the temperature range specified in [4.2.4], a subsequent new heat treatment in accordance with Tab 21 is required for all grades.

c) After cold bending at a radius lower than 4 times the external diameter of the pipe, a heat treatment in accordance with Tab 21 is required.

5 Arrangement and installation of piping systems

5.1 General

5.1.1 Unless otherwise specified, piping and pumping systems covered by the Rules are to be permanently fixed on board ship.

5.2 Location of tanks and piping system components

5.2.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with [5.10].

5.2.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board ships having to comply with the provisions of [5.5].

5.2.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, requires special arrangements such as reinforced thickness as per Tab 5 for steel pipes or tunnels, in particular for:
- bilge pipes
- ballast pipes
- scuppers and sanitary discharges
- air, sounding and overflow pipes
- fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or welded reinforced flange connections. See also [2.4.3].

5.2.4 Overboard discharges

Overboard discharges are to be so located as to prevent any discharge of water into the lifeboats while they are being lowered.

5.2.5 Piping and electrical apparatus

The installation of piping near switchboards and other electrical apparatus is to comply with Ch 2, Sec 12, [6.1.7].

5.3 Passage through watertight bulkheads or decks

5.3.1 General

This sub-article applies to cargo ships only.

5.3.2 Penetration of watertight bulkheads and decks

a) Where penetrations of watertight bulkheads and internal decks are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity.

b) Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

This applies in particular to the following systems:
- bilge system
- ballast system
- scuppers and sanitary discharge systems.

c) Where bolted connections are used when passing through watertight bulkheads or decks, the bolts are not to be screwed through the plating. Where welded connections are used, they are to be welded on both sides of the bulkhead or deck.

d) Penetrations of watertight bulkheads or decks by plastic pipes are to comply with Rules for the Classification of Ships.

5.3.3 Passage through the collision bulkhead *(1/7/2015)*

a) On cargo ships, a maximum of two pipes may pass through the collision bulkhead below the freeboard deck, unless otherwise justified. Such pipes are to be fitted with suitable valves operable from above the freeboard deck and the valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead without provision for remote contro bulkhead provided that they are readily accessible under all service conditions and the space in which they are located is not a cargo space. All valves are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable.

b) The remote operation device of the valve referred to in a) is to include an indicator to show whether the valve is open or shut.

5.4 Independence of lines

5.4.1 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying liquid cargo, lubricating oil and fuel oil, with the exception of:
- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.5 Prevention of progressive flooding

5.5.1 Principle

a) In order to comply with the subdivision and damage stability requirements of Pt E, provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is damaged or broken in any other compartment by collision or grounding.

b) For this purpose, if pipes are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.

5.5.2 Extent of damage

For the definition of the assumed transverse extent of damage, reference is to be made to Pt E.

5.5.3 Piping arrangement

a) The assumed transverse extent of damage is not to contain any pipe with an open end in a compartment located outside this extent, except where the section of such pipe does not exceed 50 cm^2.

Note 1: Where several pipes are considered, the limit of 50 cm2 applies to their total section.

b) Where the provisions of a) cannot be fulfilled, and after special examination by the Society, pipes may be situated within the assumed transverse extent of damage penetration provided that:
- either a closable valve operable from above the bulkhead deck is fitted at each penetration of a

watertight subdivision and secured directly on the bulkhead, or

- a closable valve operable from above the bulkhead deck is fitted at each end of the pipe concerned, the valves and their control system being inboard of the assumed extent of damage, or
- the tanks to which the pipe concerned leads are regarded in the damage stability calculations as being flooded when damage occurs in a compartment through which the pipe passes.

c) Valves required to be operable from above the bulkhead deck are to be fitted with an indicator to show whether the valve is open or shut.

Where the valve is remote controlled by other than mechanical means, and where the remote control system is located, even partly, within the assumed extent of damage penetration, this system is to be such that the valve is automatically closed by loss of power.

d) Air and overflow pipes are to be so arranged as to prevent the possibility of flooding of other tanks in other watertight compartments in the event of any one tank being flooded.

This arrangement is to be such that in the range of positive residual righting levers beyond the angle of equilibrium stage of flooding, the progressive flooding of tanks or watertight compartments other than that flooded does not occur.

5.6 Provision for expansion

5.6.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the ship's structure, having due regard to:

- the temperature of the fluid conveyed
- the coefficient of thermal expansion of the pipes material
- the deformation of the ship's hull.

5.6.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.7 Supporting of the pipes

5.7.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the ship's structure by means of collars or similar devices.

5.7.2 Arrangement of supports

Shipyards are to take care that :

a) The arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected.

b) Heavy components in the piping system, such as valves, are to be independently supported.

5.8 Protection of pipes

5.8.1 Protection against shocks

Pipes passing through cargo holds and 'tweendecks are to be protected against shocks by means of strong casings.

5.8.2 Protection against corrosion and erosion

a) Pipes are to be efficiently protected against corrosion, particularly in their most exposed parts, either by selection of their constituent materials, or by an appropriate coating or treatment.

b) The layout and arrangement of sea water pipes are to be such as to prevent sharp bends and abrupt changes in section as well as zones where water may stagnate. The inner surface of pipes is to be as smooth as possible, especially in way of joints. Where pipes are protected against corrosion by means of galvanising or other inner coating, arrangements are to be made so that this coating is continuous, as far as possible, in particular in way of joints.

c) If galvanised steel pipes are used for sea water systems, the water velocity is not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

5.8.3 Protection against frosting

Pipes are to be adequately insulated against cold wherever deemed necessary to prevent frost.

This applies specifically to pipes passing through refrigerated spaces and which are not intended to ensure the refrigeration of such spaces.

5.8.4 Protection of high temperature pipes and components

a) All pipes and other components where the temperature may exceed 220°C are to be efficiently insulated, as indicated in Sec 1, [3.7].

b) Particular attention is to be paid to lagging in way of flanges.

5.9 Valves, accessories and fittings

5.9.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

5.9.2 Valves and accessories

a) In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:

- above the floor,
- or, when this is not possible, immediately under the floor, provided provision is made for their easy access and control in service.

b) Control-wheels of low inlet valves are to rise at least 0,45 m above the lowest floor.

5.9.3 Flexible hoses and expansion joints

a) Flexible hoses are to be so arranged as to be clearly visible and readily accessible at all times.

b) In general, flexible hoses and expansion joints are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

c) Flexible hose assemblies and expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

d) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

e) The number of flexible hoses and expansion joints is to be kept to a minimum.

f) Where flexible hoses and expansion joints are intended to be used in piping systems conveying flammable fluids that are in close proximity to heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection to the satisfaction of the Society.

g) Expansion joints are to be protected against over-extension and over-compression.

h) The installation of flexible hose assemblies and expansion joints is to be in accordance with the Manufacturer's instructions and use limitations with particular attention to the following, as applicable:

- orientation
- end connection support (where necessary)
- avoidance of hose contact that could cause rubbing and abrasion
- minimum bend radii.

5.9.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.9.5 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.9.6 Nameplates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.10 Additional arrangements for flammable fluids

5.10.1 General

The requirements in [5.10.3] and [5.10.4] apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.10.2 Prohibition of carriage of flammable oils in forepeak tanks

In cargo ships of more than 400 tons gross tonnage and in passenger ships, fuel oil, lubricating oil and other flammable oils are not to be carried in forepeak tanks or tanks forward of the collision bulkhead.

5.10.3 Prevention of flammable oil leakage ignition

a) As far as practicable, parts of the fuel oil and lubricating oil systems containing heated oil under pressure exceeding 0,18 MPa are to be placed above the platform or in any other position where defects and leakage can readily be observed.

   The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:

   - hot surfaces, including those of boilers, heaters, steam pipes, exhaust manifolds and silencers
   - electrical equipment
   - air intakes
   - other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 0,18 MPa such as pumps, filters and heaters are to comply with the provisions of b) above.

d) Flammable oil lines are not to be located immediately above or near units of high temperature including boilers, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated in Sec 1, [3.7.1]. As far as practicable, flammable oil lines are to be arranged far from hot surfaces, electrical installations or other sources of ignition and to be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition.

Precautions are to be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

e) Any relief valve of fuel oil and lubricating oil systems is to discharge to a safe position, such as an appropriate tank. See also item (a) of [9.1.7].

5.10.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:

- under independent tanks
- under burners
- under purifiers and any other oil processing equipment
- under pumps, heat exchangers and filters
- under valves and all accessories subject to oil leakage
- surrounding internal combustion engines.

c) The coaming height of drip trays is to suit the amount of potential oil spillage.

d) Where boilers are located in machinery spaces on 'tweendecks and the boiler rooms are not separated from the machinery spaces by watertight bulkheads, the 'tweendecks are to be provided with oil-tight coamings at least 200 mm in heigh

e) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

5.10.5 Drain tank

a) The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

b) In ships required to be fitted with a double bottom, appropriate precautions are to be taken when the drain tank is constructed in the double bottom, in order to avoid flooding of the machinery space where drip trays are located, in the event of accidentally running aground.

5.10.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.10.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Bilge systems

6.1 Bilge piping arrangement

6.1.1

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces mentioned in [6.2.1] through bilge branches, distribution boxes and bilge suctions, except for some small spaces where individual suctions by means of hand pumps may be accepted as stated in [6.3.4] and [6.3.5].

b) If deemed acceptable by the Society, bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the ship is not impaired.

6.1.2 Bilge and ballast systems

The arrangement of the bilge and ballast pumping system shall be such as to prevent the possibility of water passing from the sea and from water ballast spaces into the cargo and machinery spaces, or from one compartment to another.

Provisions shall be made to prevent any deep tank having bilge and ballast connections being inadvertently flooded from the sea when containing cargo, or being discharged through a bilge pump when containing water ballast.

6.1.3 Number and distribution of bilge suctions

Bilge lines and bilge suctions are to be so arranged that the bilges can be completely pumped even under disadvantageous trim conditions.

Bilge suctions are normally to be located on both sides of the vessel. For compartments located fore and aft in the vessel, one bilge suction may be considered sufficient provided that it is capable of completely draining the relevant compartment.

Spaces located forward of the collision bulkhead and aft of the sterntube bulkhead and not connected to the general bilge system are to be drained by other suitable means of adequate capacity.

The collision bulkhead may be pierced by a pipe for filling and draining of the fore peak, provided that a screw-down valve capable of being remote operated from above the open deck is fitted at the collision bulkhead within the fore peak.

Where the fore peak is directly adjacent to a permanently accessible room which is separated from the cargo space, this shut-off valve may be fitted directly at the collision bulkhead inside this room without provision for remote control.

6.1.4 Prevention of communication between spaces - Independence of the lines

a) Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

b) Bilge lines are to be entirely independent and distinct from other lines except where permitted in [5.4].

c) In ships designed for the carriage of flammable or toxic liquids in enclosed cargo spaces, the bilge pumping system is to be designed to prevent the inadvertent pumping of such liquids through machinery space piping or pumps.

6.1.5 Use of bilge pumps for other duties

6.1.6 Bilge pipes inside tanks

Bilge pipes may not be led through tanks for lubricating oil, thermal oil, drinking water or feedwater.

6.1.7 Bilge suctions

Bilge suctions are to be so arranged as not to impede the cleaning of bilges and bilge wells. They are to be fitted with easily detachable, corrosion-resistant strums.

6.2 Bilge pumping and drainage systems

6.2.1 Pumps and piping *(1/1/2017)*

a) It is to be possible to pump out each watertight compartment separately. However, that requirement is not to apply to watertight compartments that are normally sealed hermetically during operation.

b) Vessels requiring a crew shall be equipped with two independent bilge pumps which shall not be installed within the same space. At least one of these shall be motor driven. However, for vessels with a power of less than 225 kW or with a deadweight of less than 350 t, or where vessels not intended for the carriage of goods have a displacement of less than 250 m^3 , one pump will suffice which can be either manually-operated or motor- driven.

   Each of the required pumps shall be capable of use on each watertight compartment.

   Additional bilge pumps may be required for passenger vessels according to size and propulsion power.

c) The minimum pumping capacity Q_1 of the first bilge pump is to be calculated using the following formula:

   $Q_1 = 0,1 \bullet d_1^2$ (l/min)

   d_1 is calculated via the formula:

   $$d_1 = 1,5 \cdot \sqrt{L(B+H)} + 25 \quad [mm]$$

   The minimum pumping capacity Q_2 of the second bilge pump is to be calculated using the following formula:

   $Q_2 = 0,1 \bullet d_2^2$ (l/min)

   d_2 is calculated using the formula:

   $$d_2 = 2 \cdot \sqrt{l(B+H)} + 25 \quad [mm]$$

   However, the value d_2 need not exceed value d_1.

   For the calculation of Q_2, l is to be taken to be the length of the longest watertight compartment.

   In these formulae:

   - L is the maximum length of the hull in m, excluding rudder and bowsprit;
   - B is the maximum breadth of the hull in m, measured from the outer edge of the shell plating (excluding paddle wheels, rub rails and similar);
   - H is the shortest vertical distance in m, between the lowest point of the hull or the keel and the lowest point of the deck on the side of the vessel;
   - l is the length of the watertight compartment in question, in (m);
   - d_1 is the calculated internal diameter of the main drainage pipe, in (mm);
   - d_2 is the calculated internal diameter of the branch pipe, in (mm).

d) Where the bilge pumps are connected to a drainage system, the drainage pipes are to have an internal diameter of at least d_1, in mm, and the branch pipes an internal diameter of at least d_2, in mm.

   Where vessels are less than 25 m in length, the values d_1 and d_2 may be reduced to 35 mm.

e) Only self-priming bilge pumps are permitted.

f) There is to be at least one suction on both the starboard and port sides of all flat-bottomed, drainable compartments that are wider than 5 m.

g) It may be possible to drain the aft peak via the main engine room by means of an easily accessible, automatically closable fitting.

h) Branch pipes of single compartments are to be connected to the main drainage pipe by means of a lockable non-return valve.

i) Compartments or other spaces that are capable of carrying ballast need to be connected to the drainage system only by means of a simple closing device. That requirement is not to apply to holds that are capable of carrying ballast.

j) Such holds are to be filled with ballast water by means of ballast piping that is permanently installed and independent of the drainage pipes, or by means of branch pipes that can be connected to the main drainage pipe by flexible pipes or flexible adaptors. Water intake valves located in the bottom of the hold are not to be permitted for this purpose.

k) Hold bilges are to be fitted with gauging devices.

l) Where a drainage system incorporates permanently installed pipework, the bilge-bottom drainage pipes intended to extract oily water are to be equipped with closures that have been sealed in position by an inspection body. The number and position of those closures are to be entered on the "Inland waterways vessel certificate".

m) Locking the closures in position is to be regarded as equivalent to sealing in accordance with item d). The key or keys for the locking of the closures is (are) to be indicated accordingly and kept in a marked and easily accessible location in the engine room.

Where centrifugal pumps are used for bilge pumping, they are to be self-priming.

6.2.2 Capacity of the pumps

If the capacity of a pump is less than the Rule capacity in 6.2.1, the pump can be accepted providing that the deficiency is compensated for by an excess capacity of the other independent pumps.

6.2.3 Use of other pumps

Ballast pumps, general service pumps and similar units may also be used as independent bilge pumps provided they are of the required capacity according to [6.2.1].

Oil pumps may not be connected to the bilge system.

6.3 Bilge system arrangement

6.3.1 Draining in machinery spaces

The bilge suctions in machinery spaces are to be arranged as follow:

a) through a branch bilge suction connected to the main bilge system and

b) through one direct suction connected to the largest independent bilge pump.

6.3.2 Draining fore and after peaks

Except where permitted in 5.3.3, collision bulkheads are not to be pierced.

Where the peaks are not used as tanks, separate means of pumping are to be provided.

Where the after peak terminates at the engine room, it may be drained to the engine room bilge through a pipe fitted with a shut-off valve.

Draining of the fore peak bilge into an adjacent space is not permitted.

6.3.3 Draining of spaces above peak tanks

Watertight spaces above the peaks may either be connected to the bilge system or pumped by means of hand-operated bilge pumps.

Spaces above the after peak may be drained to the machinery space, provided that the drain line is fitted with a self-closing shut-off valve at a clearly visible and easily accessible position.

Drain pipes are to have an inside diameter of at least 40 mm.

6.3.4 Draining of cofferdams and void spaces

Cofferdam and void spaces are to be drained by means of suctions connected to main bilge system.

6.3.5 Draining of chain lockers

Chain lockers may be drained by means of suctions connected to main bilge system or drained by a hand pump. Draining to the forepeak tank is not permitted.

6.4 Oil separator system

6.4.1 Vessels fitted with oil separating facilities are to have arrangements and equipment in conformity with national and international regulations.

6.5 Bilge pumps

6.5.1 Use of bilge pumps for other duties

Bilge pumps may be used for other requirements, such as fire, general service, sanitary service or ballast, provided that:

- such duties are of intermittent nature
- any failure of the piping systems connected to the bilge pumps does not render the bilge system inoperable
- pumps are immediately available for bilge duty when necessary.

6.6 Materials

6.6.1 All bilge pipes used in or under coal bunkers or fuel storage tanks or in boiler or machinery spaces, including spaces in which oil settling tanks or fuel oil pumping units are situated, are to be of steel or other suitable material non-sensitive to heat.

7 Air, sounding and overflow pipes

7.1 Air pipes

7.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations. Their open ends are to be so arranged as to prevent the free entry of sea water in the compartments.

7.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments, the ship being assumed to be on an even keel.

c) In general, two air pipes are to be fitted for each compartment, except in small compartments, where only one air pipe may be accepted. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration by the Society.

d) Where only one air pipe is provided, it is not to be used as a filling pipe.

7.1.3 Location of open ends of air pipes

Air and overflow pipes are to be laid vertically. Air and overflow pipes passing through cargo holds are to be protected against damage.

Where tanks are filled by pumping through permanently installed pipelines, the inside cross-section of the air pipes is to equal at least 125 % that of the corresponding filling pipe.

Air pipes of lubricating oil storage tanks may terminate in the engine room. Air pipes of lubricating oil storage tanks which form part of the vessel's shell are to terminate in the engine room casing above the freeboard deck.

It is necessary to ensure that no leaking oil can spread on to heated surfaces where it may ignite.

The air pipes of lubricating oil tanks and gear and engine crankshaft casings are not to be led to a common line.

Cofferdams and void spaces with bilge connections are to be provided with air pipes terminating above the open deck.

7.1.4 Height of air pipes

a) The height of air pipes extending above the freeboard deck from the deck to the point where water may have access below is to be at least 450 mm.

This height is to be measured from the upper face of the deck, including sheathing or any other covering, up to the point where water may penetrate inboard.

b) Where these heights may interfere with the working of the ship, a lower height may be approved, provided the Society is satisfied that this is justified by the closing arrangements and other circumstances. Satisfactory means which are permanently attached are to be provided for closing the openings of the air pipes.

c) The height of air pipes may be required to be increased on ships for the purpose of compliance with buoyancy calculations.

Table 22 : 760 mm Air Pipe Thickness and Bracket Standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness (mm)	Maximum projected area of head (cm^2)	Height **(1)** of brackets (mm)
65	6,0	-	480
80	6,3	-	460
100	7,0	-	380
125	7,8	-	300
150	8,5	-	300
175	8,5	-	300
200	8,5 **(2)**	1900	300 **(2)**
250	8,5 **(2)**	2500	300 **(2)**
300	8,5 **(2)**	3200	300 **(2)**
350	8,5 **(2)**	3800	300 **(2)**
400	8,5 **(2)**	4500	300 **(2)**

(1) Brackets (see [9.1.10]) need not extend over the joint flange for the head.
(2) Brackets are required where the as fitted (gross) thickness is less than 10,5 mm, or where the tabulated projected head area is exceeded.
Note 1: For other air pipe heights, the relevant requirements in [9.1.10] are to be applied.

7.2 Sounding pipes

7.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:
- a level gauge of an approved type efficiently protected against shocks, or
- a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

7.2.2 Position of sounding pipes

Sounding pipes are to be located as close as possible to suction pipes.

7.2.3 Termination of sounding pipes

a) As a general rule, sounding pipes are to end above the bulkhead deck or the freeboard deck in easily accessible places and are to be fitted with efficient, permanently attached, metallic closing appliances.

b) In machinery spaces and tunnels, where the provisions of a) cannot be satisfied, short sounding pipes led to readily accessible positions above the floor and fitted with efficient closing appliances may be accepted.

In ships required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

7.2.4 Special arrangements for sounding pipes of flammable oil tanks

Where sounding pipes cannot be extended above the open deck, they are to be provided with self-closing shut-off devices as well as with self-closing test valves.

The openings of sounding pipes are to be located at a sufficient distance from boilers, electrical equipment and hot components.

Sounding pipes are not to terminate in accommodation or service spaces. They are not to be used as filling pipes.

7.2.5 Construction of sounding pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) In cargo ships, the sounding arrangement of compartments by means of bent pipes passing through other compartments will be given special consideration by the Society. Such an arrangement is normally accepted only if the compartments passed through are cofferdams or are intended to contain the same liquid as the compartments served by the sounding pipes.

c) Bent portions of sounding pipes are to have reinforced thickness and be suitably supported.

d) The internal diameter of sounding pipes is not to be less than 32 mm. Where sounding pipes pass through refrigerated spaces, or through the insulation of refrigerated spaces in which the temperature may be below 0°C, their internal diameter is to be at least 60 mm.

e) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantlings.

7.3 Overflow pipes

7.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the diameter of cross-sectional area of air pipes is less than 50 mm, except for tanks of less than 50 mm.

7.3.2 Design of overflow systems

a) Overflow pipes are to be led:
   - either outside,
   - or, in the case of fuel oil or lubricating oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Where tanks containing the same or different liquids are connected to a common overflow system, the arrangement is to be such as to prevent any risk of:
   - intercommunication between the various tanks due to movements of liquid when emptying or filling, or due to the inclination of the ship
   - overfilling of any tank from another assumed flooded due to hull damage.

   For this purpose, overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

d) Where deep tanks which can be used to contain liquid or dry cargo or fuel oil are connected to a common overflow system, arrangements are to be made so that liquid or vapours from other compartments cannot enter such tanks when carrying dry cargo.

e) Where tanks alternately containing fuel oil and ballast water are connected to a common overflow system, arrangements are to be made to prevent the ballast water overflowing into the tanks containing fuel oil and vice-versa.

f) Additional requirements for ships subject to damage stability checks are given in [5.5.3].

7.3.3 Overflow tanks

a) Overflow tanks are to have a capacity sufficient to receive the delivery of the pumps for at least 10 minutes.

b) Overflow tanks are to be fitted with an air pipe complying with [9.1] which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

   Such means are to discharge to a position which is safe in the opinion of the Society.

c) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing. Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

7.3.4 Specific requirements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 50 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

7.4 Constructional requirements applying to sounding, air and overflow pipes

7.4.1 Materials

a) Sounding, air and overflow pipes are to be made of steel or any other material approved for the application considered.

b) Exposed parts of sounding, air and overflow pipes are to be made of approved metallic materials.

7.4.2 Passage of pipes through certain spaces

a) Air pipes and sounding pipes led through refrigerated cargo holds or spaces are to be suitably insulated.

b) When sounding, air and overflow pipes made of steel are permitted to pass through ballast tanks or fuel oil tanks, they are to comply with [5.2.3].

c) Sounding, air and overflow pipes passing through cargo holds are to be adequately protected.

7.4.3 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the ship is on an even keel.

7.4.4 Name plates

Nameplates are to be fixed at the upper part of air pipes and sounding pipes.

8 Cooling systems

8.1 Application

8.1.1 This Article applies to all cooling systems using river water. Air cooling systems will be given special consideration.

8.2 Principle

8.2.1 General *(1/1/2011)*

Cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers' recommended limits during all operations, including starting and manoeuvring, under the inclination angles and the ambient conditions specified in Sec 1.

8.2.2 Expansion tanks

Fresh water expansion tanks are to be provided with at least:

- a deaerating device
- a water level indicator
- a filling connection
- a drain.

8.3 Design of river cooling systems

8.3.1 Cooling water inlets

a) The river inlets are to be low inlets, so designed as to remain submerged under all normal navigation conditions.

b) Each river chest is to be provided with an air pipe which can be shut off and which is to extend above the bulkhead deck. The inside diameter of the air pipe is to be compatible with the size of the river chests and is not to be less than 30 mm.

c) Where compressed air is used to blow through river chests, the pressure is not to exceed 2 bar.

d) Two valves are to be provided for main propulsion plants.

e) The cooling water pumps of important auxiliaries are to be connected to the river chests over separate valves.

f) The suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

8.3.2 Fresh water coolers

When water coolers are applied to the outside part of the vessel's shell plating or are part of the vessel's shell plating and for special outboard coolers, provision is to be made for satisfactory deaeration of the cooling water.

Drawings of the cooler and the cooler arrangement are to be submitted for review/approval.

8.3.3 Filters

Suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

9 Fuel oil systems

9.1 Application

9.1.1 Scope

This Article applies to all fuel oil systems supplying any kind of installation.

9.2 Principle

9.2.1 General

a) Fuel oil systems are to be so designed as to ensure the proper characteristics (purity, viscosity, pressure) of the fuel oil supply to engines and boilers.

b) Fuel oil systems are to be so designed as to prevent:

- overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
- fuel oil from coming into contact with sources of ignition
- overheating and seizure of fuel oil.

c) Fuel oils used for engines and boilers are to have a flashpoint complying with the provisions of Sec 1.

Table 23 : Cooling systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Sea water pump pressure or flow	L	local					
Fresh water pump pressure or flow	L	local					
Level in cooling water expansion tank	L	local					

9.2.2 Availability of fuel systems

a) Fuel oil systems are to be so designed that, in the event that any one essential auxiliary of such systems becomes inoperative, the fuel oil supply to boilers and engines can be maintained (see also [9.2.1] a)). Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

b) Fuel oil tanks are to be so arranged that, in the event of damage to any one tank, complete loss of the fuel supply to essential services does not occur.

c) Where engines and boilers are operated with heavy fuel oils, provisions are to be made to supply them with fuel oils which do not need to be heated.

9.3 General

9.3.1 Arrangement of fuel oil systems

In a ship in which fuel oil is used, the arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the ship and persons on board.

9.3.2 Provision to prevent overpressure

Provision is to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

9.3.3 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

9.3.4 Access

Spaces where fuel oil is stored or handled are to be readily accessible.

9.4 Design of fuel oil filling and transfer systems

9.4.1 General

a) A system of pumps and piping for filling and transferring fuel oil is to be provided.

b) Provisions are to be made to allow the transfer of fuel oil from any storage, settling or service tank to another tank.

9.4.2 Filling systems

a) Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

b) Arrangements are to be made to avoid overpressure in the filling lines which are served by pumps on board. Where safety valves are provided for this purpose, they are to discharge to the overflow tank referred to in [7.3.3] or to other safe positions deemed satisfactory.

9.4.3 Independence of fuel oil transfer lines

Except where permitted in [9.4.5], the fuel oil transfer piping system is to be completely separate from the other piping systems of the ship.

9.4.4 Simultaneous transfer of fuel oil and ballast water

Where tanks are intended to alternately contain fuel oil and ballast water, the piping arrangement is to be such that fuel may be transferred by means of fuel pumps to or from any tank while ballast pumps are simultaneously being used.

9.4.5 Alternative carriage of fuel oil, ballast water or other liquid and dry cargo

Where certain compartments are likely to contain alternatively fuel oil, ballast water and other liquid or dry cargo, the transfer pipes supplying these compartments are to be fitted with blind flanges or other appropriate change-over devices.

9.4.6 Transfer pumps

At least one means of transfer is to be provided.

9.5 Design of fuel oil tanks and bunkers

9.5.1 General

Tanks such as collector tanks, de-aerator tanks etc. are to be considered as fuel oil tanks for the purpose of application of this sub-article, and in particular regarding the valve requirements.

Tanks with a volume lower than 500 l will be given special consideration by the Society.

9.5.2 Scantlings

a) The scantlings of fuel oil tanks and bunkers forming part of the ship's structure are to comply with the requirements stated in Part B.

b) Scantlings of fuel oil tanks and bunkers which are not part of the ship's structure are to comply with Tasneef Rules for the Classification of Ships. For cases which are not contained in the tables of Appendix 4, Ch 1, Pt C of the foregoing Rules, scantlings will be given special consideration by the Society.

9.5.3 Filling and suction pipes

a) All suction pipes from fuel oil tanks and bunkers, including those in the double bottom, are to be provided with valves.

b) For storage tanks, filling pipes may also be used for suction purposes.

c) Where the filling pipes to fuel oil bunkers and tanks are not led to the upper part of the such bunkers and tanks, they are to be provided with non-return valves at their ends, unless they are fitted with valves arranged in accordance with the requirements stated in [9.5.4].

9.5.4 Remote control of valves

a) Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space.

b) Such valves and cocks are also to include local control and on the remote and local controls it is to be possible to verify whether they are open or shut. (See [2.7.3].)

9.5.5 Drain pipes

Where fitted, drain pipes are to be provided with self-closing valves or cocks.

9.5.6 Air and overflow pipes

Air and overflow pipes are to comply with [7.1] and [7.3].

9.5.7 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided.

b) Sounding pipes of fuel oil tanks are to comply with the provisions of [7].

c) Oil-level gauges complying with [2.9.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

e) Service tanks for main engines, important auxiliaries and bow thrusters are to be provided with a low level alarm which is to be fitted at a height that will enable the vessel to reach a safe location

9.6 Design of fuel supply systems

9.6.1 General

a) In vessels where heavy fuel oil and marine diesel oil are used, a change-over system from one fuel to the other is to be provided. This system is to be so designed as to avoid:
   - overheating of marine diesel oil
   - inadvertent ingress of heavy fuel oil into marine diesel oil tanks.

b) When necessary, arrangements are to be made for cooling the marine diesel oil from engine return lines.

9.7 Construction of fuel oil piping systems

9.7.1 Materials

a) Fuel oil pipes and their valves are to be of steel or other approved material, except that the use of flexible pipes may be accepted provided they comply with [2.6.2].

b) Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by the Society having regard to the fire risk.

c) For valves fitted to fuel oil tanks and which are under a static pressure head, steel or nodular cast iron may be accepted. However, ordinary cast iron valves may be used in fuel piping systems where the design pressure is lower than 0,7 MPa and the design temperature is below 60°C.

d) Internal galvanisation of fuel oil pipes and tank or bunker walls is to be avoided.

9.7.2 Pipe thickness

The thickness of pipes containing fuel oil is to be calculated for a design pressure according to Tab 24.

9.7.3 Pipe connections

Connections and fittings of pipes containing fuel oil are to be suitable for a design pressure according to Tab 24.

9.8 Arrangement of fuel oil piping systems

9.8.1 Passage of fuel oil pipes through tanks

a) Fuel pipes are not to pass through tanks containing boiler feed water, fresh water, other flammable oil or liquid cargo, unless they are contained within tunnels.

b) Transfer pipes passing through ballast tanks are toc omply with [5.2.3].

9.8.2 Passage of pipes through fuel oil tanks

Boiler feed water, fresh water or liquid cargo pipes are not to pass through fuel oil tanks, unless such pipes are contained within tunnels.

9.8.3 Tank filling and suction systems

a) Filling and suction lines terminating below the oil level in tanks are to be fitted with remote control shutoff valves.

b) The remote control shut-off valves are to be capable of being operated from a permanently accessible open deck.

c) Air and sounding pipes are not to be used to fill fuel tanks.

d) The inlet openings of suction pipes are to be located above the drain pipes.

e) Service tanks of up to 50 litres capacity mounted directly on diesel engines need not be fitted with remote control shut-off valves.

9.9 Pipe layout

9.9.1 Fuel lines may not pass through tanks containing feed water, drinking water or lubricating oil.

9.9.2 Fuel lines may not be laid in the vicinity of hot engine components, boilers or electrical equipment. The number of detachable pipe connections is to be limited. Shut-off valves in fuel lines are to be operable from above the floor plates in machinery spaces.

Glass and plastic components are not permitted in fuel systems.

9.9.3 Shut-off valves in fuel spill lines to service tanks are not permitted.

9.9.4 Fuel supply lines to continuously operating engines are to be fitted with duplex filters with a change-over cock or with self-cleaning filters. Bypass arrangements are not permitted.

10 Lubricating oil systems

10.1 Application

10.1.1 This Article applies to lubricating oil systems serving diesel engines, steam and gas turbines, reverse and reduction gears, for lubrication or control purposes.

It also applies to separate oil systems intended for the cooling of engine pistons.

Table 24 : Definition of the design pressure for fuel oil systems

Working temperature → Working pressure ↓	T ≤ 60°C	T > 60°C
P ≤ 0,7 MPa	0,3 MPa or maximum working pressure, whichever is the greater	0,3 MPa or maximum working pressure, whichever is the greater
P > 0,7 MPa	maximum working pressure	1,4 MPa or maximum working pressure, whichever is the greater

10.2 Principle

10.2.1 General

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines, turbines and other equipment, including electric motors, intended for propulsion:

- over the whole speed range, including starting, stopping and, where applicable, manoeuvring
- for all the inclinations angles stated in Sec 1

b) Lubricating oil systems are to be so designed as to ensure sufficient heat transfer and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

10.2.2 Availability

a) Lubricating oil systems are to be so designed that, in the event that any one pump is inoperative, the lubrication of the engines and other equipment is maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

b) An emergency lubricating system, such as a gravity system, is to be provided to ensure sufficient lubrication of equipment which may be damaged due to a failure of the pump supply.

10.3 General

10.3.1 Arrangement of lubricating oil systems

a) The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems are to be such as to ensure the safety of the ship and persons on board.

b) The provisions of [5.10] are to be complied with, where applicable.

10.3.2 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) The filters provided for this purpose for main machinery and machinery driving electric propulsion generators are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

c) The fineness of the filter mesh is to comply with the requirements of the engine or turbine manufacturers.

10.4 Design of lubricating oil tanks

10.4.1 Remote control of valves

Lubricating oil tanks with a capacity of 500 litres and above are to be fitted with remote controlled valves in accordance with the provisions of [9.5.4]. Where it is determined that the unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery remote controlled valves need not be installed.

Suction valves from storage tanks need not be arranged with remote controls provided they are kept closed except during transfer operations.

10.4.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of [9.5.3].

10.4.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of [7.1] and [7.3].

10.4.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of lubricating oil contained in the tanks are to be provided.

b) Sounding pipes are to comply with the provisions of [7.2].

c) Oil-level gauges complying with [2.9.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

10.4.5 Material

Materials used for the oil piping system in machinery spaces are to comply with the provisions of [9.7].

10.4.6 Sight flow glasses

The use of sight flow glasses in lubricating systems is permitted, provided that they are shown by testing to have a suitable degree of fire resistance.

11 Thermal oil systems

11.1 Application

11.1.1 This Article applies to all thermal oil systems involving organic liquids heated below their initial boiling temperature at atmospheric pressure by means of:

- oil fired heaters,
- exhaust gas heaters,
- or electric heaters.

11.2 Principle

11.2.1 General

Thermal oil systems are to be so designed as to:

- avoid overheating of the thermal oil and contact with air
- take into account the compatibility of the thermal oil with the heated products in case of contact due to leakage of coils or heater tubes
- prevent oil from coming into contact with sources of ignition.

11.2.2 Availability

Thermal oil systems are to be so designed that, in the event that any one essential auxiliary is inoperative, the thermal oil supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

11.3 General

11.3.1 Limitations on use of thermal oil

a) The oil is to be used in the temperature ranges specified by the producer. The delivery temperature is, however, to be kept 50°C below the oil distillation point.

b) Thermal oil is not to be used for the direct heating of:

- accommodation,
- fresh drinking water
- liquid cargoes with flashpoints below 60°C, except where permitted in Pt E, Ch 1, Sec 12.

11.3.2 Location of thermal oil system components

Thermal oil heaters are normally to be located in spaces separated from main and auxiliary machinery spaces.

However, thermal oil heaters located in machinery spaces and protected by adequate screening may be accepted, subject to special consideration by the Society.

Note 1: For the purpose of application of Chapter 3, spaces where thermal oil heaters are located are to be considered as machinery spaces of category A.

11.3.3 Provision for quick drainage and alternative arrangements

a) Inlet and outlet valves of oil fired and exhaust fired heaters are to be arranged for remote closing from outside the compartment where they are situated.

As an alternative, thermal oil systems are to be arranged for quick gravity drainage of the thermal oil contained in the system into a draining tank.

b) The expansion tank is to be arranged for quick gravity drainage into a draining tank.

However, where the expansion tank is located in a low fire risk space, the quick drainage system may be replaced by a remote controlled closing device for isolating the expansion tank.

The quick drainage system and the alternative closing device are to be capable of being controlled from inside and outside the space containing the expansion tank.

11.3.4 Ventilation

a) Spaces containing thermal oil heaters are to be suitably mechanically ventilated.

b) Ventilation is to be capable of being stopped from outside these spaces.

11.4 Design of thermal oil heaters and heat exchangers

11.4.1 Thermal oil heaters

Oil fired and exhaust-fired thermal oil heaters are to be designed, equipped and controlled in accordance with the requirements specified in Sec 3.

11.4.2 Heat exchangers

Heat exchangers are to be designed and equipped in accordance with the requirements specified in Sec 3.

11.5 Design of storage, expansion and draining tanks

11.5.1 Storage and draining tanks

a) The capacity of the storage tank is to be sufficient to compensate the losses expected in service.

b) The capacity of the draining tank is to be sufficient to collect the quantity of thermal oil contained in the system, including the expansion tank.

c) Storage and draining tanks may be combined.

11.5.2 Expansion tanks

a) The capacity of the expansion tank is to be sufficient to allow volume variations, due to temperature changes, of all the circulating oil.

b) The expansion tank is to be so designed, installed and connected to the circuit as to ensure that the temperature inside the tank remains below 50°C.

11.5.3 Drain pipes

Where provided, drains pipes of thermal oil tanks are to be fitted with self-closing valves or cocks.

11.5.4 Air pipes

a) Air pipes fitted to the expansion and drainage tanks are to be suitably sized to allow the quick gravity drainage referred to in [11.3.3].

b) The applicable requirements of [7.1] are to be complied with.

11.5.5 Overflow pipes

a) The expansion tank is to be fitted with an overflow pipe led to the drainage tank. This overflow pipe may be combined with the quick draining line provided for in [13.3.3], item b).

b) The applicable requirements of [7.3] are to be complied with.

11.5.6 Sounding pipes and level gauges

a) Sounding pipes are to comply with the provisions of [7.2].

b) Level gauges are to comply with the provisions of [2.9.2].

11.6 Design of circulation and heat exchange systems

11.6.1 Circulating pumps

At least two circulating pumps are to be provided, of such a capacity as to maintain a sufficient flow in the heaters with any one pump out of action.

However, for circulating systems supplying non-essential services, one circulating pump only may be accepted.

11.6.2 Filters

A device which efficiently filters the thermal oil is to be provided in the circuit.

In the case of essential services, the filters provided for this purpose are to be so arranged that they can be easily cleaned without stopping the thermal oil supply.

The fineness of the filter mesh is to comply with the requirements of the thermal oil heating installation manufacturer.

11.7 Control and monitoring

11.7.1 General

In addition to the requirements specified in Sec 3, [2.5.2] for thermal heaters and heat exchangers, alarms and safeguards for thermal oil systems are to be provided in accordance with Sec 3, Tab 13.

11.7.2 Remote control

a) Remote control is to be arranged for:
   - shut-off of circulating pumps
   - inlet and outlet valves of heaters (see item a) of [11.3.3])
   - quick drainage of expansion tank, or shut-off of the alternative devices (see item b) of [11.3.3].
   - shut-off of the fuel supply to the oil fired heaters or of the exhaust gas supply to the exhaust gas heaters (see Sec 3, [5.3]).

b) Such control is to be possible from the space containing the thermal oil heaters and from another position located outside such space.

11.8 Construction of thermal oil piping systems

11.8.1 Materials

a) Materials are to comply with the provisions of [9.7.1].

b) Casings of pumps, valves and fittings are to be made of steel or other ductile material.

11.8.2 Pipe connections

a) Pipe connections are to comply with Article [2.4] and to be suitable for the design temperature of the thermal oil system.

b) Screw couplings of a type approved by the Society may be accepted for pipes of an outside diameter not exceeding 15 mm provided they are fitted with cutting rings or equivalent arrangements.

c) The materials of the joints are to be impervious to thermal oil.

11.9 Thermal oil piping arrangements

11.9.1 Passage of thermal oil pipes through certain spaces

a) Thermal oil pipes are not to pass through accommodation or public spaces or control stations.

b) Thermal oil pipes passing through main and auxiliary machinery spaces are to be restricted as far as possible.

11.9.2 Discharge of relief valves

Relief valves are to discharge to the drain tank.

11.9.3 Provision for de-aerating

Provisions are to be made for automatic evacuation of air, steam and gases from the thermal oil system to a safe location.

12 Hydraulic systems

12.1 Application

12.1.1 Hydraulic installations intended for essential services

Unless otherwise specified, this Article applies to all hydraulic power installations intended for essential services, including:

- actuating systems of thrusters
- actuating systems of steering gear
- actuating systems of lifting appliances
- manoeuvring systems of hatch covers
- manoeuvring systems of stern, bow and side doors and bow visors
- manoeuvring systems of mobile ramps, movable platforms, elevators and telescopic wheelhouses
- starting systems of diesel engines and gas turbines
- remote control of valves.

12.1.2 Hydraulic installations located in spaces containing sources of ignition

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of [12.3.2], [12.3.3], [12.4.3] and [12.4.4].

12.1.3 Low pressure or low power hydraulic installations

Hydraulic power installations with a design pressure of less than 2,5 MPa and hydraulic power packs of less than 5 kW will be given special consideration by the Society.

12.1.4 Very high pressure hydraulic installations

Hydraulic power installations with a design pressure exceeding 35 MPa will be given special consideration by the Society.

12.2 Principle

12.2.1 General

Hydraulic systems are to be so designed as to:

- avoid any overload of the system
- maintain the actuated equipment in the requested position (or the driven equipment at the requested speed)
- avoid overheating of the hydraulic oil
- prevent hydraulic oil from coming into contact with sources of ignition.

12.2.2 Availability

a) Hydraulic systems are to be so designed that, in the event that any one essential component becomes inoperative, the hydraulic power supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired. Such reduction of capability is not acceptable for steering gear.

b) When a hydraulic power system is simultaneously serving one essential system and other systems, it is to be ensured that:
   - any operation of such other systems, or
   - any failure in the whole installation external to the essential system

   does not affect the operation of the essential system.

c) Provision b) applies in particular to steering gear.

d) Hydraulic systems serving lifting or hoisting appliances, including platforms, ramps, hatch covers, lifts, etc., are to be so designed that a single failure of any component of the system may not result in a sudden undue displacement of the load or in any other situation detrimental to the safety of the ship and persons on board.

12.3 General

12.3.1 Definitions

a) A power unit is the assembly formed by the hydraulic pump and its driving motor.

b) An actuator is a component which directly converts hydraulic pressure into mechanical action.

12.3.2 Limitations of use of hydraulic oils

a) Oils used for hydraulic power installations are to have a flashpoint not lower than 150°C and be suitable for the entire service temperature range.

b) The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

12.3.3 Location of hydraulic power units

a) Whenever practicable, hydraulic power units are to be located outside main engine or boiler rooms.

b) Where this requirement is not complied with, shields or similar devices are to be provided around the units in order to avoid an accidental oil spray or mist on heated surfaces which may ignite oil.

12.4 Design of hydraulic systems

12.4.1 Power units

a) Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance not affecting the safety of the ship may be accepted, except for steering gear.

b) Low power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

12.4.2 Filtering equipment

a) A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

b) Where filters are fitted on the discharge side of hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

12.4.3 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

12.4.4 Provision against overpressure

a) Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

b) Safety valves are to discharge to the low pressure side of the installation or to the service tank.

12.4.5 Provision for venting

Cocks are to be provided in suitable positions to vent the air from the circuit.

12.5 Design of hydraulic tanks and other components

12.5.1 Hydraulic oil service tanks

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:

- a level gauge complying with [2.9.2]
- a temperature indicator
- a level switch complying with [12.6.2].

b) The free volume in the service tank is to be at least 10% of the tank capacity.

12.5.2 Hydraulic oil storage tanks

a) Hydraulic power installations supplying essential services are to include a storage tank of sufficient capacity to refill the whole installation should the need arise case of necessity.

b) For hydraulic power installations of less than 5 kW, the storage means may consist of sealed drums or tins stored in satisfactory conditions.

12.5.3 Hydraulic accumulators

The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

12.6 Control and monitoring

12.6.1 General

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

12.6.2 Monitoring

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Sec 9 apply, are to be provided in accordance with Tab 25 .

Note 1: Some departures from Tab 25 may be accepted by the Society in the case of ships with a restricted navigation notation.

Note 2: Tab 25 does not apply to steering gear.

12.7 Construction of hydraulic oil piping systems

12.7.1 Materials

a) Pipes are to be made of seamless steel. The use of welded steel pipes will be given special consideration by the Society.

b) Casings of pumps, valves and fittings are to be made of steel or other ductile material.

Table 25 : Hydraulic oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Pump pressure	L						
Service tank level	L **(1)**						

(1) The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 50 % of the circuit volume , whichever is the less.

13 Boiler feed water and condensate systems

13.1 Application

13.1.1 This Article applies to:

- feed water systems of oil fired and exhaust gas boilers
- steam drain and condensate systems.

13.2 Principle

13.2.1 General

Boiler feed water and condensate systems are to be so designed that:

- reserve feed water is available in sufficient quantity to compensate for losses
- feed water is free from contamination by oils or chlorides.

13.2.2 Availability

a) Feed water systems are to be so designed that, in the event of failure of any one component, the steam supply to essential services can be maintained or restored.

b) Condensate systems are to be so designed that, in the event of failure:
   - of one condensate pump,
   - or of the arrangements to maintain vacuum in the condenser,

   the steam supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

13.3 Design of boiler feed water systems

13.3.1 Number of feed water systems

a) Every steam generating system which provides services essential for the safety of the ship, or which could be rendered dangerous by the failure of its feed water supply, is to be provided with not less than two separate feed water systems from and including the feed pumps, noting that a single penetration of the steam drum is acceptable.

b) The requirement stated in a) may be dispensed with for boilers heated exclusively by engine exhaust gases or by steam for which one feed system is considered as sufficient, provided an alternative supply of steam is available on board.

c) Each boiler is to be provided with feed regulators as specified in Sec 3, [5].

13.3.2 Feed pumps

a) The following pumps are to be provided:
   - at least one main feed pump of sufficient capacity to supply the boilers under nominal conditions,
   - and one standby feed pump.

b) The capacity of the standby pump may be less than that of the main feed pumps provided it is demonstrated that, taking into account the reduction of the propulsion capability, the ship remains safely operable.

c) Main feed pumps may be either independent or driven by the main turbines. The standby feed pump is to be independent.

d) In twin-screw ships in which there is only one independent feed pump, each main turbine is to be fitted with a driven pump. Where all feed pumps are independent, they are to be so arranged as to be capable of dealing with the feed water necessary to supply steam either to both turbines or to one turbine only.

e) Independent feed pumps for main boilers are to be fitted with a delivery control and regulating system.

f) Unless overpressure is prevented by the feed pump characteristics, means are to be provided which will prevent overpressure in any part of the feed water system.

g) The pressure head of feed pumps is to take into account the maximum service pressure in the boiler as well as the pressure losses in the discharge piping. The suction head of feed pumps is to be such as to prevent any risk of cavitation.

h) Feed pumps and pipes are to be provided with valves so arranged that any one pump can be overhauled while the boilers are operating at full load.

13.3.3 Feed water tanks

a) All ships fitted with main boilers or auxiliary boilers for essential services are to be provided with reserve feed water tanks of sufficient capacity having regard to the service of the ship.

b) Boilers are to be provided with means to supervise and control the quality of the feed water. Suitable arrangements are to be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

c) Feed water tanks are not to be located adjacent to fuel oil tanks. Fuel oil pipes are not to pass through feed water tanks.

13.3.4 Provision for de-aerating feed water

A de-aerator is to be provided to ensure the de-aeration of the feed water intended for main boilers before it enters such boilers.

13.4 Arrangement of feed water and condensate piping

13.4.1

a) Feed water pipes are not to pass through fuel oil or lubricating oil tanks.

b) Pipes connected to feed water tanks are to be so arranged as to prevent the contamination of feed water by fuel oil, lubricating oil or chlorides.

14 Compressed air systems

14.1 Arrangement of compressed air piping systems

14.1.1 Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.

Provision is to be made to reduce to a minimum the entry of oil and water into the air pressure system (oil and water traps in filling lines to receivers).

Starting air lines may not be used as filling lines for air receivers.

The starting air line to each engine is to be fitted with a non-return valve and a drain.

Means are to be provided to prevent overpressure in any part of the compressed air system: a safety relief valve is to be fitted at the delivery output of any pressure reducing valve.

Pressure water tanks and other tanks connected to the compressed air system are to be considered as pressure vessels and are to comply with the requirements in Ch 1, Sec 3.

14.2 Compressed air connections for blowing through river chests

14.2.1 Where compressed air is used to blow through river chests, the pressure is not to exceed 2 bar.

15 Exhaust gas systems

15.1 General

15.1.1 Application

This Article applies to:

- exhaust gas pipes from engines and gas turbines
- smoke ducts from boilers and incinerators.

15.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

15.2 Design of exhaust systems

15.2.1 General

Exhaust systems are to be so arranged as to minimise the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes.

15.2.2 Limitation of exhaust line surface temperature

a) Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:
   - their surface temperature may exceed 220°C, or
   - they pass through spaces of the ship where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Sec 1, [3.7.1].

15.2.3 Limitation of pressure losses

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine or boiler Manufacturers.

15.2.4 Intercommunication of engine exhaust gas lines or boiler smoke ducts

a) Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas boiler or economiser, unless each exhaust pipe is provided with a suitable isolating device.

b) Smoke ducts from boilers discharging to a common funnel are to be separated to a height sufficient to prevent smoke passing from a boiler which is operating to a boiler out of action.

15.2.5 Exhaust gas pipe terminations

a) Where exhaust pipes are led overboard close to the load waterline, means are to be provided to prevent water from entering the engine or the ship.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

15.2.6 Control and monitoring

A high temperature alarm is to be provided in the exhaust gas manifolds of thermal oil heaters to detect any outbreak of fire.

15.3 Materials

15.3.1 General

Materials of exhaust gas pipes and fittings are to be resistant to exhaust gases and suitable for the maximum temperature expected.

15.3.2 Use of plastics

The use of non-metallic materials may be accepted in water-cooled systems in accordance with the provisions of the Rules for the Classification of Ships.

15.4 Arrangement of exhaust piping systems

15.4.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

15.4.2 Provision for draining

a) Drains are to be provided where necessary in exhaust systems, and in particular in exhaust ducting below exhaust gas boilers, in order to prevent water flowing into the engine.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

15.4.3 Flexible hoses

The use of flexible hoses in water cooled exhaust systems will be given special consideration by the Society.

15.4.4 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

16 Certification, inspection and testing of piping systems

16.1 Application

16.1.1 The proof of the quality of materials for pipe class II is to be in the form of an inspection certificate according to EN 10.204 or equivalent. For this purpose, the Manufacturer of the material is to have been accepted by the Society.

16.1.2 For components in pipe class III, a works' certificate issued by the Manufacturer of the material is sufficient.

16.1.3 Welded joints in pipelines of class II are to be tested in accordance with the Society's Rules for Materials and Welding

16.2 Type tests

16.2.1 Type tests of flexible hoses and expansion joints

The requirements of Pt C, Ch 1, Sec 10, 20.2.1 of Tasneef Rules for the Classification of Ships are to be applied.

16.3 Testing of materials

16.3.1 General

Detailed specifications for material tests are given in Pt D.

16.4 Hydrostatic testing of piping systems and their components

16.4.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

16.4.2 Hydrostatic pressure tests of piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor's satisfaction for:
   - all class I and II pipes and their integral fittings
   - all steam pipes, feed water pipes, compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings.

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Note 1: Classes of pipes are defined in [1.5.2].

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) Where the design temperature does not exceed 300°C, the test pressure is to be equal to 1,5 p.

e) Where the design temperature exceeds 300°C, the test pressure is to be as follows:
   - for carbon and carbon-manganese steel pipes, the test pressure is to be equal to 2 p
   - for alloy steel pipes, the test pressure P_H is to be determined by the following formula, but need not exceed 2 p:

   $$p_H = 1{,}5\frac{K_{100}}{K_T}p$$

   where:

   K_{100} : permissible stress for 100°C, as stated in Tab 10

   K_T : permissible stress for the design temperature, as stated in Tab 10.

Note 2: Where alloy steels not included in Tab 10 are used, the permissible stresses will be given special consideration.

f) Where it is necessary to avoid excessive stress in way of bends, branches, etc., the Society may give special consideration to the reduction of the test pressure to a value not less than 1,5 p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

g) While satisfying the condition stated in b), the test pressure of pipes located on the discharge side of centrifugal pumps driven by steam turbines is not to be less than the maximum pressure liable to be developed by such pumps with closed discharge at the operating speed of their overspeed device.

h) When the hydrostatic test of piping is carried out on board, these tests may be carried out in conjunction with the tests required in [16.4.7].

16.4.3 Hydrostatic tests of valves

a) Valves and fittings non-integral with the piping system and intended for class I and II pipes are to be subjected to hydrostatic tests in accordance with standards recognised by the Society, at a pressure not less than 1,5 times the design pressure p defined in [1.3.2].

b) Valves intended to be fitted on the ship side below the load waterline are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in Sec 3.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

e) For coolers of internal combustion engines, see Sec 2.

16.4.4 Hydrostatic tests of fuel oil bunkers and tanks not forming part of the ship's structure

Fuel oil bunkers and tanks not forming part of the ship's structure are to be subjected to a hydrostatic test under a pressure corresponding to the maximum liquid level in such spaces or in the air or overflow pipes, witha minimum of 2,40 m above the top. The minimum height is to be 3,60 m for tanks intended to contain fuel oil with a flashpoint below 60°C.

16.4.5 Hydrostatic tests of pumps and compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the pressure p_H determined by the following formulae:

- $p_H = 1,5\ p$ where $p \le 4$
- $p_H = 1,4\ p + 0,4$ where $4 < p \le 25$
- $p_H = p + 10,4$ where $p > 25$

where

- p_H : test pressure, in MPa
- p : design pressure, as defined in [1.3.2], in MPa.

p_H is not to be less than 0,4 MPa.

b) While satisfying the condition stated in a), the test pressure for centrifugal pumps driven by steam turbines is not to be less than 1,05 times the maximum pressure likely to be recorded with closed discharge at the operating speed of the overspeed device.

c) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure p_H defined in a). When determining p_H, the pressure p to be considered is that which may result from accidental communication between the cooler and the adjoining stage of higher pressure, allowance being made for any safety device fitted on the cooler.

d) The test pressure for water spaces of compressors and their intermediate coolers is not to be less than 1,5 times the design pressure in the space concerned, subject to a minimum of 0,2 MPa.

e) For air compressors and pumps driven by diesel engines, see Sec 2.

16.4.6 Hydrostatic test of flexible hoses and expansion joints

a) Each flexible hose or expansion joint, together with its connections, is to undergo a hydrostatic test under a pressure at least equal to 1,5 times the maximum service pressure.

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

16.4.7 Pressure tests of piping after assembly on board

After assembly on board, the following tightness tests are to be carried out in the presence of the Surveyor.

In general, all the piping systems covered by these requirements are to be checked for leakage under operational conditions and, if necessary, using special techniques other than hydrostatic testing. In particular, heating coils in tanks and liquid or gas fuel lines are to be tested to not less than 1,5 times the design pressure but in no case less than 0,4 MPa.

16.5 Testing of piping system components during manufacturing

16.5.1 Pumps

a) Bilge and fire pumps are to undergo a performance test.

b) Rotors of centrifugal feed pumps for main boilers are to undergo a balancing test.

16.5.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

SECTION 9 STEERING GEAR

1 General

1.1 Application

1.1.1 Scope

Every vessel is to be equipped with at least one set of main and one set of auxiliary steering gear.

1.1.2 Power source

Steering systems fitted with two powered drive units are to have at least two power sources.

If the second power source for the powered steering apparatus is not constantly available while the vessel is under way, a buffer device carrying adequate capacity is to provide backup during the period needed for start-up.

In the case of electrical power sources, no other power consumers may be supplied by the main power source for the steering system.

1.1.3 General requirements

Vessels are to be fitted with a reliable steering system, which provides at least the manoeuvrability required by Chapter 1, Section 12.

Powered steering systems are to be designed in such a way that the rudder cannot change position unintentionally.

The steering system as a whole is to be designed for permanent lists of up to 15° and ambient temperatures from 20°C to + 50°C .

The component parts of the steering system are to be robust enough to always be able to withstand the stresses to which they may be subjected during normal operation. No external forces applied to the rudder are to impair the operating capacity of the steering apparatus and its drive unit.

The steering system is to incorporate a powered drive unit if so required by the forces needed to actuate the rudder.

A steering apparatus with powered drive unit is to be protected against overloads by means of a system that restricts the torque applied by the drive unit.

The penetrations for the rudder stocks are to be so designed as to prevent the spread of water-polluting lubricants.

1.2 Documentation to be submitted

1.2.1 Documents to be submitted for all steering gear

Before starting construction, all plans and specifications listed in Tab 1 are to be submitted to the Society for approval.

Table 1 : Documents to be submitted for steering gear

No.	I / A (2)	Document (1)
1	I	Assembly drawing of the steering gear including sliding blocks, guides, stops and other similar components
2	I	General description of the installation and of its functioning principle
3	I	Operating manuals of the steering gear and of its main components
4	I	Description of the operational modes intended for steering in normal and emergency conditions
5	A	For hydraulic steering gear, the schematic layout of the hydraulic piping of power actuating systems, including the hydraulic fluid refilling system, with indication of: • the design pressure • the maximum working pressure expected in service • the diameter, thickness, material specification and connection details of the pipes • the hydraulic fluid tank capacity • the flashpoint of the hydraulic fluid
6	I	For hydraulic pumps of power units, the assembly longitudinal and transverse sectional drawings and the characteristic curves
7	A	Assembly drawings of the rudder actuators and constructional drawings of their components, with, for hydraulic actuators, indication of: • the design torque • the maximum working pressure • the relief valve setting pressure
8	I	Constructional drawings of the relief valves for protection of the hydraulic actuators, with indication of: • the setting pressure • the relieving capacity
9	A	Diagrams of the electric power circuits

No.	I / A **(2)**	Document **(1)**
10	A	Functional diagram of control, monitoring and safety systems including the remote control from the navigating bridge, with indication of the location of control, monitoring and safety devices
11	A	Constructional drawings of the strength parts providing a mechanical transmission of forces to the rudder stock (tiller, quadrant, connecting rods and other similar items), with the calculation notes of the shrink-fit connections
12	I/A	For azimuth thrusters used as steering means, the specification and drawings of the steering mechanism and, where applicable, documents 2 to 6 and 8 to 11 above

(1) Constructional drawings are to be accompanied by the specification of the materials employed and, where applicable, by the welding details and welding procedures.
(2) A = to be submitted for approval in four copies
I = to be submitted for information in duplicate.

1.3 Definitions

1.3.1 Main steering gear

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

1.3.2 Steering gear power unit

Steering gear power unit is:

- in the case of electric steering gear, an electric motor and its associated electrical equipment
- in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump
- in the case of other hydraulic steering gear, a driving engine and connected pump.

1.3.3 Auxiliary steering gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.3.4 Power actuating system

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

1.3.5 Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.6 Steering gear control system

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3.7 Maximum ahead service speed

Maximum ahead service speed is the greatest speed which the ship is designed to maintain in service at sea at the deepest seagoing draught.

1.3.8 Maximum astern speed

Maximum astern speed is the speed which it is estimated the ship can attain at the designed maximum astern power at the deepest seagoing draught.

1.3.9 Maximum working pressure

Maximum working pressure is the maximum expected pressure in the system when the steering gear is operated to comply with the provisions of [2.5.1].

1.4 Symbols

1.4.1 The following symbols are used for strength criteria of steering gear components:

V : Maximum service speed, in knots, with the ship on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the value $(V+20)/3$

d_s : Rule diameter of the rudder stock in way of the tiller, in mm, as defined in Pt B, Ch 2, Sec 1

d_{se} : Actual diameter of the upper part of the rudder stock in way of the tiller, in mm

(in the case of a tapered coupling, this diameter is measured at the base of the assembly)

T_R : Rule design torque of the rudder stock given, in kN.m, by the following formula:

$$T_R = 13{,}5 \cdot d_s^3 \cdot 10^{-6}$$

T_E : For hand emergency operation, design torque due to forces induced by the rudder, in kN.m, given by the following formula:

$$T_E = 0{,}62 \cdot \left(\frac{V_E + 2}{V + 2}\right)^2 \cdot T_R$$

where:

- $V_E = 7$, where $V \le 14$
- $V_E = 0{,}5\ V$, where $V > 14$

T_G : For main hydraulic or electrohydraulic steering gear, torque induced by the main steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

Note 1: for hand-operated main steering gear, the following value is to be used:

$T_G = 1,25.T_R$

T_A : For auxiliary hydraulic or electrohydraulic steering geas, torque induced by the auxiliary steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

Note 2: for hand-operated auxiliary steering gear, the following value is to be used:

$T_A = 1,25.T_E$

T'_G : For steering gear which can activate the rudder with a reduced number of actuators, the value of T_G in such conditions

σ : Normal stress due to the bending moments and the tensile and compressive forces, in N/mm^2

τ : Tangential stress due to the torsional moment and the shear forces, in N/mm^2

σ_a : Permissible stress, in N/mm^2

σ_c : Combined stress, determined by the following formula:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2}$$

R : Value of the minimum specified tensile strength of the material at ambient temperature, in N/mm^2

R_e : Value of the minimum specified yield strength of the material at ambient temperature, in N/mm^2

R'_e : Design yield strength, in N/mm^2, determined by the following formulae:

- $R'_e = R_e$, where $R \geq 1,4\ R_e$
- $R'_e = 0,417\ (R_e+R)$ where $R < 1,4\ R_e$

1.5 Design and equipment

1.5.1 If the steering apparatus has a powered drive unit, it is to be possible to bring a second independent drive unit, or manual drive, into use within five seconds if the steering apparatus drive unit fails or malfunctions.

1.5.2 If the second drive unit or manual drive is not placed in service automatically, it is to be possible to do so immediately by means of a single operation by the helmsman that is both simple and quick.

1.5.3 The second drive unit or manual drive is to ensure the manoeuvrability required by [2.5.2] as well.

1.5.4 No other power consumers may be connected to the hydraulic steering apparatus drive unit. Where there are two independent drive units, such a connection to one of the units is, however, acceptable if the consumers are connected to the return line and may be disconnected from the drive unit by means of an isolating device.

1.5.5 Where there are two hydraulic drive units, a separate hydraulic reservoir is needed for each of the units. However, double reservoirs are acceptable. Hydraulic reservoirs are to be fitted with a warning system that monitors any drop in the oil level below the lowest content level needed for reliable operation.

1.5.6 The pilot valve does not need to be duplicated if this can be actuated manually or by manually-controlled hydraulic actuation from the wheelhouse.

1.5.7 The dimensions, design and arrangement of the pipework is to as far as possible exclude mechanical damage or damage resulting from fire.

1.5.8 As far as hydraulic drive units are concerned, no separate pipework system is to be required for the second unit if independent operation of the two units is guaranteed and if the pipework system is able to withstand a pressure of at least 1,5 times that of the maximum service pressure.

1.5.9 Flexible piping is only permitted where its use is essential in order to damp vibrations or to allow freedom of movement of components. It is to be designed for a pressure that is at least equal to the maximum service pressure.

1.5.10 Steering systems fitted with two powered drive units are to have at least two power sources.

1.5.11 If the second power source for the powered steering apparatus is not constantly available while the vessel is under way, a buffer device carrying adequate capacity is to provide backup during the period needed for start-up.

1.5.12 In the case of electrical power sources; no other power consumers may be supplied by the main power source for the steering system.

1.5.13 The manual wheel is not to be driven by a powered drive unit.

1.5.14 Regardless of rudder position, a kick-back of the wheel is to be prevented when the manual drive is engaged automatically.

2 Design and construction

2.1 Mechanical components

2.1.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of the Society.

b) Any non-duplicated essential component is, where appropriate, to utilise anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings, which are to be permanently lubricated or provided with lubrication fittings.

c) The construction is to be such as to minimise local concentration of stress.

d) All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

2.1.2 Materials and welds

a) All steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material complying with the requirements of Part D. In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

b) The use of grey cast iron is not permitted, except for redundant parts with low stress level, subject to special consideration by the Society. It is not permitted for cylinders.

c) The welding details and welding procedures are to be submitted for approval.

d) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

2.1.3 Scantling of components

The scantling of steering gear components is to be determined considering the design torque M_T and the permissible value σ_a of the combined stress, as given in:

- Tab 2 for components which are protected against overloads induced by the rudder
- Tab 3 for components which are not protected against overloads induced by the rudder.

Table 2 : Scantling of components protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_G	• if $T_G \leq 1{,}25\ T_R : \sigma_a = 1{,}25\ \sigma_0$ • if $1{,}25\ T_R < T_G < 1{,}50\ T_R : \sigma_a = \sigma_0\ T_G/T_R$ • if $T_G \geq 1{,}50\ T_R : \sigma_a = 1{,}50\ \sigma_0$ where $\sigma_0 = 0{,}55\ R'_e$
Normal operation, with a reduced number of actuators	T'_G	• if $T'_G \leq 1{,}25\ T_R : \sigma_a = 1{,}25\ \sigma_0$ • if $1{,}25\ T_R < T'_G < 1{,}50\ T_R : \sigma_a = \sigma_0\ T_G/T_R$ • if $T'_G \geq 1{,}50\ T_R : \sigma_a = 1{,}50\ \sigma_0$ where $\sigma_0 = 0{,}55\ R'_e$
Emergency operation achieved by hydraulic or electrohydraulic steering gear	lower of T_R and $0{,}8\ T_A$	$0{,}69\ R'_e$
Emergency operation, with a reduced number of actuators	lower of T_R and $0{,}8\ T'_G$	$0{,}69\ R'_e$
Emergency operation achieved by hand	T_E	$0{,}69\ R'_e$

Table 3 : Scantling of components not protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_R	$0{,}55\ R'_e$
Normal operation, with a reduced number of actuators	lower of T_R and $0{,}8\ T'_G$	$0{,}55\ R'_e$
Emergency operation achieved by hydraulic or electrohydraulic steering gear	lower of T_R and $0{,}8\ T_A$	$0{,}69\ R'_e$
Emergency operation, with a reduced number of actuators	lower of T_R and $0{,}8\ T'_G$	$0{,}69\ R'_e$
Emergency operation achieved by hand	T_E	$0{,}69\ R'_e$

2.1.4 Tillers, quadrants and rotors

a) The scantling of the tiller is to be determined as follows:

- the depth H_0 of the boss is not to be less than d_s
- the radial thickness of the boss in way of the tiller is not to be less than $0{,}4.d_s$
- the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value Z_b, in cm^3, calculated from the following formula:

$$Z_b = \frac{0{,}147 \cdot d_s}{1000} \cdot \frac{L'}{L} \cdot \frac{R_e}{R'_e}$$

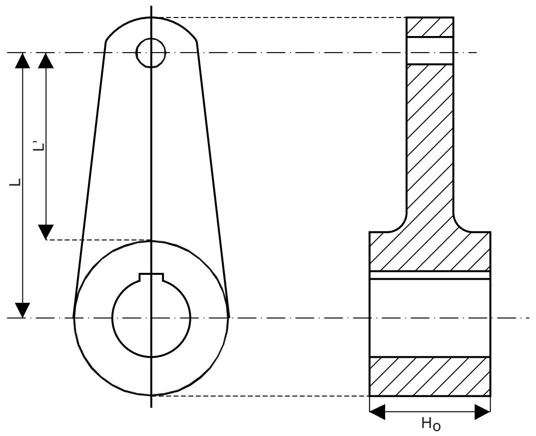
where:

L : Distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig 1)

L′ : Distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig 1)

- the width and thickness of the tiller arm in way of the point of application of the load are not to be less than one half of those required by the above formula
- in the case of double arm tillers, the section modulus of each arm is not to be less than one half of the section modulus required by the above formula.

Figure 1 : Tiller arm



b) The scantling of the quadrants is to be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm is not to be less than one half or one third, respectively, of the section modulus required for the tiller.

   Arms of loose quadrants not keyed to the rudder stock may be of reduced dimensions to the satisfaction of the Society, and the depth of the boss may be reduced by 10 per cent.

c) Keys are to satisfy the following provisions:
   - the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm^2
   - the width of the key is not to be less than $0{,}25.d_s$
   - the thickness of the key is not to be less than $0{,}10.d_s$
   - the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5 per cent of the key thickness.

d) Bolted tillers and quadrants are to satisfy the following provisions:
   - the diameter of the bolts is not to be less than the value d_b, in mm, calculated from the following formula:

$$d_b = 153\sqrt{\frac{T_R}{n(b+0{,}5d_{se})}\cdot\frac{235}{R_{eb}}}$$

where:

n : Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2)

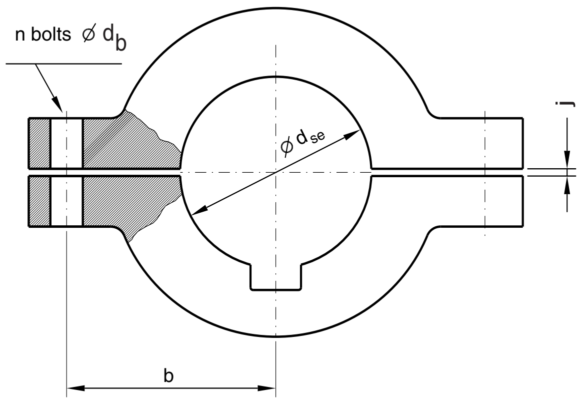
b : Distance between bolts and stock axis, in mm (see Fig 2)

R_{eb} : Yield stress, in N/mm^2, of the bolt material

   - the thickness of the coupling flanges is not to be less than the diameter of the bolts
   - in order to ensure the efficient tightening of the coupling around the stock, the two parts of the tiller are to bored together with a shim having a thickness not less than the value j, in mm, calculated from the following formula:

$$j = 0{,}0015 \cdot d_s$$

Figure 2 : Bolted tillers



e) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:
   - the safety factor against slippage is not to be less than:
     - 1 for keyed connections
     - 2 for keyless connections
   - the friction coefficient is to be taken equal to:
     - 0,15 for steel and 0,13 for spheroidal graphite cast iron, in the case of hydraulic fit
     - 0,17 in the case of dry shrink fitting
   - the combined stress according to the von Mises criterion, due to the maximum pressure induced by the shrink fitting and calculated in way of the most stressed points of the shrunk parts, is not to exceed 80 per cent of the yield stress of the material considered

Note 1: Alternative stress values based on FEM calculations may also be considered by the Society.

   - the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

2.1.5 Piston rods

The scantling of the piston rod is to be determined taking into account the bending moments, if any, in addition to compressive or traction forces and is to satisfy the following provisions:

a) $\sigma_c \le \sigma_a$

   where:

σ_c : Combined stress as per [1.4.1]

σ_a : Permissible stress as per [2.1.3]

b) in respect of the buckling strength:

$$\frac{4}{\pi D_2{}^2} \cdot \left(\omega F_c + \frac{8M}{D_2}\right) \leq 0{,}9\sigma_a$$

where:

D_2 : Piston rod diameter, in mm

F_c : Compression force in the rod, in N, when it extends to its maximum stroke

M : Possible bending moment in the piston rod, in N.mm, in way of the fore end of the cylinder rod bearing

ω : $= \alpha + (\beta^2 - \alpha)^{0,5}$

with:

$\alpha = 0{,}0072\ (l_s/d_s)^2.R'_e/235$,

$\beta = 0{,}48 + 0{,}5\ \alpha + 0{,}1\ \alpha^{0,5}$,

l_s = Length, in mm, of the maximum unsupported reach of the cylinder rod.

2.2 Hydraulic system

2.2.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure shall be at least 1,25 times the maximum working pressure to be expected under the operational conditions specified in [3] and [4], taking into account any pressure which may exist in the low pressure side of the system.

At the discretion of the Society, high cycle and cumulative fatigue analysis may be required for the design of piping and components, taking into account pulsating pressures due to dynamic loads.

b) The power piping for hydraulic steering gear is to be arranged so that transfer between units can be readily effected.

c) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirements of Sec 8 for class I piping systems, and in particular with the requirements of Sec 8, [12] unless otherwise stated.

2.2.2 Materials

a) Ram cylinders, pressure housings of rotary vane type actuators, hydraulic power piping, valves, flanges and fittings are to be of steel or other approved ductile material.

b) In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

Grey cast iron may be accepted for valve bodies and redundant parts with low stress level, excluding cylinders, subject to special consideration.

2.2.3 Isolating valves

Shut-off valves, non-return valves or other appropriate devices are to be provided:

- to comply with the availability requirements
- to keep the rudder steady in position in case of emergency.

In particular, for all ships with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly fitted on the actuator.

2.2.4 Flexible hoses

a) Flexible hoses may be installed between two points where flexibility is required but are not to be subjected to torsional deflexion (twisting) under normal operation. In general, the hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery.

b) Hoses are to be high pressure hydraulic hoses according to recognised standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

c) They are to be of a type approved by the Society according to Sec 8, [2.6].

2.2.5 Relief valves

a) Relief valves shall be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves shall not exceed the design pressure. The valves shall be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

b) The setting pressure of the relief valves is not to be less than 1,25 times the maximum working pressure.

c) The minimum discharge capacity of the relief valve(s) is not to be less than the total capacity of the pumps which can deliver through it (them), increased by 10%. Under such conditions, the rise in pressure is not to exceed 10% of the setting pressure. In this respect, due consideration is to be given to the foreseen extreme ambient conditions in relation to oil viscosity.

d) The torque transmitted by the rudder as a result of grounding is to be limited by safety valves.

2.2.6 Hydraulic oil reservoirs

Hydraulic power-operated steering gear shall be provided with the following:

- a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms shall be given on the navigation bridge and in the machinery space where they can be readily observed.

2.2.7 Hydraulic pumps

Special care is to be given to the alignment of the pump and the driving motor.

2.2.8 Filters

a) Hydraulic power-operated steering gear shall be provided with arrangements to maintain the cleanliness of *the hydraulic fluid taking into consideration the type and design of the hydraulic system.*

b) Filters of appropriate mesh fineness are to be provided in the piping system, in particular to ensure the protection of the pumps.

2.2.9 Accumulators

Accumulators, if fitted, are to be designed in accordance with Sec 8, [12.5.3].

2.2.10 Rudder actuators

a) Rudder actuators in accordance with the relevant requirements of Sec 3 for class I pressure vessels also considering the following provisions.

b) The permissible primary general membrane stress is not to exceed the lower of the following values:

$$\frac{R}{A} \quad \text{or} \quad \frac{R_e}{B}$$

where A and B are given in Tab 4.

c) Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal or equivalent type.

d) Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted.

e) The strength and connection of the cylinder heads (or, in the case of actuators of the rotary type, the fixed vanes) acting as rudder stops are to comply with the provisions of [5.3.1].

Table 4 : Value of coefficients A and B

Coefficient	Steel	Cast steel	Nodular cast iron
A	3,5	4	5
B	1,7	2	3

2.3 Electrical systems

2.3.1 General design

The electrical systems of the main steering gear and the auxiliary steering gear are to be so arranged that the failure of one will not render the other inoperative.

2.3.2 Power circuit supply

a) Electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard; however, one of the circuits may be supplied through the emergency switchboard.

b) Auxiliary electric or electrohydraulic steering gear, associated with main electric or electrohydraulic steering gear, may be connected to one of the circuits supplying the main steering gear.

c) The circuits supplying electric or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

d) When, in a ship of less than 1600 tons gross tonnage, auxiliary steering gear which is required by [2.5.2], item c) to be operated by power is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard.

e) Where the rudder stock is required to be over 230 millimetres in diameter in way of the tiller, excluding strengthening for navigation in ice, an alternative power supply either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment is to be provided, sufficient at least to supply the steering gear power unit such that the latter is able to perform the duties of auxiliary steering gear.

This power source is to be activated automatically, within 45 seconds, in the event of failure of the main source(s) of electrical power.

The independent source is to be used only for this purpose.

The alternative power source is also to supply the steering gear control system, the remote control of the power unit and the rudder angle indicator.

2.3.3 Motors and associated control gear

a) To determine the required characteristics of the electric motors for power units, the breakaway torque and maximum working torque of the steering gear under all operating conditions are to be considered. The ratio of pull-out torque to rated torque is to be at least 1,6.

b) Motors for steering gear power units may be rated for intermittent power demand.

The rating is to be determined on the basis of the steering gear characteristics of the ship in question; the rating is always to be at least:

- S3 - 40% for motors of electric steering gear power units
- S6 - 25% for motors of electrohydraulic steering gear power units and for convertors.

c) Each electric motor of a main or auxiliary steering gear power unit is to be provided with its own separate motor starter gear, located within the steering gear compartment.

2.3.4 Supply of motor control circuits and steering gear control systems

a) Each control for starting and stopping of motors for power units is to be served by its own control circuits supplied from its respective power circuits.

b) Any electrical main and auxiliary steering gear control system operable from the navigating bridge is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit. The power supply systems are to be protected selectively.

c) The remote control of the power unit and the steering gear control systems is to be supplied also by the alternative power source when required by [2.3.2], item e).

2.3.5 Circuit protection

a) Short-circuit protection is to be provided for each control circuit and each power circuit of electric or electrohydraulic main and auxiliary steering gear.

b) No protection other than short-circuit protection is to be provided for steering gear control system supply circuits.

c) Protection against excess current (e.g. by thermal relays), including starting current, if provided for power circuits, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

d) Where fuses are fitted, their current ratings are to be two step higher than the rated current of the motors. However, in the case of intermittent service motors, the fuse rating is not to exceed 160% of the rated motor current.

e) The instantaneous short-circuit trip of circuit breakers is to be set to a value not greater than 15 times the rated current of the drive motor.

f) The protection of control circuits is to correspond to at least twice the maximum rated current of the circuit, though not, if possible, below 6 A.

2.3.6 Starting and stopping of motors for steering gear power units

a) Motors for power units are to be capable of being started and stopped from a position on the navigation bridge and from a point within the steering gear compartment.

b) Means are to be provided at the position of motor starters for isolating any remote control starting and stopping devices (e.g. by removal of the fuse-links or switching off the automatic circuit breakers).

c) Main and auxiliary steering gear power units are to be arranged to restart automatically when power is restored after a power failure.

2.3.7 Separation

a) Duplicated electric power circuits are to be separated as far as practicable.

b) Cables for duplicated electric power circuits with their associated components are to be separated as far as practicable. They are to follow different routes separated both vertically and horizontally, as far as practicable, throughout their entire length.

2.4 Indications and monitoring devices

2.4.1 The rudder position is to be clearly displayed at the steering position. If the rudder-position indicator is electric it is to have its own power supply.

2.4.2 There are to be at least the following indicators and monitoring devices at the steering position:

a) oil level in the hydraulic reservoirs in accordance with Article 6.03(2), and service pressure of the hydraulic system;

b) failure of the electrical supply for the steering control;

c) failure of the electrical supply for the drive units;

d) failure of the rate-of-turn regulator;

e) failure of the required buffer devices.

2.5 Strength, performance and power operation of the steering gear

2.5.1 Main steering gear

The main steering gear and rudder stock shall be:

a) of adequate strength and capable of steering the ship at maximum ahead service speed which shall be demonstrated,

b) capable of putting the rudder over from 35° on one side to 35° on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28s,

c) operated by power where necessary to meet the requirements of b) and in any case when the Society requires a rudder stock of over 120 mm diameter in way of the tiller, excluding strengthening for navigation in ice, and

d) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

2.5.2 Auxiliary steering gear

The auxiliary steering gear and rudder stock shall be:

a) of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency,

b) capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60s with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater, and

c) operated by power where necessary to meet the requirements of b) and in any case when the Society requires a rudder stock of over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice.

2.5.3 Hand operation

Hand operation of steering gear is permitted when the rudder stock diameter in way of the tiller is less than 150 mm.

2.6 Control of the steering gear

2.6.1 Main and auxiliary steering gear control

a) Control of the main steering gear is to be provided on the navigation bridge.

b) Where the main steering gear is arranged in accordance with [2.7.2], two independent control systems are to be provided, both operable from the navigation bridge. This does not require duplication of the steering wheel or steering lever.

2.6.2 Control of the auxiliary steering gear

a) Control of the auxiliary steering gear is to be provided on the navigation bridge, in the steering gear compartment or in another suitable position.

b) If the auxiliary steering gear is power operated, its control system is also to be independent of that of the main steering gear.

2.7 Availability

2.7.1 Arrangement of main and auxiliary means for actuating the rudder

The main steering gear and the auxiliary means for actuating the rudder are to be arranged so that a single failure in one will not render the other inoperative.

2.7.2 Omission of the auxiliary steering gear

Where the main steering gear comprises two or more identical power units, auxiliary steering gear need not be fitted, provided that the main steering gear is capable of operating the rudder:

a) as required in [2.5.1], item b), while operating with all power units

b) as required in [2.5.2], item b), while any one of the power units is out of operation.

2.7.3 Hydraulic power supply

Hydraulic power installations supplying steering gear may also supply other equipment at the same time provided that the operation of the steering gear is not affected:

a) by the operation of this equipment, or

b) by any failure of this equipment or of its hydraulic supply piping.

3 Design and construction - Requirements for ships equipped with several rudders

3.1 Principle

3.1.1 General

In addition to the provisions of Article [2], as applicable, ships equipped with two or more aft rudders are to comply with the provisions of this Article.

3.1.2 Availability

Where the ship is fitted with two or more rudders, each having its own actuation system, the latter need not be duplicated.

3.1.3 Equivalent rudder stock diameter

Where the rudders are served by a common actuating system, the diameter of the rudder stock referred to in [3.3.1], item c) and in [3.3.2] item c) is to be replaced by the equivalent diameter d obtained from the following formula:

$$d = \sqrt[3]{\sum_j d_j^3}$$

with:

d_j : Rule diameter of the upper part of the rudder stock of each rudder in way of the tiller, excluding strengthening for navigation in ice.

3.2 Synchronisation

3.2.1 General

A system for synchronising the movement of the rudders is to be fitted, either:

- by a mechanical coupling, or
- by other systems giving automatic synchronising adjustment.

3.2.2 Non-mechanical synchronisation

Where the synchronisation of the rudder motion is not achieved by a mechanical coupling, the following provisions are to be met:

a) the angular position of each rudder is to be indicated on the navigation bridge,

b) the rudder angle indicators are to be independent from each other and, in particular, from the synchronising system,

c) in case of failure of the synchronising system, means are to be provided for disconnecting this system so that steering capability can be maintained or rapidly regained.

4 Design and construction - Requirements for ships equipped with thrusters as steering means

4.1 Principle

4.1.1 General

The main and auxiliary steering gear referred to in [3] and [4]above may consist of thrusters of the following types:

- azimuth thrusters
- water-jets
- cycloidal propellers

complying with the provisions of Sec 12, as far as applicable.

4.1.2 Actuation system

Thrusters used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

4.1.3 Control system

Where the steering means of the ship consists of two or more thrusters, their control system is to include a device ensuring an automatic synchronisation of the thruster rotation, unless each thruster is so designed as to withstand any additional forces resulting from the thrust exerted by the other thrusters.

4.2 Use of azimuth thrusters

4.2.1 Azimuth thrusters used as sole steering means

Where the ship is fitted with one azimuth thruster used as the sole steering means, this thruster is to comply with [2.5.1], as applicable, except that:

a) the main actuation system is required to be capable of a rotational speed of at least 0,4 RPM and to be operated by power where the expected steering torque exceeds 1,5 kN·m

b) the auxiliary actuation system is required to be capable of a rotational speed of at least 0,1 RPM and to be operated by power where the expected steering torque exceeds 3 kN·m.

4.2.2 Azimuth thrusters used as auxiliary steering gear

Where the auxiliary steering gear referred to in [1] consists of one or more azimuth thrusters, at least one such thruster is to be capable of:

- steering the ship at maximum ahead service speed
- being brought speedily into action in case of emergency
- a rotational speed of at least 0,4 RPM.

The auxiliary actuation system referred to in [4.1.2] need not be fitted.

4.2.3 Omission of the auxiliary actuation system

Where the steering means of the ship consists of two independent azimuth thrusters or more, the auxiliary actuation system referred to in [4.1.2] need not be fitted provided that:

- the thrusters are so designed that the ship can be steered with any one out of operation
- the actuation system of each thruster complies with [4.2.1], item b).

4.3 Use of water-jets

4.3.1 The use of water-jets as steering means will be given special consideration by the Society.

5 Arrangement and installation

5.1 Steering gear room arrangement

5.1.1 The steering gear compartment shall be:

a) readily accessible and, as far as practicable, separated from machinery spaces, and

b) provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements shall include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

5.2 Rudder actuator installation

5.2.1

a) Rudder actuators are to be installed on foundations of strong construction so designed as to allow the transmission to the ship structure of the forces resulting from the torque applied by the rudder and/or by the actuator, considering the strength criteria defined in [2.1.3] and [5.3.1]. The structure of the ship in way of the foundations is to be suitably strengthened.

b) Where the rudder actuators are bolted to the hull, the grade of the bolts used is not to be less than 8.8. Unless the bolts are adjusted and fitted with a controlled tightening, strong shocks are to be fitted in order to prevent any lateral displacement of the rudder actuator.

5.3 Overload protections

5.3.1 Mechanical rudder stops

a) The steering gear is to be provided with strong rudder stops capable of mechanically stopping the rotation of the rudder at an angle slightly greater than its maximum working angle. Alternatively, these stops may be fitted on the ship to act on another point of the mechanical transmission system between the rudder actuator and the rudder blade.

b) The scantlings of the rudder stops and of the components transmitting to the ship's structure the forces applied on these stops are to be determined for the greater value of the torques T_R or T_G.

   Where $T_G \geq 1,5 T_R$, the rudder stops are to be fitted between the rudder actuator and the rudder stock, unless the rudder stock as well as all the components transmitting mechanical forces between the rudder actuator and the rudder blade are suitably strengthened.

5.3.2 Rudder angle limiters

a) Power-operated steering gear is to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronised with the gear itself and not with the steering gear control.

b) Special consideration will be given to power-operated steering gear where the rudder may be oriented to more than 35°.

5.3.3 Relief valves

Relief valves are to be fitted in accordance with [2.2.5].

5.3.4 Buffers

Buffers are to be provided on all ships fitted with mechanical steering gear. They may be omitted on hydraulic gear equipped with relief valves or with calibrated bypasses.

5.4 Means of communication

5.4.1 *A means of communication is to be provided between the navigation bridge and the steering gear compartment.*

If electrical, it is to be fed through the emergency switchboard or to be sound powered.

5.5 Operating instructions

5.5.1 For steering gear comprising two identical power units intended for simultaneous operation, both normally provided with their own (partly or mutually) separate control systems, the following standard notice is either to be placed on a signboard fitted at a suitable place on the steering control post on the bridge or incorporated into the operation manual:

CAUTION

IN SOME CIRCUMSTANCES WHEN 2 POWER UNITS ARE RUNNING SIMULTANEOUSLY, THE RUDDER MAY NOT RESPOND TO THE HELM. IF THIS HAPPENS STOP EACH PUMP IN TURN UNTIL CONTROL IS REGAINED.

6 Certification, inspection and testing

6.1 Testing of power units

6.1.1 The power units are required to undergo testing on a test stand. The relevant works' certificates are to be presented at the time of the final inspection of the steering gear.

For electric motors, see Ch 2, Sec 4.

Hydraulic pumps are to be subjected to pressure and operational tests. Where the drive power of the hydraulic pump is 50 kW or more, these tests are to be carried out in the presence of a Surveyor of the Society.

6.2 Pressure and tightness tests

6.2.1 Pressure components are to undergo a pressure test, using the following testing pressure:

$p_{ST} = 1,5p$

where:

p_{ST} : testing pressure, in bar

p : maximum allowable working pressure or pressure at which the relief valve is open; however, for working pressures above 200 bar, the testing pressure need not exceed p+100 bar.

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see Ch 1, Sec 8.

Tightness tests are to be performed on components to which this is appropriate.

6.3 Final inspection and operational test

6.3.1 Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of a Surveyor of the Society. The overload protection is to be adjusted at this time.

SECTION 10 THRUSTERS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the following types of thrusters:

- Transverse thrusters intended for manoeuvring developing power equal to 500 kW or more
- Thrusters intended for propulsion, steering and dynamic positioning developing power equal to 220 kW or more; for power less than 220 kW the requirements apply only to the propeller and relevant shaft.

1.2 Definitions

1.2.1 Transverse thruster

A transverse thruster is an athwartship thruster developing a thrust in a transverse direction for manoeuvring purposes.

1.2.2 Azimuth thruster

An azimuth thruster is a thruster which has the capability to develop thrust in any direction through 360°.

1.2.3 Water-jet

A water-jet is equipment constituted by a tubular casing (or duct) enclosing an impeller. The shape of the casing is such as to enable the impeller to produce a water-jet of such intensity as to give a positive thrust. Water-jets may have means for deviating the jet of water in order to provide a steering function.

1.2.4 Continuous duty thruster

A continuous duty thruster is a thruster which is designed for continuous operation, such as a propulsion thruster.

1.2.5 Intermittent duty thruster

An intermittent duty thruster is a thruster designed for operation at full power for a period not exceeding 1 hour, followed by operation at reduced rating for a limited period of time not exceeding a certain percentage of the hours in a day and a certain (lesser) percentage of the hours in a year. In general, athwartship thrusters are intermittent duty thrusters.

1.3 Thrusters intended for propulsion

1.3.1 In general, at least two azimuth thrusters are to be fitted in ships where these are the sole means of propulsion. Single azimuth thruster installations will be specially considered by the Society on a case by case basis.

Single water-jet installations are permitted.

1.4 Documentation to be submitted

1.4.1 Plans to be submitted for athwartship thrusters and azimuth thrusters

For thrusters:

- intended for propulsion, steering and dynamic positioning
- intended for manoeuvring developing power equal to 500 kW or more,

the plans listed in Tab 1 are to be submitted. Plans as per item 6 of Tab 1 are also to be submitted for thrusters developing power less than 500 kW.

1.4.2 Plans to be submitted for water-jets

The plans listed in Tab 2 are to be submitted.

1.4.3 Additional data to be submitted

The data and documents listed in Tab 3 are to be submitted by the Manufacturer together with the plans.

2 Design and Construction

2.1 Materials

2.1.1 Propellers

For requirements relative to material intended for propellers, see Sec 6.

2.1.2 Other thruster components

For the requirements relative to materials intended for other parts of the thrusters, such as gears, shaft, couplings, etc., refer to the applicable parts of the Rules.

Table 1 : Plans to be submitted for athwartship thrusters and azimuth thrusters

No.	A/I (1)	ITEM
General requirements for all thrusters		
1	I	General arrangement of the thruster
2	A	Propeller, including the applicable details mentioned in Sec 8
3	A	Bearing details
4	A	Propeller and intermediate shafts
5	A	Gears, including the calculations according to Sec 6 for cylindrical gears or standards recognised by the Society for bevel gears
Specific requirements for transverse thrusters		
6	A	Structure of the tunnel showing the materials and their thickness
7	A	Structural equipment or other connecting devices which transmit the thrust from the propeller to the tunnel
8	A	Sealing devices (propeller shaft gland and thruster-tunnel connection)
9	A	For the adjustable pitch propellers: pitch control device and corresponding monitoring system
Specific requirements for rotating and azimuth thrusters		
10	A	Structural items (nozzle, bracing, etc.)
11	A	Structural connection to hull
12	A	Rotating mechanism of the thruster
13	A	Thruster control system
14	A	Piping systems connected to thruster
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

Table 2 : Plans to be submitted for water-jets

No.	A/I (1)	ITEM
1	I	General arrangement of the water-jet
2	A	Casing (duct) (location and shape) showing the materials and the thicknesses as well as the forces acting on the hull
3	A	Details of the shafts, flanges, keys
4	I	Sealing gland
5	A	Bearings
6	A	Impeller
7	A	Steering and reversing buckets and their control devices as well as the corresponding hydraulic diagrams
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

Table 3 : Data and documents to be submitted for athwartship thrusters, azimuth thrusters and water-jets

No.	A/I (1)	ITEM
1	I	Rated power and revolutions
2	I	Rated thrust
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties
4	A	Where parts of thrusters are of welded construction, all particulars on the design of welded joints, welding procedures, heat treatments and non-destructive examinations after welding
5	I	Where applicable, background information on previous operating experience in similar applications
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

2.2 Transverse thrusters and azimuth thrusters

2.2.1 Prime movers

a) Diesel engines intended for driving thrusters are to comply with the applicable requirements of Sec 2.

b) Electric motors intended for driving thrusters and their feeding systems are to comply with the requirements of Chapter 2. In particular:

- Provisions are to be made to prevent starting of the motors whenever there are insufficient generators in operation.
- Intermittent duty thrusters will be the subject of special consideration by the Society.

2.2.2 Propellers

a) For propellers of thrusters intended for propulsion, steering and dynamic positioning, the requirements of Sec 6 apply.

b) For propellers of thrusters intended for manoeuvring only, the requirements of Sec 6 also apply, although the increase in thickness of 10% required in Sec 6, [2.5] does not need to be applied.

2.2.3 Shafts

a) For propeller shafts of thrusters, the requirements of Sec 5 apply to the portion of propellershaft between the inner edge of the aftermost shaft bearing and the inner face of the propeller boss or the face of the integral propeller shaft flange for the connection to the propeller boss.

b) For other shafts of thrusters, the requirement of Sec 4, [3.4.2], apply.

2.2.4 Gears

a) Gears of thrusters intended for propulsion steering and dynamic positioning are to be in accordance with the applicable requirements of Sec 4 for cylindrical gears or standards recognised by the Society for bevel gears, applying the safety factors for propulsion gears.

b) Gears of thrusters intended for manoeuvring only are to be in accordance with the applicable requirements of Sec 4 for cylindrical gears or Standards recognised by the Society for bevel gears, applying the safety factors for auxiliary gears.

2.2.5 Nozzles and connections to hull for azimuth thrusters

a) For the requirements relative to the nozzle structure, see Part B.

b) The scantlings of the nozzle connection to the hull and the welding type and size will be specially considered by the Society, which reserves the right to require detailed stress analysis in the case of certain high power installations.

c) For steerable thrusters, the equivalent rudder stock diameter is to be calculated in accordance with the requirements of Part B.

2.2.6 Transverse thruster tunnel

a) The thickness of the tunnel is not to be less than the adjacent part of the hull.

b) Special consideration will be given by the Society to tunnels connected to the hull by connecting devices other than welding.

2.2.7 Bearings

Bearing are to be identifiable and are to have a life adequate for the intended purpose. However, their life cannot be less than:

- 40 000 hours for continuous duty thrusters. For ships with restricted service, a lesser value may be considered by the Society.
- 5 000 hours for intermittent duty thrusters.

Table 4 : Azimuth thrusters

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Thruster			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Steering oil pressure	L						
Oil tank level	L						

2.3 Water-jets

2.3.1 Shafts

The diameter of the shaft supporting the impeller, measured at bottom of keyway or at spline inner diameter, is not to be less than the diameter d_2, in mm, obtained by the following formula:

$$d_2 = 100fh \cdot \left(\frac{P}{N}\right)^{1/3}$$

where:

P : Power, in kW

N : Rotational speed, in rpm

f : Calculated as follows:

$$f = \left(\frac{560}{R_m + 160}\right)^{1/3}$$

where R_m is the ultimate tensile strength of the shaft material, in N/mm²

h : 1 when the shaft is only transmitting torque loads, and when the weight and thrust of the propeller are totally supported by devices located in the fixed part of the thruster

1,22 otherwise.

The shafts are to be protected against corrosion by means of either a continuous liner or an oil-gland of an approved type, or by the nature of the material of the shaft.

2.3.2 Casings and impellers

Casings and impellers are subject of special consideration by the Society.

2.3.3 Steering performance

Steering performance and emergency steering availability are to be at least equivalent to the requirements in Sec 9.

2.4 Steering thruster controls

2.4.1 Steering thruster controls

Controls for steering thrusters are to be provided from the wheelhouse, machinery control station and locally.

Means are to be provided to stop any running thruster at each of the control stations.

A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

3 Test at the manufacturer's works

3.1 Testing of power units

3.1.1 The power units are required to undergo a test on a test stand. The relevant Manufacturer's test certificates are to be presented at the time of the final inspection of the unit.

For electric motors, see Rules for Rotating Machines, in Part C, Chapter 2.

Hydraulic pumps are to be subjected to pressure and operational tests.

3.2 Pressure and tightness tests

3.2.1 Pressure components are to undergo a pressure test, using the following testing pressure:

p_{ST}=1,5p

where:

p_{ST} : testing pressure, in bar

p : maximum allowable working pressure or pressure at which the relief valve is open; however, for working pressures above 200 bar, the testing pressure need not exceed p+100 bar.

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see Ch 1, Sec 8.

Tightness tests are to be performed on components to which this is appropriate.

3.3 Final inspection and operational test

3.3.1 ollowing testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of a Surveyor of the Society. The overload protection is to be adjusted at this time.

SECTION 11 DOMESTIC ARRANGEMENTS

1 Cooking and heating and refrigerating equipment for domestic purpose

1.1 Application

1.1.1 The requirements of this Section are to be applied to permanent domestic applications on ships; for vessels carrying dangerous goods, in addition to the requirements given in this Section, the provisions of Pt E, Ch 2, Sec 1 and 2 is toare also to be complied with.

1.2 General provisions

1.2.1

a) Heating, cooking and refrigeration equipment running on liquefied gas is to meet the requirements of this Section

b) Heating, cooking and refrigeration equipment, together with its accessories, is to be designed and installed in such a way that even in the event of overheating the safety against a fire risk is not impaired. The equipment is to be installed so that it cannot overturn or be moved accidentally.

c) The equipment referred to in paragraph 2 is not to be installed in areas in which substances with a flashpoint below 55°C are used or stored. No flues from these installations may pass through such areas.

d) The supply of air necessary for combustion is to be ensured.

e) Heating appliances are to be securely connected to flues, which are to be fitted with suitable cowls or devices affording protection against the wind. They are to be arranged in such a manner as to permit cleaning.

1.3 Use of liquid fuels, oil fired equipment

1.3.1

a) Heating, cooking and refrigeration equipment which uses liquid fuel may be operated only with fuels whose flashpoint is above 55°C.

b) By way of derogation from paragraph 1, cooking appliances and heating and refrigeration appliances fitted with burners with wicks and running on commercial paraffin oil may be permitted in the accommodation and wheelhouse provided the capacity of the fuel tank does not exceed 12 litres.

c) Appliances fitted with burners with wicks are to be:

   1) fitted with a metal fuel tank whose filling aperture may be locked and which has no soft solder joints below the maximum filling level, and are to be designed and installed in such a way that the fuel tank cannot be opened or emptied accidentally;

   2) capable of being lit without the aid of another liquid fuel;

   3) so installed as to ensure the safe evacuation of combustion gases.

1.4 Vaporising oil burner stoves and atomising oil burner heating appliances

1.4.1

a) Vaporising oil burner stoves and atomising oil burner heating appliances are to be built in accordance with best practice.

b) Where a vaporising oil burner stove or an atomising oil burner heating appliance is installed in an engine room, the air supply to the heating appliance and the engines is to be designed in such a way that the heating appliance and the engines can operate properly and safely independently of one another. Where necessary, there is to be a separate air supply. The equipment is to be so installed that no flame from the burner can reach other parts of the engine room installations.

1.5 Vaporising oil burner stoves

1.5.1

a) It is to be possible to light vaporising oil burner stoves without the aid of another combustible liquid. They are to be fixed above a metal drip pan which encompasses all the fuel carrying parts, whose sides are at least 20 mm high and which has a capacity of at least two litres.

b) For vaporising oil burner stoves installed in an engine room, the sides of the metal drip pan prescribed in paragraph 1 are to be at least 200 mm high. The lower edge of the vaporising burner is to be located above the edge of the drip pan. In addition, the upper edge of the drip pan is to extend at least 100 mm above the floor.

c) Vaporising oil burner stoves are to be fitted with a suitable regulator which, at all settings, ensures a virtually constant flow of fuel to the burner and in case of any fuel leakage the arrangement is to be such as to avoid that the flame go out. Regulators are to be considered suitable provided that they function properly even when exposed to vibration and inclined up to 12° and on condition that, in addition to a level-regulating float, they have

   1) a second float which closes off the fuel supply safely and reliably when the permitted level is exceeded, or

   2) an overflow pipe, but only if the drip pan has sufficient capacity to accommodate at least the contents of the fuel tank.

d) Where the fuel tank of a vaporising oil burner stove is installed separately:
   1) the drop between the tank and the burner feed may not exceed that laid down in the Manufacturer's operating instructions;
   2) it is to be so installed as to be protected from unacceptable heating;
   3) it is to be possible to interrupt the fuel supply from the deck.

e) The flues of vaporising oil burner stoves are to be fitted with a device to prevent draught inversion.

1.6 Atomising oil burner heating appliances

1.6.1 Atomising oil burner heating appliances are, in particular, to meet the following requirements:

a) adequate ventilation of the burner is to be ensured before the fuel is supplied;

b) the fuel supply is to be regulated by a thermostat;

c) the fuel is to be ignited by an electrical device or by a pilot flame;

d) a flame monitoring device is to cut off the fuel supply when the flame goes out;

e) the main switch is to be placed at an easily accessible point outside the installation room.

1.7 Forced air heating appliances

1.7.1 Forced air heating appliances consisting of a combustion chamber around which the heating air is conducted under pressure to a distribution system or to a room are to meet the following requirements:

a) if the fuel is atomised under pressure, the combustion air is to be supplied by a blower;

b) the combustion chamber is to be well ventilated before the burner can be lit. Ventilation may be considered complete when the combustion air blower continues to operate after the flame has gone out;

c) the fuel supply is to be automatically cut off if:
   1) the fire goes out;
   2) the supply of combustion air is not sufficient;
   3) the heated air exceeds a previously set temperature; or
   4) the power supply of the safety devices fails.

   In the above cases the fuel supply is not to be re-established automatically after being cut off.

d) it is to be possible to switch off the combustion air and heating air blowers from outside the room where the heating appliance is located;

e) where heating air is drawn from outside, the intake vents are to be located as far as possible above the deck. They are to be installed in such a manner that rain and spray water cannot enter;

f) heating air pipes are to be made of metal;

g) it is not to be possible to close the heating air outlet apertures completely;

h) it is not to be possible for any leaking fuel to reach the heating air pipes;

i) it is not to be possible for forced air heating appliances to draw their heating air from an engine room.

1.8 Solid fuel heating

1.8.1

a) Solid fuel heating appliances are to be placed on a metal plate with raised edges such that no burning fuel or hot cinders fall outside the plate. This requirement does not apply to appliances installed in compartments built of non-combustible materials and intended solely to house boilers.

b) Solid fuel boilers are to be fitted with thermostatic controls to regulate the flow of combustion air.

c) A means by which cinders can be quickly doused is to be placed in the vicinity of each heating appliance.

2 Liquefied gas installations for domestic purpose

2.1 General

2.1.1

a) Liquefied gas installations consist essentially of a supply unit comprising one or more gas receptacles, and of one or more pressure regulators, a distribution system and a number of gas-consuming appliances.

   Spare and empty receptacles not in the supply unit are not to be considered part of the installation.

   Paragraph 2.4 is to apply to them mutatis mutandis.

b) Installations may be operated only with commercial propane.

2.2 Installations

2.2.1

a) Liquefied gas installations are to be suitable throughout for use with propane and to be built and installed in accordance with best practice.

b) Liquefied gas installations may be used only for domestic purposes in the accommodation and the wheelhouse, and for corresponding purposes on passenger vessels.

c) There may be a number of separate installations on board. A single installation is not to be used to serve accommodation areas separated by a hold or a fixed tank.

d) No part of a liquefied gas installation is to be located in the engine room.

2.3 Receptacles

2.3.1

a) Only receptacles with an approved content of between 5 and 35 kg are permitted. In the case of passenger vessels, the use of receptacles with a larger content may generally be applied.

b) Receptacles are to bear the official stamp certifying that they have been accepted following the required tests.

2.4 Location and arrangement of supply units

2.4.1

a) 1.Supply units are to be installed on deck in a freestanding or wall cupboard located outside the accommodation in a position such that it does not interfere with movement on board. They are not, however, to be installed against the fore or aft bulwark. The cupboard may be a wall cupboard set into the superstructure provided that it is gas-tight and can only be opened from outside the superstructure. It is to be so located that the distribution pipes leading to the gas consumption points are as short as possible.

   No more receptacles may be in operation simultaneously than are necessary for the functioning of the installation. Several receptacles may be connected only if a reversing coupler is used. Up to four receptacles may be connected per supply unit. The number of receptacles on board, including spare receptacles, is not to exceed six per installation.

   Up to six receptacles may be connected on passenger vessels with galleys or canteens for passengers. The number of receptacles on board, including spare receptacles, is not to exceed nine per installation.

   Pressure regulators, or in case of two-stage regulation the first pressure regulator, are to be fitted to a wall in the same cupboard as the receptacles.

b) Supply units are to be so installed that any leaking gas can escape from the cupboard into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition.

c) Cupboards are to be constructed of flame-retardant materials and are to be sufficiently ventilated by apertures in the top and bottom. Receptacles are to be placed upright in the cupboards in such a way that they cannot overturn.

d) Cupboards are to be so built and placed that the temperature of the receptacles cannot exceed 50°C.

e) The words 'Liquefied gas' and a 'Fire, naked flame and smoking prohibited' symbol at least 10 cm in diameter are to be affixed to the outer wall of the cupboard.

2.5 Spare and empty receptacles

2.5.1 Spare and empty receptacles not located in the supply unit are to be stored outside the accommodation and the wheelhouse in a cupboard built in accordance with [2.4].

2.6 Pressure regulators

2.6.1

a) Gas-consuming appliances may be connected to receptacles only through a distribution system fitted with one or more pressure regulators to bring the gas pressure down to the utilisation pressure. The pressure may be reduced in one or two stages. All pressure regulators are to be set permanently at a pressure determined in accordance with [2.7].

b) The final pressure regulators are to be either fitted with or immediately followed by a device to protect the pipe automatically against excess pressure in the event of a malfunction of the pressure regulator. It is to be ensured that, in the event of a leak in the protection device, any leaking gas can escape into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition; if necessary, a special pipe is to be fitted for this purpose.

c) The protection devices and vents are to be protected against the entry of water.

2.7 Pressure

2.7.1

a) Where two-stage regulating systems are used, the mean pressure is to be not more than 2,5 bar above atmospheric pressure.

b) The pressure at the outlet from the last pressure regulator is to be not more than 0,05 bar above atmospheric pressure, with a tolerance of 10%.

2.8 Piping and flexible tubes

2.8.1

a) Pipes are to consist of permanently installed steel or copper tubing, in compliance with the requirements of Ch 1, Sec 8.

   However, pipes connecting with the receptacles are to be high-pressure flexible tubes or spiral tubes suitable for propane. Gas-consuming appliances may, if not permanently installed, be connected by means of suitable flexible tubes not more than 1 m long.

b) Pipes are to be able to withstand any stresses, in particular regarding corrosion and strength, which may occur under normal operating conditions on board, and their characteristics and layout are to be such that they ensure a satisfactory flow of gas at the appropriate pressure to the gas-consuming appliances.

c) Pipes are to have as few joints as possible. Both pipes and joints are to be gas-tight and to remain gas-tight despite any vibration or expansion to which they may be subjected.

d) Pipes are to be readily accessible, properly fixed and protected at every point where they might be subject to impact or friction, particularly where they pass through steel bulkheads or metal walls. The entire surface of steel pipes is to be treated against corrosion.

e) Flexible pipes and their joints are to be able to withstand any stresses which may occur under normal operating conditions on board. They are to be installed in such a way that they are free of tension, cannot be heated excessively and can be inspected over their entire length.

2.9 Distribution system

2.9.1

a) It is to be possible to shut off the entire distribution system by means of a main valve which is at all times easily and rapidly accessible.

b) Each gas-consuming appliance is to be supplied by a separate branch of the distribution system, and each branch is to be controlled by a separate closing device.

c) Valves are to be fitted at points where they are protected from the weather and from impact.

d) An inspection connection is to be fitted after each pressure regulator. It is to be ensured using a closing device that in pressure tests the pressure regulator is not exposed to the test pressure.

2.10 Gas-consuming appliances and their installation

2.10.1

a) The only appliances that may be installed are propane-consuming appliances approved in one of the Member States and equipped with devices that effectively prevent the escape of gas in the event of either the flame or the pilot light being extinguished.

b) Appliances are to be so placed and connected that they cannot overturn or be accidentally moved and any risk of accidental wrenching of the connecting pipes is avoided.

c) Heating and water heating appliances and refrigerators are to be connected to a flue for evacuating combustion gases into the open air.

d) The installation of gas-consuming appliances in the wheelhouse is permitted only if the wheelhouse is so constructed that no leaking gas can escape into the lower parts of the craft, in particular through the penetrations for control lines to the engine room.

e) Gas-consuming appliances may be installed in sleeping quarters only if combustion is independent of ambient air in the quarters.

f) Gas-consuming appliances in which combustion depends on ambient air are to be installed in rooms which are sufficiently large.

2.11 Ventilation and evacuation of combustion gases

2.11.1

a) In rooms containing gas-consuming appliances in which combustion depends on ambient air, fresh air is to be supplied and combustion gases evacuated by means of ventilation apertures of adequate dimensions, with a clear section of at least 150 cm^2 per aperture.

b) Ventilation apertures are not to have any closing device and not to lead to sleeping quarters.

c) Evacuation devices are to be so designed as to ensure the safe evacuation of combustion gases. They are to be reliable in operation and made of non-combustible materials. Their operation is not to be affected by forced ventilation.

2.12 Operating and safety requirements

2.12.1 An operating instruction is to be affixed on board in a suitable place. It is to contain at least the following:

a) The valves of receptacles not connected to the distribution system are to be closed, even if the receptacles are presumed empty;

b) Flexible pipes are to be replaced as soon as their condition so requires;

c) All gas-consuming appliances are to be connected or the corresponding connecting pipes are to be sealed.

2.13 Tests

2.13.1 The installation after completion is to be subjected to tests according to the requirements defined in this paragraph.

Tests on the installation are to be carried out under the following conditions:

a) Medium-pressure pipes between the closing device, referred to in [2.9] (4), of the first pressure regulator and the valves fitted before the final pressure regulator:

   1) pressure test, carried out with air, an inert gas or a liquid at a pressure 20 bar above atmospheric pressure;

   2) tightness test, carried out with air or an inert gas at a pressure 3,5 bar above atmospheric pressure.

b) Pipes at the service pressure between the closing device, referred to in [2.9] (4), of the only pressure regulator or the final pressure regulator and the valves fitted before the gas-consuming appliances:

   tightness test, carried out with air or an inert gas at a pressure of 1 bar above atmospheric pressure.

c) Pipes situated between the closing device, referred to in [2.9] (4), of the only pressure regulator or the final pressure regulator and the controls of gas-consuming appliances: tightness test at a pressure of 0,15 bar above atmospheric pressure.

d) In the tests referred to in paragraphs 1(b), 2 and 3, the pipes are deemed gas-tight if, after sufficient time to allow for equalisation with ambient temperature, no decrease in the test pressure is observed during a further 10-minute test period.

e) Receptacle connectors, pipe joints and other fittings subjected to the pressure in the receptacles, and joints between pressure regulators and the distribution pipe: tightness test, carried out with a foaming substance, at the service pressure.

f) All gas-consuming appliances are to be brought into service at the nominal capacity and to be tested for satisfactory and undisturbed combustion at different capacity settings.

   Flame failure devices are to be checked to ensure that they operate satisfactorily.

g) After the test referred to in paragraph 6, it is to be verified for each gas-consuming appliance connected to a flue, whether, after five minutes' operation at the nominal capacity, with windows and doors closed and the ventilation devices in operation, any combustion gases are escaping into the room through the air intake.

If there is a more than momentary escape of such gases, the cause is to immediately be detected and remedied. The appliance is not to be approved for use until all defects have been eliminated.

SECTION 12 TESTS ON BOARD

1 General

1.1 Application

1.1.1 This Section covers shipboard tests, both at the moorings and during sea trials. Such tests are additional to the workshop tests required in the other Sections of this Chapter.

1.2 Purpose of shipboard tests

1.2.1 Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in particular in respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the shipboard tests intended to be carried out by the shipyard is to be submitted to the Society.

For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded.

2 General requirements for shipboard tests

2.1 Trials at the moorings

2.1.1 Trials at the moorings are to demonstrate the following:

a) satisfactory operation of the machinery in relation to the service for which it is intended

b) quick and easy response to operational commands

c) safety of the various installations, as regards:
   - the protection of mechanical parts
   - the safeguards for personnel

d) accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Navigation tests

2.2.1 Navigability and manoeuvrability are to be checked by means of navigation tests. Compliance with the requirements of paragraph 3.3 of this Section is, in particular, to be examined.

2.3 Exemptions

2.3.1 The Society may dispense with all or part of the tests where compliance with the navigability and manoeuvrability requirements is proven in another manner:

- i.e. in the case of vessels having a sister ship for which the satisfactory behaviour in service is demonstrated.
- Such exemption is, in any event, to be agreed upon by the Interested Parties and is subject to the satisfactory results of trials at the moorings to verify the safe and efficient operation of the propulsion system.

3 Shipboard tests for machinery

3.1 Conditions of navigation test

3.1.1 Displacement of the ship

Except in cases of practical impossibility, or in other cases to be considered individually, during navigation tests, vessels and convoys intended to carry goods are to be loaded to at least 70% of their tonnage and loading, distributed in such a way as to ensure a horizontal attitude as far as possible. If the tests are carried out with a lesser load, the approval for downstream navigation is to be restricted to that loading.

3.1.2 Test area

a) The navigation tests are to be carried out on areas of inland waterways that have been designated by the competent authorities.

b) Those test areas are to be situated on a stretch of flowing or standing water that is if possible straight, at least 2 km long and sufficiently wide, and equipped with highly distinctive marks for determining the position of the vessel.

c) It is to be possible to plot the hydrological data such as depth of water, width of navigable channel and average speed of the current in the navigation area as a function of the various water levels.

3.1.3 Power of the machinery

a) The power developed by the propulsion machinery in the course of the sea trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.4 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the sea trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by the Society.

   As an alternative, for reciprocating internal combustion engines and gas turbines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

   Other methods of determining the power may be considered by the Society on a case by case basis.

3.2 Navigation and manoeuvribility tests

3.2.1 Use of on-board facilities for navigation test

a) During the navigation test, all of the equipment referred to in items 34 and 52 of the "Inland waterways vessel certificate" which may be actuated from the wheelhouse may be used, apart from anchors.

b) However, during the test involving turning into the current, bow anchors may be used.

3.2.2 Stopping capacity

a) Vessels and convoys are to be able to stop facing downstream in good time while remaining adequately manoeuvrable.

b) Where vessels and convoys are no longer than 86 m and no wider than 22,90 m, the stopping capacity mentioned above may be replaced by turning capacity.

c) The stopping capacity is to be proven by means of stopping manoeuvres and the turning capacity by turning manoeuvres in accordance with [3.2.5].

3.2.3 Capacity for going astern

Where the stopping manoeuvre required above is carried out in standing water, it is to be followed by a navigation test while going astern.

3.2.4 Capacity for taking evasive action

Vessels and convoys are to be able to take evasive action in good time. That capacity is to be proven by means of evasive manoeuvres.

3.2.5 Turning capacity

Vessels and convoys not exceeding 86 m in length or 22,90 m in breadth are to be able to turn in good time.

That turning capacity may be replaced by the stopping capacity referred to in [3.2.2].

The turning capacity is to be proven by means of turning manoeuvres against the current.

3.3 Tests of diesel engines

3.3.1 General

a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, trawling, etc.

b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

3.3.2 Main propulsion engines driving fixed propellers

Trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 4 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 2 hours

c) operation at engine speed $n = 1,032\ n_0$ for 30 minutes

Note 1: The test in c) is to be performed only where permitted by the engine adjustment, see Note 1 to Sec 2, [4.5.3].

d) operation at minimum load speed

e) starting and reversing manoeuvres

f) operation in reverse direction of propeller rotation at a minimum engine speed of $n = 0,7\ n_0$ for 10 minutes

Note 2: The test in f) may be performed during the dock or sea trials

g) tests of the monitoring, alarm and safety systems

h) for engines fitted with independently driven blowers, emergency operation of the engine with one blower inoperative.

3.3.3 Main propulsion engines driving controllable pitch propellers or reversing gears

a) The scope of the trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of [3.4.2].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.4 Single main engines driving generators for propulsion

Trials of engines driving generators for propulsion are to include the following tests:

a) operation at 100% power (rated propulsion power) for at least 4 hours

b) operation at normal continuous cruise propulsion power for at least 2 hours

c) operation at 110% rated propulsion power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

e) starting manoeuvres

f) tests of the monitoring, alarm and safety systems.

Note 1: The above tests a) to f) are to be performed at rated speed with a constant governor setting. The powers refer to the rated electrical powers of the electric propulsion motors.

3.3.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 2 hours. During the test, the set concerned is required to operate at its rated power for at least 1 hour.

b) It is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account is to be taken of the times needed to actuate the generator's overload protection system.

3.4 Tests of gears

3.4.1 Tests during sea trials

During the sea trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required
- test of the monitoring, alarm and safety systems.

3.4.2 Check of the tooth contact

a) Prior to the sea trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

   Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

   The tooth contact is to comply with Tab 1.

b) The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.

c) In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20 000 N·m, the check of the tooth contact may be reduced at the Society's discretion.

   Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

   In any case, the teeth of the gears are to be examined by the Surveyor after the sea trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

Table 1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
	across the whole face width	of the tooth working depth
quenched and tempered, cut	70	40
• quenched and tempered, shaved or ground • surface-hardened	90	40

3.5 Tests of main propulsion shafting and propellers

3.5.1 Shafting alignment

Where alignment calculations are required to be submitted, the alignment conditions are to be checked on board as follows:

a) shafting installation and intermediate bearing position, before and during assembling of the shafts:
   - optical check of the relative position of bushes after fitting
   - check of the flanged coupling parameters (gap and sag)
   - check of the centring of the shaft sealing glands

b) engine (or gearbox) installation, with floating ship:
   - check of the engine (or gearbox) flanged coupling parameters (gap and sag)
   - check of the crankshaft deflections before and after the connection of the engine with the shaft line, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine

Note 1: The ship is to be in the loading conditions defined in the alignment calculations.

c) load on the bearings:
   - check of the intermediate bearing load by means of jack-up load measurements
   - check of the bearing contact area by means of coating with an appropriate compound.

3.5.2 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by Sec 7. The type of the measuring equipment and the location of the measurement points are to be specified.

3.5.3 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.3].

3.5.4 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.5.5 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations is to be tested during the sea trials.

3.6 Tests of piping systems

3.6.1 Functional tests

During the sea trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment Manufacturer.

3.6.2 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.7 Tests of steering gear

3.7.1 General

a) The steering gear is to be tested during the sea trials under the conditions stated in [3.1] in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of Sec 9 are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

c) If the ship cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by the Society. In such case, the ship speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.7.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary steering gear with demonstration of the performances required by Sec 9, [2.6]

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the isolation of one power actuating system, checking the time for regaining steering capability

d) test of the hydraulic fluid refilling system

e) test of the alternative power supply required by Sec 9, [2.3.2], item e)

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the sea trials.

Note 2: For ships of less than 500 tons gross tonnage and for fishing vessels, the Society may accept departures from the above list, in particular to take into account the actual design features of their steering gear.

Note 3: Azimuth thrusters are to be subjected to the above tests, as far as applicable.

3.7.3 Tests of windlass

The working test of the windlass is to be carried out in the presence of a Surveyor. The anchor equipment is to be tested during river trials. Requirements of the "Rules for the Classification of Ships" for testing on board of the windlass are to be fullfilled to the satisfaction of the Surveyor.

4 Inspection of machinery after river trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the sea trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

   Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to the Society for information.

4.2 Diesel engines

4.2.1

a) In general, for all diesel engines, the following items are to be verified:
   - the deflection of the crankshafts, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine
   - the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the sea trials.

Part C

Machinery, Systems and Fire Protection

Chapter 2

ELECTRICAL INSTALLATIONS

SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 The requirements of this Chapter apply to electrical installations on ships. In particular, they apply to the components of electrical installations for:

- primary essential services
- secondary essential services
- essential services for special purposes connected with ships specifically intended for such purposes (e.g. cargo pumps on tankers, cargo refrigerating systems, air conditioning systems on passenger ships)
- services for habitability.

The other parts of the installation are to be so designed as not to introduce any risks or malfunctions to the above services.

1.1.2 The Society may consider modified requirements for installations not exceeding either 50 V or 50 kW total generator capacity (and for ships classed for "restricted navigation").

1.2 References to other regulations and standards

1.2.1 The Society may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series.

1.2.2 When referred to by the Society, publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards, are those currently in force at the date of agreement for ship classification.

2 Documentation to be submitted

2.1

2.1.1 The documents listed in Tab 1 are to be submitted.

The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Unless otherwise agreed with the Society, documents for approval are to be sent in triplicate if submitted by the Shipyard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in duplicate.

In any case, the Society reserves the right to require additional copies when deemed necessary.

2.1.2 Adequate rating of the power supply is to be demonstrated by means of a power balance. An appropriate simultaneity factor may be taken into account.

3 Definitions

3.1 General

3.1.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down by the IEC standards.

The definitions given in the following requirements also apply.

3.2 Essential services

3.2.1 Essential services are those services essential for propulsion and steering, and the safety of the ship, and services to ensure minimum comfortable conditions of habitability and necessary for special purposes connected with ships specifically intended for such purposes (e.g. cargo pumps on tankers, cargo refrigerating systems, air conditioning systems on passenger ships).

3.3 Primary essential services

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

Examples of equipment for primary essential services are the following:

- Steering gear
- Pumps for controllable pitch propellers
- Scavenging air blowers, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for the propulsion
- Forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations, for steam plants or steam turbines ship, and also for aux-

iliary boilers on ship where steam is used for equipment supplying primary essential services

- Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps
- Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- Electric generators and associated power sources supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Viscosity control equipment for heavy fuel oil
- Control, monitoring and safety devices/systems for equipment for primary essential services
- Speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion.

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

3.4 Secondary essential services

3.4.1 Secondary essential services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Documents to be submitted
1	A	Single line diagram of main and emergency power and lighting systems.
2	A	Electrical power balance (main and emergency supply).
3	A	Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW).
4	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices.
5	A	Single line diagram and detailed diagram of the main switchboard.
6	A	Single line diagram and detailed diagram of the emergency switchboard.
7	A	Diagram of the most important section boards and motor control centres (above 100 kW).
8	A	Diagram of the general emergency alarm system, of the public address system and other intercommunication systems.
9	A	Detailed diagram of the navigation-light switchboard.
10	A	Diagram of the remote stop system (ventilation, fuel pump, fuel valves etc).
11	I	Schedule for recording of the type, location and maintenance cycle of batteries.
12	A **(2)**	Selectivity and coordination of the electrical protection.
13	A **(3)**	Single line diagram.
14	A **(3)**	Principles of control system and its power supply.
15	A **(3)**	Alarm and monitoring system including: • list of alarms and monitoring points • power supply diagram.
16	A **(3)**	Safety system including: • list of monitored parameters for safety system • power supply diagram.
17	A **(3)**	Arrangements and details of the propulsion control consoles and panels.
18	A **(3)**	Arrangements and details of electrical coupling.
19	A **(3)**	Arrangements and details of the frequency converters together with the justification of their characteristics.
20	A **(3)**	Arrangements of the cooling system provided for the frequency converter and motor enclosure.
21	A **(3)**	Test program for converters and rotating machines having rated power > 3 MW, dock and sea trials.

(1) A: to be submitted for approval
I: to be submitted for information
(2) for high voltage installations
(3) for electric propulsion installations.

Examples of equipment for secondary essential services are the following:

- Windlasses
- Fuel oil transfer pumps and fuel oil treatment equipment
- Lubrication oil transfer pumps and lubrication oil treatment equipment
- Preheaters for heavy fuel oil
- Sea water pumps
- Starting air and control air compressors
- Bilge, ballast and heeling pumps
- Fire pumps and other fire-extinguishing medium pumps
- Ventilation fans for engine and boiler rooms
- Services considered necessary to maintain dangerous cargo in a safe condition
- Navigation lights, aids and signals
- Internal safety communication equipment
- Fire detection and alarm systems
- Electrical equipment for watertight closing appliances
- Electric generators and associated power supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety for cargo containment systems
- Control, monitoring and safety devices/systems for equipment for secondary essential services.

3.4.2 Services for habitability are those which need to be in operation to maintain the vessel's minimum comfort conditions for people on board.

Examples of equipment for maintaining conditions of habitability:

- Cooking
- Heating
- Domestic refrigeration
- Mechanical ventilation
- Sanitary and fresh water
- Electric generators and associated power sources supplying the above equipment.

3.5 Safety voltage

3.5.1 A voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer.

3.5.2 A voltage which does not exceed 50 V d.c. between conductors or between any conductor and earth in a circuit isolated from higher voltage circuits.

3.6 Low-voltage systems

3.6.1 Alternating current systems with rated voltages greater than 50 V r.m.s. up to 1000 V r.m.s. inclusive and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 50 V up to 1500 V inclusive.

3.7 High-voltage systems

3.7.1 Alternating current systems with rated voltages greater than 1000 V r.m.s. and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 1500 V.

3.8 Basic insulation

3.8.1 Insulation applied to live parts to provide basic protection against electric shock.

Note 1: Basic insulation does not necessarily include insulation used exclusively for functional purposes.

3.9 Supplementary insulation

3.9.1 Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

3.10 Double insulation

3.10.1 Insulation comprising both basic insulation and supplementary insulation.

3.11 Reinforced insulation

3.11.1 A single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation.

Note 1: The term "single insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

3.12 Earthing

3.12.1 The earth connection to the general mass of the hull of the ship in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

3.13 Normal operational and habitable condition

3.13.1 A condition under which the ship as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, and emergency boat winches, as well as the designed comfortable conditions of habitability are in working order and functioning normally.

3.14 Emergency condition

3.14.1 A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.

3.15 Main source of electrical power

3.15.1 A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable condition.

3.16 Dead ship condition

3.16.1 The condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power.

Note 1: Dead ship condition is a condition in which the entire machinery installation, including the power supply, is out of operation and the auxiliary services such as compressed air, starting current from batteries etc., for bringing the main propulsion into operation and for the restoration of the main power supply are not available.

3.17 Main generating station

3.17.1 The space in which the main source of electrical power is situated.

3.18 Main switchboard

3.18.1 A switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ship's services.

3.19 Emergency switchboard

3.19.1 A switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or the transitional source of emergency and is intended to distribute electrical energy to the emergency services.

3.20 Emergency source of electrical power

3.20.1 A source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

3.21 Section boards

3.21.1 A switchgear and controlgear assembly which is supplied by another assembly and arranged for the distribution of electrical energy to other section boards or distribution boards.

3.22 Distribution board

3.22.1 A switchgear and controlgear assembly arranged for the distribution of electrical energy to final sub-circuits.

3.23 Final sub-circuit

3.23.1 That portion of a wiring system extending beyond the final required overcurrent protective device of a board.

3.24 Hazardous areas

3.24.1 Areas in which an explosive atmosphere is present, or may be expected to be present due to the presence of vapours, gases, flammable dusts or explosives in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

3.24.2 Hazardous areas are classified in zones based upon the frequency and the duration of the occurrence of explosive atmosphere.

3.24.3 Hazardous areas for explosive gas atmosphere are classified in the following zones:

- Zone 0: an area in which an explosive gas atmosphere is present continuously or is present for long periods
- Zone 1: an area in which an explosive gas atmosphere is likely to occur in normal operation
- Zone 2: an area in which an explosive gas atmosphere is not likely to occur in normal operation and if it does occur, is likely to do only infrequently and will exist for a short period only.

3.25 Certified safe-type equipment

3.25.1 Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

3.26 Environmental categories

3.26.1 Electrical equipment is classified into environmental categories according to the temperature range, vibration levels, and resistance to chemically active substances and to humidity.

The designation of the environmental categories is indicated by the EC Code in Tab 2

The first characteristic numeral indicates the temperature range in which the electrical equipment operates satisfactorily, as specified in Tab 3

The second characteristic numeral indicates the vibration level in which the electrical equipment operates satisfactorily, as specified in Tab 4.

3.26.2 The tests for verifying the additional and supplementary letters and the characteristic numeral of the environmental categories are defined in Ch 3, Sec 6.

Table 2 : EC Code

Code letter	First characteristic numeral	Second characteristic numeral	Additional letter	Supplementary letter
EC	(numerals 1 to 4)	(numerals 1 to 3)	(letter S) **(1)**	(letter C) **(2)**

(1) The additional letter S indicates the resistance to salt mist (exposed decks, masts) of the electrical equipment.
(2) The supplementary letter C indicates the relative humidity up to 80% (air conditioned areas) in which the electrical equipment operates satisfactorily.

Table 3 : First characteristic numeral

First characteristic numeral	Brief description of location	Temperature range °C	
1	Air conditioned areas	+ 5	+ 40
2	Enclosed spaces	+ 5	+ 45
3	Inside consoles or close to combustion engines and similar	+ 5	+ 55
4	Exposed decks, masts	- 25	+ 45

Table 4 : Second characteristic numeral

Second characteristic numeral	Brief description of location	Frequency range Hz	Displacement amplitude mm	Acceleration amplitude g
1	Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2,0 to 13,2 from 13,2 to 100	1,0 -	- 0,7
2	Masts	from 2,0 to 13,2 from 13,2 to 50	3,0 -	- 2,1
3	On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6 -	- 4,0

4 Type approvals

4.1 General

4.1.1 The installations, equipment and assemblies mentioned in [4.1.5] are subject to mandatory type approval.

4.1.2 Type tests are to be carried out in the presence of the Society's Surveyor(s) either in the Manufacturer's works or, by agreement, in suitable institutions.

4.1.3 Type tests are carried out according to the Society's Rules for Approval of Equipment.

4.1.4 Type tested installations, apparatuses and assemblies are to be used within the scope of valid construction Rules only. The suitability for the subject application is to be ensured.

4.1.5 Installations, apparatuses and assemblies subject to type testing

The following installations, apparatuses and assemblies are subject to type testing:

a) Steering gear electronic control systems
b) Variable pitch propeller electronic control systems
c) Main engine electronic control systems for speed and power
d) Fire detection and alarm systems on passenger vessels
e) Tank level gauging equipment on tankers
f) Computer systems with class 3 requirements and higher.

4.2 Exceptions

4.2.1 Instead of the stipulated type approvals, in well-founded cases routine tests may be carried out in the presence of a Surveyor. An agreement with the Society is required prior to testing.

SECTION 2 GENERAL DESIGN REQUIREMENTS

1 Environmental conditions

1.1 General

1.1.1 The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

In particular, the conditions shown in the tables in this Article are to be taken into account.

Table 1 : Ambient air temperature

Location	Temperature range, in °C	
Enclosed spaces	+ 5	+ 45
Inside consoles or fitted on combustion engines and similar	+ 5	+ 55
Exposed decks	- 25	+ 45

Table 2 : Humidity

Location	Humidity
General	95% at 55 °C
Air conditioned areas	Different values may be considered on a case by case basis

1.2 Cooling water temperatures

1.2.1 The temperatures shown in Tab 3 are applicable to ships classed for unrestricted service.

1.2.2 For ships classed for service in specific zones, the Society may accept different values for the cooling water temperature (e.g. for ships operating outside the tropical belt, the maximum cooling water temperature may be assumed as equal to + 25 °C instead of + 32 °C).

Table 3 : Water temperature

Coolant	Temperature range, in °C	
Sea water	0	+ 32

1.3 Inclinations

1.3.1 The inclinations applicable are those shown in Tab 4.

1.4 Vibrations

1.4.1 In relation to the location of the electrical components, the vibration levels given in Tab 5 are to be assumed.

1.4.2 The natural frequencies of the equipment, their suspensions and their supports are to be outside the frequency ranges specified.

Where this is not possible using a suitable constructional technique, the equipment vibrations are to be dumped so as to avoid unacceptable amplifications.

2 Quality of power supply

2.1 Voltage and frequency variation

2.1.1 All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency.

2.1.2 Unless otherwise stated in national or international standards, all equipment is to operate satisfactorily with the variations from its rated value shown in Tab 6.

2.2 Harmonic distortions

2.2.1 For components intended for systems without substantially static converter loads and supplied by synchronous generators, it is assumed that the total voltage harmonic distortion does not exceed 5%.

2.2.2 For components intended for systems fed by static converters, and/or systems in which the static converter load predominates, it is assumed that:

- the total harmonic distortion does not exceed 10%.

Table 4 : Inclination of ship

Type of machinery, equipment or component	Angles of inclination, in degrees **(1)**			
	Athwartship		Fore-and-aft	
	static	dynamic **(4)**	static	dynamic **(5)**
Machinery and equipment relative to main electrical power installation	12	-	5	-
Switchgear and associated electrical and electronic components and remote control systems	12	3,42	5	-
(1) Athwartship and fore-and-aft angles may occur simultaneously in their most unfavourable combination.				

Table 5 : Vibration levels

Location	Frequency range Hz	Displacement amplitude mm	Acceleration amplitude g
Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2,0 to 13,2 from 13,2 to 100	1,0 -	- 0,7
On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6 -	- 4,0
Masts	from 2,0 to 13,2 from 13,2 to 50	3,0 -	- 2,1

Table 6 : Voltage and frequency variations

	Variable	Variations	
		Permanent	Transient
General	Frequency Voltage	+ 5% + 6% - 10%	± 10% 5 s ± 20% 1,5 s
Battery operation	Voltage	± 20%	-

2.2.3 Higher values for the harmonic content (e.g. in electric propulsion plant systems) may be accepted on the basis of correct operation of all electrical devices.

3 Materials

3.1 General

3.1.1 In general, and unless it is adequately protected, all electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials which are not subject to deterioration in the atmosphere and at the temperatures to which they are likely to be exposed. Particular consideration is to be given to sea air and oil vapour contamination.

Note 1: The flame-retardant and moisture-resistant characteristics may be verified by means of the tests cited in IEC Publication 60092-101 or in other recognised standards.

3.1.2 Where the use of incombustible materials or lining with such materials is required, the incombustibility characteristics may be verified by means of the test cited in IEC Publication 60092-101 or in other recognised standards.

3.2 Insulating materials for windings

3.2.1 Insulated windings are to be resistant to moisture, sea air and oil vapour unless special precautions are taken to protect insulants against such agents.

3.2.2 The insulation classes given in Tab 7 may be used.

Table 7 : Insulation Classes

Class	Maximum continuous operating temperature °C
A	105
E	120
B	130
F	155
H	180

3.3 Insulating materials for cables

3.3.1 See Sec 9, [1.3].

4 Construction

4.1 General

4.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

4.1.2 The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also taking into account its arrangement on board.

4.1.3 Enclosures are to be of adequate mechanical strength and rigidity.

4.1.4 Enclosures for electrical equipment are generally to be of metal; other materials may be accepted for accessories such as connection boxes, socket-outlets, switches and luminaires. Other exemptions for enclosures or parts of enclosures not made of metal will be specially considered by the Society.

4.1.5 Cable entrance are not to impair the degree of protection of the relevant enclosure (see Sec 3, Tab 3).

4.1.6 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

4.1.7 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

4.2 Degree of protection of enclosures

4.2.1 Electrical equipment is to be protected against the ingress of foreign bodies and water.

The minimum required degree of protection, in relation to the place of installation, is generally that specified in Sec 3, Tab 3.

4.2.2 The degrees of protection are to be in accordance with:

- IEC Publication No. 60529 for equipment in general
- IEC Publication No. 60034-5 for rotating machines.

4.2.3 For cable entries see [3.3.1].

5 Protection against explosion hazard

5.1 Protection against explosive gas or vapour atmosphere hazard

5.1.1 Electrical equipment intended for use in areas where explosive gas or vapour atmospheres may occur (e.g. oil tankers, liquefied gas carriers, chemical tankers, etc.), is to be of a "safe type" suitable for the relevant flammable atmosphere and for shipboard use.

5.1.2 The following “certified safe type” equipment is considered:

- intrinsically-safe: Ex(ia) - Ex(ib)
- flameproof: Ex(d)
- increased safety: Ex(e)
- pressurised enclosure: Ex(p)
- encapsulated: Ex(m)
- sand filled: Ex(q)
- special protection: Ex(s)
- oil-immersed apparatus (see Note 1): Ex(o)

Note 1: Only when required by the application.

5.1.3 Other equipment complying with types of protection other than those in [5.1.2] may be considered by the Society, such as:

- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules
- electrical apparatus specifically designed and certified by the appropriate authority for use in Zone 0 or specially tested for Zone 2 (e.g. type “n” protection)
- equipment the type of which ensures the absence of sparks and arcs and of “hot spots” during its normal operation
- pressurised equipment
- equipment having an enclosure filled with a liquid dielectric, or encapsulated.

5.2 Protection against combustible dust hazard

5.2.1 Electrical appliances intended for use in areas where a combustible dust hazard may be present are to be arranged with enclosures having a degree of protection and maximum surface temperature suitable for the dust to which they may be exposed.

Note 1: Where the characteristics of the dust are unknown, the appliances are to have a degree of protection IP6X. For most dusts a maximum surface temperature of 200°C is considered adequate.

5.2.2 Only lighting fittings with IP 55 protection, as a minimum requirement, may be used in areas where ignitable dusts may be deposited. In continuous service, the surface temperature of horizontal surfaces and surfaces inclined up to 60° to the horizontal is to be at least 75 K below the glow temperature of a 5 mm thick layer of the deposit dust.

SECTION 3 SYSTEM DESIGN

1 Supply systems and characteristics of the supply

1.1 Supply systems

1.1.1 The following distribution systems may be used:

a) on d.c. installations:
   - two-wire insulated
   - two-wire with one pole earthed
   - single conductor with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)

b) on a.c. installations:
   - three-phase three-wire with neutral insulated
   - three-phase three-wire with neutral directly earthed or earthed through an impedance
   - three-phase four-wire with neutral directly earthed or earthed through an impedance
   - single-phase two-wire insulated
   - single-phase two-wire with one phase earthed
   - single conductor with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)

1.1.2 Distribution systems other than those listed in [1.1.1] (e.g. with hull return, three-phase four-wire insulated) will be considered by the Society on a case-by-case basis.

1.1.3 For the supply systems of ships carrying liquid developing combustible gases or vapours, see Part E.

1.2 Maximum voltages

1.2.1 The maximum voltages for both alternating current and direct current low-voltage systems of supply for the ship's services are given in Tab 1.

Table 1 : Maximum permissible operating voltages

Type of installation	Maximum permissibile operating voltage		
	DC	1-phase AC	3-phase AC
Power and heating installations including the relevant sockets	250 V	250 V	500 V
Lighting, communications, command and information installations including the relevant sockets	250 V	250 V	-
Socket intended to supply portable devices used on open deks or within narrow or damp metal lockers, apart from boilers and tanks:			
• In general	50 V (1)	50 V (1)	-
• Where protective circuit-separation transformer only supplies one appliances	-	250 V(2)	-
• Where protective-insulation (double insulation) aplliances are used	250 V	250 V	-
• Where ≤ 30 mA default current circuit breackers are used.	-	250 V	500 V
Mobile power consumers such as electrical equipment for containers, motors, blowers and mobile pumps which are not normally moved during service and whose conducting parts which are open to physical contact are grounded by means of a grounding conductor that is incorporated into the connecting cable and which, in addition to that grounding conductor, are connected to the hull by their specific positioning or by an additional conductor	250 V	250 V	250 V
Sockets intended to suppy portable appliances used inside boilers and tanks	50 V (1)	50 V (1)	-

(1) Where that voltage comes from higher voltage networks galvanic separation is to be used (safety transformer).
(2) All of the poles of the secondary circuit are to insulated from the ground.

1.2.2 Voltages exceeding those shown will be specially considered in the case of specific systems.

2 Sources of electrical power

2.1 General

2.1.1 *(1/1/2017)*

Every ship is to have at least two power sources (main and emergency power source).

2.1.2 *(1/1/2017)*

The Society may consider modified requirements for small ships intended for restricted navigation (e.g. lakes having small stretch of water) provided that the safety of the ship is guaranteed also taking into consideration the maximum sailing time.

2.1.3 *(1/3/2019)*

For ships covered by Directive 2016/1629/EU see Pt G, Ch 1, Sec 8 [1.1.1].

2.2 Main source of electrical power

2.2.1 *(1/1/2017)*

The main source of electrical power is to consist of at least two generating sets.

The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary to provide:

a) normal operational conditions of propulsion and safety (see [2.2.2])

b) minimum comfortable conditions of habitability (see Sec 1, [3.4.2])

c) preservation of the cargo.

Such capacity is, in addition, to be sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

Note 1: for small ships intended for restricted navigation (e.g. lakes having small stretch of water) the Society may accept that the main source of electrical power consists of one generator (which may have the ship's propulsion machinery as prime mover), and one accumulator battery, provided that the capacity of the accumulator battery is sufficient to supply, without being recharged, all essential services for not less than 30 minutes.

2.2.2 *(1/1/2017)*

Those services necessary to provide normal operational conditions of propulsion and safety include primary and secondary essential services.

2.2.3 *(1/1/2017)*

The services in [2.2.2] do not include:

a) thrusters not forming part of the main propulsion

b) cargo handling gear

c) cargo pumps

d) refrigerators for air conditioning.

2.2.4 *(1/1/2017)*

Where transformers constitute an essential part of the main electrical supply system, at least two three-phase or three single-phase transformers supplied, protected and installed as indicated in Fig 1, are to be provided, so that with any one transformer not in operation, the remaining transformer(s) is (are) sufficient to ensure the supply to the essential services.

2.2.5 *(1/1/2017)*

Where essential services are supplied from an accumulator battery by means of semiconductor convertors, means are to be provided for supplying such services also in the event of failure of the convertor (e.g. providing a bypass feeder or a duplication of convertor).

2.2.6 *(1/1/2017)*

For starting arrangements for main generating sets, see Ch 1, Sec 2.

2.3 Emergency source of electrical power

2.3.1 *(1/1/2017)*

An emergency power plant is to be provided, consisting of an emergency power source and an emergency switchboard, which, in the event of a failure of the main power supply, is to be capable of supplying simultaneously at least the following services, if they depend upon an electrical source for their operation:

a) signal lights;

b) audible warning devices;

c) emergency lighting;

d) radiotelephone installations;

e) alarm, loudspeaker and on-board message communications systems;

f) searchlights;

g) fire alarm system;

h) other safety equipment such as automatic pressurized sprinkler systems or fire-extinguishing pumps, only for passenger ship;

i) lifts and lifting equipment for ship safety, only for passenger ship.

2.3.2 *(1/1/2017)*

Emergency source of electrical power is to be installed outside the main engine room, outside the rooms housing the main source of electrical power and outside the room where the main switchboard is located; it is to be separated from these rooms by adequate fire divisions, as stated by these rules, and watertight bulkheads.

2.3.3 *(1/1/2017)*

The emergency source of power is to be installed either above the margin line or as far away as possible from the main power sources, so to ensure that, in the event of flooding in accordance with Section 3, it is not flooded at the same time as the main power sources.

2.3.4 *(1/1/2017)*

Cables feeding the electrical installations in the event of an emergency are to be installed and routed in such a way as to maintain the continuity of supply to these installations in the event of fire or flooding. These cables are never to be routed through the main engine room, galleys or rooms where the main power source and its connected equipment are installed, except insofar as it is necessary to provide emergency equipment in such areas.

2.3.5 *(1/1/2017)*

The following are admissible for use as an emergency power source:

a) auxiliary generator sets with their own independent fuel supply and independent cooling system which, in the event of a power failure, turn on and take over the supply of power within 30 seconds automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crewmembers, can be turned on manually; or

b) accumulator batteries, which, in the event of a power failure, turn on automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be turned on manually. They are to be capable of powering the above-mentioned power consumers throughout the prescribed period without recharging and without an unacceptable voltage reduction.

The projected operating period for the emergency power supply is to be defined according to the defined purpose of the vessel. It is to be not less than 30 minutes. The emergency power supply defined in point (a) is to remain fully serviceable with a permanent list angle of 22,5 degrees and or a trim of 10 degrees.

2.3.6 *(1/1/2017)*

Provision is to be made for the periodical testing of the complete emergency source of power; in particular the automatic starting and the automatic connection to the emergency switchboard, when required, in case of failure of the main electrical supply system, are to be tested.

2.3.7 *(1/1/2017)*

For starting arrangements for emergency generating sets, see Ch 1, Sec 2.

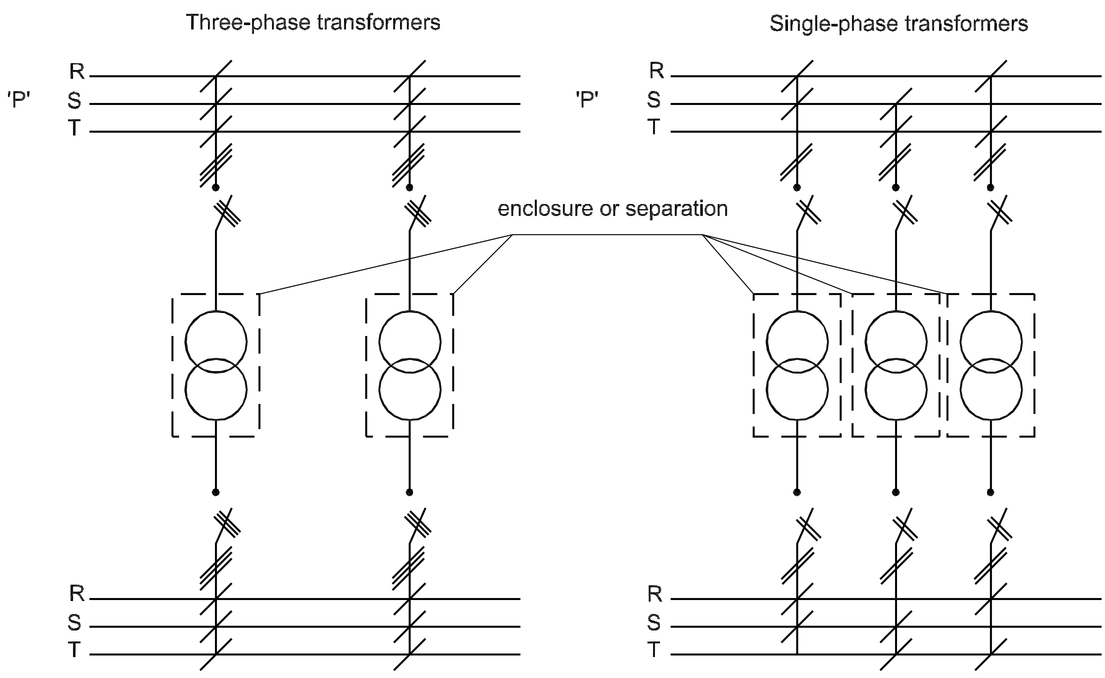
2.3.8 *(1/1/2017)*

Where emergency generator is used in port, the fuel oil supply tank to the prime mover is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services.

2.4 Use of emergency generator in port

2.4.1 The fuel oil supply tank to the prime mover is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services.

Figure 1



3 Distribution

3.1 Earthed distribution systems

3.1.1 Consumers are to be arranged in sections or consumer groups. The following main groups are to be supplied separately:

- Lighting circuits
- Power plants
- Heating plants
- Navigation, communication, command and alarm system.

3.2 Distribution systems with hull return

3.2.1 *Where the hull return system is used,* if permitted*, all final sub-circuits, i.e. all circuits fitted after the last protective device, shall be two-wire.*

The hull return is to be achieved by connecting to the hull one of the busbars of the distribution board from which the final sub-circuits originate.

3.3 General requirements for distribution systems

3.3.1 Earth connections are to be at least equal in cross-section to the supply leads. Bare leads may not be used. Casings and their retaining bolts may not be used for the earth return or for connecting the return lead to the vessel's hull.

3.4 Shore supply

3.4.1 Where arrangements are made for supplying the electrical installation from a source on shore or elsewhere, a suitable connection box is to be installed on the ship in a convenient location to receive the flexible cable from the external source.

3.4.2 Permanently fixed cables of adequate rating are to be provided for connecting the box to the main switchboard or emergency switchboard.

3.4.3 Where necessary for systems with earthed neutrals, the box is to be provided with an earthed terminal for connection between the shore's and ship's neutrals or for connection of a protective conductor.

3.4.4 The connection box is to contain a circuit-breaker or a switch-disconnector and fuses.

The shore connection is to be protected against short-circuit and overload; however, the overload protection may be omitted in the connection box if provided on the main switchboard.

3.4.5 Means are to be provided for checking the phase sequence of the incoming supply in relation to the ship's system.

3.4.6 The cable connection to the box is to be provided with at least one switch-disconnector on the main switchboard.

3.4.7 The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

3.4.8 At the connection box a notice is to be provided giving full information on the nominal voltage and frequency of the installation.

3.4.9 The switch-disconnector on the main switchboard is to be interlocked with the generator circuit-breakers in order to prevent its closure when any generator is supplying the main switchboard unless special provisions to the satisfaction of the Society are taken to permit safe transfer of electrical load.

3.4.10 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the ship is supplied from shore.

3.4.11 When using plug-type shore connectors with a current rating of more than 16 A, an interlocking device with switch is to be fitted so that the connection on board can only be made in the dead condition.

Short-circuit protection at the connection can then be dispensed with.

In order to prevent contact with live parts, plug-type shore connectors are to be designed as appliance connectors comprising a coupler plug mounted on board and a coupler socket supplied from the shore.

3.5 Supply of motors

3.5.1 A separate final sub-circuit is to be provided for every motor required for an essential service (and for every motor rated at 1 kW or more).

3.6 Power supply to lighting installations

3.6.1 Final sub-circuits for lighting supplying more than one lighting point and for socket-outlets are to be fitted with protective devices having a current rating not exceeding 16 A.

3.6.2 The load on each lighting circuit is not to exceed 10 A.

The number of lighting points supplied by a final sub-circuit shall not exceed the following maximums:

Table 2

Voltage	Maximum number of lighting points
Up to 55 V	10
form 56 V to 120 V	14
form 121 V to 250 V	24

3.6.3 Plug sockets (outlets) are to be connected to separate circuits wherever possible. Final circuits for lighting in accommodation spaces may, as far as practicable, include socket outlets. In that case, each socket outlet counts for 2 lighting points.

3.7 Special lighting services

3.7.1 In spaces such as:

- main and large machinery spaces
- large galleys
- passageways
- stairways leading to boat-decks
- public spaces

there is to be more than one final sub-circuit for lighting such that failure of any one circuit does not reduce the lighting to an insufficient level.

3.8 Navigation lights

3.8.1 Navigation lights are to be connected separately to a distribution board specially reserved for this purpose.

Signalling lights may be connected to the navigation light distribution board, or to a separate distribution board.

3.8.2 The transfer of supply is to be practicable from the bridge, for example by means of a switch.

3.8.3 Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [3.13.1].

3.8.4 Where there are double navigation lights, i.e. lights with two lamps or where for every navigation light a spare is also fitted, the connections to such lights may run in a single cable provided that means are foreseen in the distribution board to ensure that only one lamp or light may be supplied at any one time.

3.8.5 Each navigation light is to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of the light. If an audible device alone is fitted, it is to be connected to a separate source of supply from that of the navigation lights, for example an accumulator (storage) battery.

If a visual signal is used connected in series with the navigation light, means are to be provided to prevent the extinction of the navigation light due to the failure of the visual signal.

A minimum level of visibility is to be assured in the case of use of dimmer devices.

Navigations lights are to be designed for the standard voltages: 24 V, 110 V or 220 V.

3.9 Power supply to the speed control systems of main propulsion engines

3.9.1 Electrically operated speed control systems of main engines are to be fed from the main source of electrical power.

3.9.2 Where more than one main propulsion engine is foreseen, each speed control system is to be provided with an individual supply by means of separate wiring from the main switchboard or from two independent section boards.

Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied equally from the two sections.

3.9.3 In the case of propulsion engines which do not depend for their operation on electrical power, i.e. pumps driven from the main engine, the speed control systems are to be fed both from the main source of electrical power and from an accumulator battery for at least 15 minutes or from a similar supply source.

Such battery may also be used for other services such as automation systems, where foreseen.

3.10 Power supply to the speed control systems of generator sets

3.10.1 Each electrically operated control and/or speed control system of generator sets is to be provided with a separate supply from the main source of electric power and from an accumulator battery for at least 15 minutes or from a similar supply source.

3.10.2 The wiring supplying the main source of electrical power is to be from the main switchboard or from independent section boards.

Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied from the sections to which the relevant generators are connected.

4 Degrees of protection of the enclosures

4.1 General

4.1.1 The minimum required degree of protection for electrical equipment, in relation to the place of installation, is generally that specified in Tab 3.

4.1.2 Protection against direct contact includes all the measures designed to protect persons against the dangers arising from contact with live parts of electrical appliances. Live parts are deemed to be conductors and conductive parts of appliances which are live under normal operating conditions.

Electrical appliances are to be so designed that the person cannot touch or come dangerously close to live parts, in way of the determined operation.

Protection against direct contact may be dispensed with in the case of equipment using safety voltage.

In service spaces, live parts of the electrical appliances are to remain protected against accidental contact when doors and covers which can be opened without a key or tool are opened for operation purpose.

4.1.3 Protection against electric shock: indirect contact

Electrical appliances are to be made in such a way that persons are protected against dangerous contact voltages even in the event of an insulation failure.

For this purpose, the construction of the appliances is to incorporate one of the following protective measures:

- Protective earthing (see [4.1.4])
- Protective insulation (double insulation)
- Operation at very low voltages presenting no danger even in the event of a fault.

The additional usage of Residual Current Protective Devices is allowed except for steering and propulsion plant.

4.1.4 Protective earthing

Metal casings and all metal parts accessible to touch which are not live in normal operation but may become so in the event of a fault are to be earthed except where their mounting already provides a conductive connection to the vessel's hull.

Special earthing may be dispensed with in the case of:

a) metal parts insulated by a non-conductor from the dead or earthed parts

b) bearings of electrical machines which are insulated to prevent currents flowing between them and the shaft

c) electrical equipment whose service voltage does not exceed 50 V.

Where machines and equipment are earthed to the hull via their mountings, care is to be taken to ensure good conductivity by clean metal contact faces at the mounting. Where the stipulated earth is not provided via the mountings of machinery and equipment, a special earthing conductor is to be fitted for this purpose.

It is necessary to effect the continuous conductive connection of all metal cable sheaths, particularly inside

cable distribution and junction containers.

Metal cable sheaths, armouring, screening and shielding are normally to be conductively connected to the vessel's

hull at both ends. In the case of single-core cables in single-phase AC systems, only one end is to be earthed.

The earthing at one end only of cables and wires in electronic systems is recommended.

Protection is to be provided by an additional cable, an additional lead or an additional core in the power cable.

Metal cable armouring may not be used as an earthing conductor.

A conductor normally carrying current may not be used simultaneously as an earthing conductor and may not be connected with the latter by a common connection to the vessel's hull.

The cross-section of the earthing conductor is to be at least in accordance with Tab 3.

The connections of earthing conductors to the metal parts to be earthed and to the vessel's hull are to be made with care

and are to be protected against corrosion.

Electrical equipment in the area subject to explosion hazard is in every case to be fitted with an earthing conductor irrespective of the type of mounting used.

Table 3 : Minimum required degrees of protection

Condition in location	Example of location	Switchboard Control gear Motor starters	Generators	Motors	Transformers	Luminaires	Heating appliances	Cooking appliances	Socket outiets	Accessories (e.g. switches, connection boxes)
Danger of touching live parts only	Dry accommodation spaces Dry control rooms	I P 20	X **(1)**	I P 20	I P 20	I P 20	I P20	I P 20	I P 20	I P 20
Danger of dripping liquid and/for moderate mechanical damage	Control rooms, wheel-house, radio room	I P 22	X	I P 22	I P 22	I P 22	I P22	I P 22	I P 22	I P 22
	Engine and boiler rooms above floor	I P 22	I P 22	I P 22	I P 22	I P 22	I P22	I P 22	I P 44	I P 44
	Steering gear rooms	I P 22	I P 22	I P 22	I P 22	I P 22	I P22	X	I P 44	I P 44
	Emergency machinery rooms	I P 22	I P 22	I P 22	I P 22	I P 22	I P22	X	I P 44	I P 44
	General store-rooms	I P 22	X	I P 22	I P 22	I P 22	I P22	X	I P 22	I P 44
	Pantries	I P 22	X	I P 22	I P 22	I P 22	I P22	I P 22	I P 44	I P 44
	Provision rooms	I P 22	X	I P 22	I P 22	I P 22	I P22	X	I P 44	I P 44
	Ventilation ducts	X	X	I P 22	X	X	X	X	X	X
Increased danger of liquid and/for mechanical damage	Bathrooms and/or showers	X	X	X	X	I P 34	I P44	X	I P 55	I P 55
	Engine and boiler rooms below floor	X	X	I P 44	X	I P 34	I P44	X	X	I P 55
	Closed fuel oil separator rooms	I P 44	X	I P 44	I P 44	I P 34	I P44	X	X	I P 55
	Closed lubricating oil separator rooms	I P 44	X	I P 44	I P 44	I P 34	I P44	X	X	I P 55
Increased danger of liquid and mechanical damage	Ballast pump rooms	I P 44	X	I P 44 **(2)**	I P 44 **(2)**	I P 34	I P44	X	I P 55	I P 55
	Refrigerated rooms	X	X	I P 44	X	I P 34	I P44	X	I P 55	I P 55
	Galleys and laundries	I P 44	X	I P 44	I P 44	I P 34	I P44	I P 44	I P 44	I P 44
	Public bathrooms and shower	X	X	I P 44	I P 44	I P 34	I P44	X	I P 44	I P 44
Danger of liquid spraying. Presence of cargo dust. Serious mechanical damage. Aggressive fumes	Shaft or pipe tunnels in double bottom	I P 55	X	I P 55	I P 55	I P 55	I P55	X	I P 56	I P 56
	Holds for general cargo	X	X	I P 55	X	I P 55	I P55	X	I P 56	I P 56
	Ventilation trunks	X	X	I P 55	X	X	X	X	X	X
Danger of liquid in massive quantities	Open decks	I P 56	X	I P 56	X	I P 55	I P56	X	I P 56	I P 56

(1) The symbol "X" denotes equipment which it is not advised to install.

(2) Electric motors and starting transformers for lateral thrust propellers located in spaces similar to ballast pump rooms may have degree of protection IP22.

Table 4 : Cross-section of earthing conductors

Cross section of main conductors, in mm²	Minimum cross-scetion of earthing conductor	
	Earthing conductor incorporated in the calble, in mm²	Earthing conductor separated from the calble, in mm²
0,5 up to 4	Equal to the main conductor	4
> 4 up to 16	Equal to the main conductor	Equal to the main conductor
> 16 up to 35	16	16
> 35 up to 120	Equal to the main conductor	Equal to the main conductor
> 120	70	70

Table 5 : Required Environmental Categories

	Location within main area			
Main Areas on Board	General	Inside cubicles, desks, etc.	On machinery such as internal combustion engines, compressors	Masts
Machinery Spaces/Steering Gear	EC21	EC31	EC23	X **(1)**
Control Room, Accommodation	EC21 EC11C	EC31	X	X
Bridge	EC21 EC11C	EC31	X	X
Pump Room, Holds, Rooms with no Heating	EC41	X	X	X
Exposed Decks	EC41S	X	X	EC42S

(1) The symbol “X” denotes locations which are generally not applicable.

5 Diversity (demand) factors

5.1 General

5.1.1 The cables and protective devices of final sub-circuits are to be rated in accordance with their connected load.

5.1.2 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor.

5.1.3 A diversity (demand) factor may be applied provided that the known or anticipated operating conditions in a particular part of an installation are suitable for the application of diversity.

6 Environmental categories of the equipment

6.1 Environmental categories

6.1.1 The environmental categories of the electrical equipment, in relation to the place of installation, are generally to be those specified in Tab 5.

6.1.2 For ships operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to + 40 °C instead of + 45 °C, so that the first characteristic numeral changes from 1 to 3.

7 Electrical protection

7.1 General requirements for overcurrent protection

7.1.1 Electrical installations are to be protected against accidental overcurrents including short-circuit.

The choice, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection in order to ensure as far as possible:

- continuity of service in the event of a fault, through coordinated and discriminative action of the protective devices
- elimination of the effects of faults to reduce damage to the system and the hazard of fire as far as possible.

Note 1: An overcurrent is a current exceeding the nominal current.

Note 2: A short-circuit is the accidental connection by a relatively low resistance or impedance of two or more points in a circuit which are normally at different voltages.

7.1.2 Devices provided for overcurrent protection are to be chosen according to the requirements, especially with regard to overload and short-circuit.

Note 1: Overload is an operating condition in an electrically undamaged circuit which causes an overcurrent.

7.1.3 Systems are to be such as to withstand the thermal and electrodynamic stresses caused by the possible overcurrent, including short-circuit, for the admissible duration.

7.2 Short-circuit currents

7.2.1 In calculating the maximum prospective short-circuit current, the source of current is to include the maximum number of generators which can be simultaneously connected (as far as permitted by any interlocking arrangements), and the maximum number of motors which are normally simultaneously connected in the system.

The maximum number of generators or transformers is to be evaluated without taking into consideration short-term parallel operation (e.g. for load transfer) provided that suitable interlock is foreseen.

7.2.2 Short-circuit current calculations are to be performed in accordance with a method recognised by the Society, such as that given in IEC Publication 60363.

7.2.3 In the absence of precise data concerning the characteristics of generators, accumulator batteries and motors, the maximum short-circuit currents on the main busbars may be calculated as follows:

- for alternating current systems:

  $I_{ac} = 10\ I_{TG} + 3{,}5\ I_{TM}$

  $I_{pk} = 2{,}4\ I_{ac}$

- for direct current systems supplied by batteries:

  $I_p = K\ C_{10} + 6\ I_{TM}$

where:

I_p	:	Maximum short-circuit current
I_{ac}	:	r.m.s. value of the symmetrical component (at the instant T/2)
I_{pk}	:	Maximum peak value
I_{TG}	:	Rated current of all generators which can be connected simultaneously
C_{10}	:	Battery capacity in Ah for a discharge duration of 10 hours
K	:	Ratio of the short-circuit current of the batteries to C_{10}; (see Note 1)
I_{TM}	:	Rated current of all motors which are normally simultaneously connected in the system.

Note 1: For stationary batteries the following values may be assumed for guidance:

- vented lead-acid batteries: K = 8
- vented alkaline type batteries intended for discharge at low rates corresponding to a battery duration exceeding three hours: K = 15
- sealed lead-acid batteries having a capacity of 100 Ah or more or alkaline type batteries intended for discharge at high rates corresponding to a battery duration not exceeding three hours: K = 30.

7.3 Selection of equipment

7.3.1 Circuit-breakers of withdrawable type are required where they are not suitable for isolation.

7.3.2 Equipment is to be chosen on the basis of its rated current and its making/breaking capacity.

7.3.3 In the selection of circuit-breakers with intentional short-time delay for short-circuit release, those of utilisation category B are to be used and they are to be selected also taking into account their rated short-time withstand current capacity (I_{cw}).

For circuit-breakers without intentional short-time delay for short-circuit release, circuit breakers of utilisation category A may be used and they are to be selected according to their rated service short-circuit breaking capacity (I_{cs}).

Note 1: For the purpose of these Rules, utilisation categories A and B are defined as follows:

- Utilisation category A: circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without an intentional short-time delay provided for selectivity under short-circuit conditions
- Utilisation category B: circuit-breakers specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with an intentional short-time delay (which may be adjustable) provided for selectivity under short-circuit conditions.

7.3.4 For duplicated essential services and non-essential services, circuit-breakers may be selected according to their ultimate short-circuit breaking capacity (I_{cu}).

7.3.5 For switches, the making/breaking capacity is to be in accordance with utilisation category AC-22 A or DC-22 A (in compliance with IEC Publication 60947-3).

7.3.6 For fuse-switch disconnectors or switch-disconnector fuse units, the making/breaking capacity is to be in accordance with utilisation categories AC-23 A or DC-23 A (in compliance with IEC Publication 60947-3).

7.4 Protection against short-circuit

7.4.1 Protection against short-circuit currents is to be provided by circuit- breakers or fuses.

7.4.2 The rated short-circuit breaking capacity of every protective device is to be not less than the maximum prospective value of the short-circuit current at the point of installation at the instant of contact separation.

7.4.3 The rated short-circuit making capacity of every mechanical switching device intended to be capable of being closed 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.

7.4.4 Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current liable to occur at the point of installation having regard to the time required for the short-circuit to be removed.

7.4.5 The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is permitted, provided that it is backed up on the generator side by a fuse or by a circuit-breaker having at least the necessary short-circuit rating and not being the generator circuit-breaker.

7.4.6 The same fuse or circuit-breaker may back up more than one circuit-breaker where the circuits concerned do not involve essential services.

7.4.7 The short-circuit performance of the back-up arrangement is to be equal to the requirements of IEC Publication 60947-2 for a single circuit-breaker having the same short-circuit performance category as the backed-up circuit-breaker and rated for the maximum prospective short-circuit level at the supply terminals of the arrangement.

7.4.8 Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuses and the circuit-breakers are of coordinated design, in order to ensure that the operation of the fuses takes place in due time so as to prevent arcing between poles or against metal parts of the circuit-breakers when they are submitted to overcurrents involving the operation of the fuse.

7.4.9 When determining the performance requirements for the above-mentioned back-up protection arrangement, it is permissible to take into account the impedance of the various circuit elements of the arrangement, such as the impedance of a cable connection when the backed-up circuit-breaker is located away from the back-up breaker or fuse.

7.5 Continuity of supply and continuity of service

7.5.1 The protection of circuits is to be such that a fault in one service does not cause the loss of any essential services.

7.5.2 The protection of the emergency circuit is to be such that a failure in one circuit does not cause a loss of other emergency services.

Note 1: The continuity of supply for the primary essential services and the continuity of service for the secondary essential services are to be ensured.

The continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits (see circuit 3 in Fig 2) is permanently ensured.

The continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits (see circuit 3 in Fig 2) is re-established.

7.6 Protection against overload

7.6.1 Devices provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

7.6.2 The use of fuses up to 320 A for overload protection is permitted.

7.7 Localisation of overcurrent protection

7.7.1 Short-circuit protection is to be provided for every non-earthed conductor.

7.7.2 Overload protection is to be provided for every non-earthed conductor; nevertheless, in insulated single-phase circuits or insulated three-phase circuits having substantially balanced loads, the overload protection may be omitted on one conductor.

7.7.3 Short-circuit and overload protective devices are not to interrupt earthed conductors, except in the case of multiple disconnection devices which simultaneously interrupt all the conductors, whether earthed or not.

7.7.4 Electrical protection is to be located as close as possible to the origin of the protected circuit.

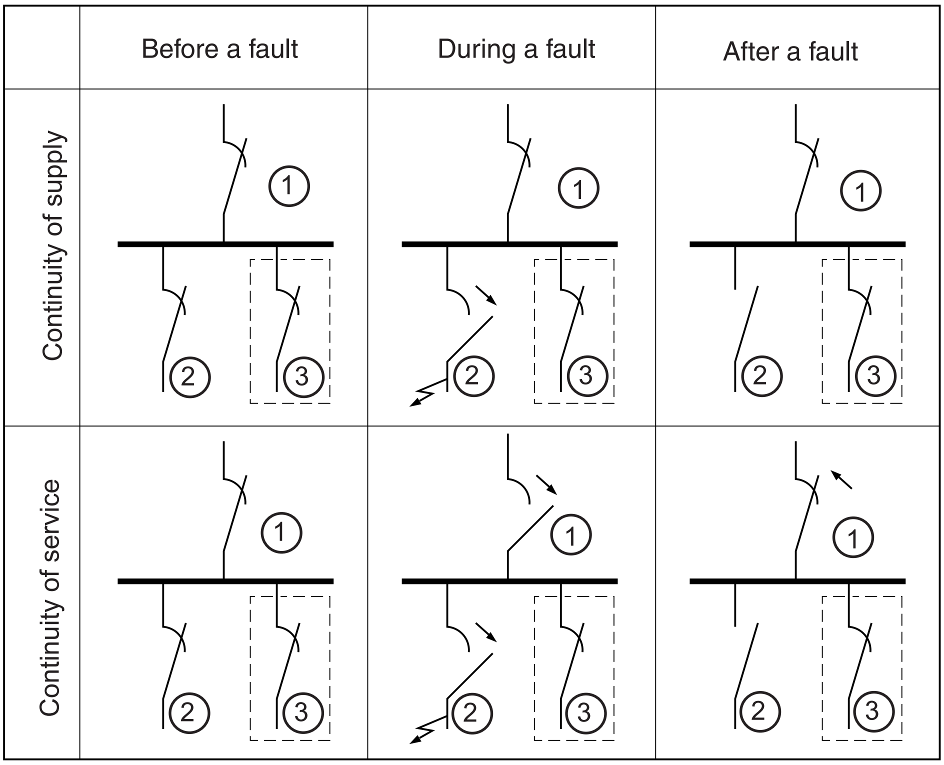
7.8 Protection of generators

7.8.1 Generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

For generators not arranged to operate in parallel with a rated output equal to or less than 50 kVA, a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

7.8.2 When multipole switch and fuses are used, the fuse rating is to be maximum 110% of the generator rated current.

Figure 2



7.8.3 Where a circuit-breaker is used:

a) the overload protection is to trip the generator circuit-breaker at an overload between 10% and 50%; for an overload of 50% of the rated current of the generator the time delay is not to exceed 2 minutes; however, the figure of 50% or the time delay of 2 minutes may be exceeded if the construction of the generator permits this

b) the setting of the short-circuit protection is to instantaneously trip the generator circuit-breaker at an overcurrent less than the steady short-circuit current of the generator. Short time delays (e.g. from 0,5 s to 1 s) may be introduced for discrimination requirements in "instantaneous" tripping devices.

7.8.4 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in a permanently attended space.

7.8.5 After disconnection of a generator due to overload, the circuit-breaker is to be ready for immediate reclosure.

7.8.6 Generator circuit-breakers are to be provided with a reclosing inhibitor which prevents their automatic reclosure after tripping due to a short-circuit.

7.8.7 Generators having a capacity of 1500 kVA or above are to be equipped with a suitable protective device or system which, in the event of a short-circuit in the generator or in the supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker (e.g. by means of differential protection).

7.8.8 *Where the main source of electrical power is necessary for the propulsion of the ship, load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.*

7.8.9 Arrangements are to be made to disconnect or reduce automatically the excess load when the generators are overloaded in such a way as to prevent a sustained loss of speed and/or voltage (see Sec 2, Tab 6). The operation of such device is to activate a visual and audible alarm. A time delay of 5-20 s is considered acceptable.

7.8.10 When an overload is detected the load shedding system is to disconnect automatically, after an appropriate time delay, the circuits supplying the non-essential services and, if necessary, the secondary essential services in a second stage.

7.8.11 Alternating current generators arranged to operate in parallel are to be provided with reverse-power protection.

The protection is to be selected in accordance with the characteristics of the prime mover.

The following values are recommended:

- 2-6% of the rated power for turbogenerators
- 8-15% of the rated power for diesel generators.

The reverse-power protection may be replaced by other devices ensuring adequate protection of the prime movers.

7.8.12 Generators are to be provided with an undervoltage protection which trips the breaker if the voltage falls to 70% - 35% of the rated voltage.

For generators arranged for parallel operation, measures are to be taken to prevent the generator breaker from closing if the generator is not generating and to prevent the generator remaining connected to the busbars if voltage collapses.

The operation of the undervoltage release is to be instantaneous when preventing closure of the breaker, but it is to be delayed for selectivity purposes when tripping the breaker.

7.9 Protection of circuits

7.9.1 Each separate circuit shall be protected against short-circuit and against overload, unless otherwise specified in these Rules or where the Society may exceptionally otherwise permit.

7.9.2 Each circuit is to be protected by a multipole circuit-breaker or switch and fuses against overloads and short-circuits.

7.9.3 Circuits for lighting are to be disconnected on both non-earthed conductors; single-pole disconnection of final sub-circuits with both poles insulated is permitted only in accommodation spaces.

7.9.4 The protective devices of the circuits supplying motors are to allow excess current to pass during transient starting of motors.

7.9.5 Final sub-circuits which supply one consumer with its own overload protection (for example motors), or consumers which cannot be overloaded (for example permanently wired heating circuits and lighting circuits), may be provided with short-circuit protection only.

7.9.6 Steering gear circuits are to be provided with short-circuit protection only.

7.10 Protection of motors

7.10.1 Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable (see [7.9.5]).

7.10.2 For motors intended for essential services, the overload protection may be replaced by an overload alarm (for steering gear motors see Ch 1, Sec 9).

7.10.3 The protective devices are to be designed so as to allow excess current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use.

If the current/time characteristic of the overload protection device does not correspond to the starting conditions of a motor (e.g. for motors with extra-long starting period), provision may be made to suppress operation of the device during the acceleration period on condition that the short-circuit protection remains operative and the suppression of overload protection is only temporary.

7.10.4 For continuous duty motors the protective gear is to have a time delay characteristic which ensures reliable thermal protection against overload.

7.10.5 The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105% - 120% of the motor's rated full load current.

7.10.6 For intermittent duty motors the current setting and the delay (as a function of time) of the protective devices are to be chosen in relation to the actual service conditions of the motor.

7.10.7 Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

7.10.8 Motors rated above 1 kW are to be provided with:

- undervoltage protection, operative on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted or
- undervoltage release, operative on the reduction or failure of voltage, so arranged that the motor restarts automatically when power is restored after a power failure.

7.10.9 The automatic restart of a motor is not to produce a starting current such as to cause excessive voltage drop.

In the case of several motors required to restart automatically, the total starting current is not to cause an excessive voltage drop or sudden surge current; to this end, it may be necessary to achieve a sequence start.

7.10.10 The undervoltage protective devices are to allow the motor to be started when the voltage exceeds 85% of the rated voltage and are to intervene without fail when the voltage drops to less than approximately 20% of the rated voltage, at the rated frequency and with a time delay as necessary.

7.11 Protection of storage batteries

7.11.1 Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers at a position adjacent to the battery compartment.

Overcurrent protection may be omitted for the circuit to the starter motors when the current drawn is so large that is impracticable to obtain short-circuit protection.

7.12 Protection of shore power connection

7.12.1 Permanently fixed cables connecting the shore connection box to the main switchboard are to be protected by fuses or circuit-breakers.

7.13 Protection of measuring instruments, pilot lamps and control circuits

7.13.1 Measuring circuits and devices (voltage transformers, voltmeters, voltage coils of measuring instruments, insulation monitoring devices etc.) and pilot lamps are to be protected against short-circuit by means of multipole circuit-breakers or fuses.

The protective devices are to be placed as near as possible to the tapping from the supply.

The secondary side of current transformers is not to be protected.

7.13.2 Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole circuit-breakers or fuses on each pole not connected to earth.

Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side.

The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

7.13.3 Where a fault in a pilot lamp would impair the operation of essential services, such lamps are to be protected separately from other circuits such as control circuits.

Note 1: Pilot lamps connected via short-circuit-proof transformers may be protected in common with control circuits.

7.13.4 Circuits whose failure could endanger operation, such as steering gear control feeder circuits, are to be protected only against short-circuit.

7.13.5 The protection is to be adequate for the minimum cross-section of the protected circuits.

7.14 Protection of transformers

7.14.1 The primary winding side of power transformers is to be protected against short-circuit and overload by means of multipole circuit-breakers or switches and fuses.

Overload protection on the primary side may be dispensed with where it is provided on the secondary side or when the total possible load cannot reach the rated power of the transformer.

7.14.2 The protection against short-circuit is to be such as to ensure the selectivity between the circuits supplied by the secondary side of the transformer and the feeder circuit of the transformer.

7.14.3 When transformers are arranged to operate in parallel, means are to be provided so as to trip the switch on the secondary winding side when the corresponding switch on the primary side is open.

8 System components

8.1 General

8.1.1 The components of the electrical system are to be dimensioned such as to withstand the currents that can pass through them during normal service without their rating being exceeded.

8.1.2 The components of the electrical system are to be designed and constructed so as to withstand for the admissible duration the thermal and electrodynamic stresses caused by possible overcurrents, including short-circuit.

9 Electrical cables

9.1 General

9.1.1 All electrical cables and wiring external to equipment shall be at least of a flame-retardant type, in accordance with IEC Publication 60332-1.

9.1.2 In addition to the provisions of [9.1.1], when cables are laid in bundles, cable types are to be chosen in compliance with IEC Publication 60332-3 Category A, or other means (see Sec 12) are to be provided such as not to impair their original flame-retarding properties.

9.1.3 Where necessary for specific applications such as radio frequency or digital communication systems, which require the use of particular types of cables, the Society may permit the use of cables which do not comply with the provisions of [9.1.1] and [9.1.2].

9.1.4 Cables which are required to have fire-resisting characteristics are to comply with the requirements stipulated in IEC 60331.

9.2 Choice of insulation

9.2.1 The maximum rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to occur or to be produced in the space where the cable is installed.

9.2.2 The maximum rated conductor temperature for normal and short-circuit operation, for the type of insulating compounds normally used for shipboard cables, is not to exceed the values stated in Tab 5. Special consideration will be given to other insulating materials.

9.2.3 PVC insulated cables are not to be used either in refrigerated spaces, or on decks exposed to the weather of ships classed for unrestricted service.

9.2.4 Mineral insulated cables will be considered on a case by case basis.

9.3 Choice of protective covering

9.3.1 The conductor insulating materials are to be enclosed in an impervious sheath of material appropriate to the expected ambient conditions where cables are installed in the following locations:

- on decks exposed to the weather,
- in damp or wet spaces (e.g. in bathrooms),
- in refrigerated spaces,
- in machinery spaces and, in general,
- where condensation water or harmful vapour may be present.

9.3.2 Where cables are provided with armour or metallic braid (e.g. for cables installed in hazardous areas), an overall impervious sheath or other means to protect the metallic elements against corrosion is to be provided; see Sec 9.

9.3.3 An impervious sheath is not required for single-core cables installed in tubes or ducts inside accommodation spaces, in circuits with maximum system voltage 250 V.

9.3.4 In choosing different types of protective coverings, due consideration is to be given to the mechanical action to which each cable may be subjected during installation and in service.

If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected (e.g. by an armour or by installation inside pipes or conduits).

9.3.5 Single-core cables for a.c. circuits with rated current exceeding 20 A are to be either non-armoured or armoured with non-magnetic material.

9.4 Cables in refrigerated spaces

9.4.1 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armour is applied on the sheath, the armour is to be protected against corrosion by a further moisture-resisting covering.

9.5 Cables in areas with a risk of explosion

9.5.1 For cables in areas with a risk of explosion, see [10].

9.6 Electrical services required to be operable under fire conditions and fire-resistant cables

9.6.1 Electrical services required to be operable under fire conditions are as follows:

- Control and power systems to power-operated fire doors and status indication for all fire doors
- Control and power systems to power-operated watertight doors and their status indication
- Emergency fire pump
- Emergency lighting
- Fire and general alarms
- Fire detection systems
- Fire-extinguishing systems and fire-extinguishing media release alarms
- Low location lighting
- Public address systems
- Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

9.6.2 Where cables for services specified in [9.6.1] including their power supplies pass through high fire risk areas (see Note 1), and in addition for passenger ships, main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables being of a fire-resistant type complying with IEC 60331-31 for cables of greater than 20 mm overall diameter, otherwise 60331-21, are installed and run continuous to keep the fire integrity within the high fire risk area (see Fig 3).

b) At least two loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

Note 1:

a) For the purpose of application of this item [9.6], the definition of "high fire risk areas" is the following:

(1) Machinery spaces as defined Chapter 4

(2) Spaces containing fuel treatment equipment and other highly flammable substances

(3) Galley and Pantries containing cooking appliances

(4) Laundry containing drying equipment

(5) Spaces as defined by paragraphs (8), (12), and (14) of Chap. II-2 / Reg. 9.2.2.3.2.2 of SOLAS for ships carrying more than 36 passengers;

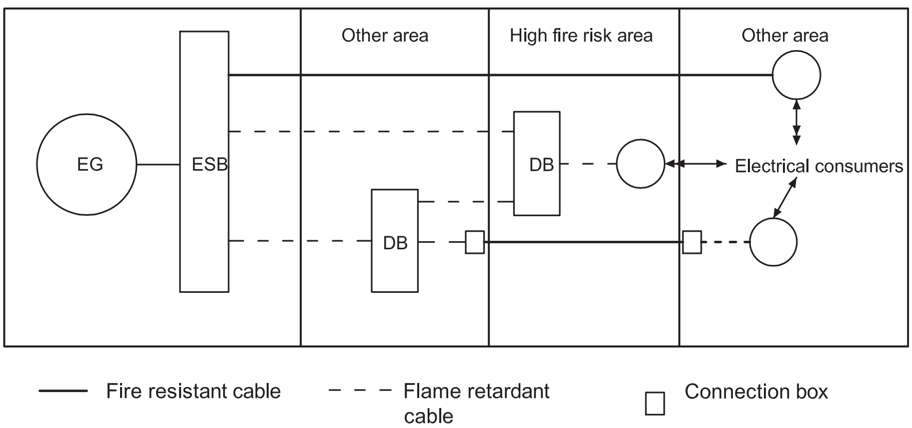
b) Fire-resistant type cables are to be easily distinguishable.

c) For special cables, requirements in the following standards may be used:

(1) IEC60331-23: Procedures and requirements - Electric data cables

(2) IEC60331-25: Procedures and requirements - Optical fibre cables.

Figure 3



9.6.3 Cables connecting fire pumps to the emergency switchboard are to be of a fire-resistant type where they pass through high fire risk areas.

9.7 Cables for submerged bilge pumps

9.7.1 Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cable is to be impervious-sheathed and armoured, is to be installed in continuous lengths from above the bulkhead to the motor terminals and is to enter the air bell from the bottom.

9.8 Internal wiring of switchboards and other enclosures for equipment

9.8.1 For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath).

Other types of flame-retardant switchboard wiring may be accepted at the discretion of the Society.

9.9 Current carrying capacity of cables

9.9.1 The current carrying capacity for continuous service of cables given in Tab 6 to Tab 10 is based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

9.9.2 The current carrying capacity cited in [9.9.1] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

9.9.3 Values other than those shown in Tab 6 to Tab 10 may be accepted provided they are determined on the basis of calculation methods or experimental values approved by the Society.

9.9.4 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 10 may be applied to the current carrying capacity in Tab 6 to Tab 10.

9.9.5 Where more than six cables are bunched together in such a way that there is an absence of free air circulating around them, and the cables can be expected to be under full load simultaneously, a correction factor of 0,85 is to be applied.

Table 6 : Maximum rated conductor temperature

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature, in °C	
		Normal operation	Short-circuit
a) Thermoplastic:			
- based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC/A	60	150
b) Elastomeric or thermosetting:			
- based upon ethylene-propylene rubber or similar (EPM or EPDM)	EPR	85	250
- based upon high modulus or hardgrade ethylene propylene rubber	HEPR	85	250
- based upon cross-linked polyethylene	XLPE	85	250
- based upon rubber silicon	S 95	95	350
- based upon ethylene-propylene rubber or similar (EPM or EPDM) halogen free	HF EPR	85	250
- based upon high modulus or hardgrade halogen free ethylene propylene rubber	HF HEPR	85	250
- based upon cross-linked polyethylene halogen free	HF XLPE	85	250
- based upon rubber silicon halogen free	HF S 95	95	350
- based upon cross-linked polyolefin material for halogen free cable **(1)**	HF 85	85	250

(1) Used on sheathed cable only

Table 7 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 60°C (ambient temperature 45°C)

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1	8	7	6
1,5	12	10	8
2,5	17	14	12
4	22	19	15
6	29	25	20
10	40	34	28
16	54	46	38
25	71	60	50
35	87	74	61
50	105	89	74
70	135	115	95
95	165	140	116
120	190	162	133
150	220	187	154
185	250	213	175
240	290	247	203
300	335	285	235

Table 8 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 75°C (ambient temperature 45°C)

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1	13	11	9
1,5	17	14	12
2,5	24	20	17
4	32	27	22
6	41	35	29
10	57	48	40
16	76	65	53
25	100	85	70
35	125	106	88
50	150	128	105
70	190	162	133
95	230	196	161
120	270	230	189
150	310	264	217
185	350	298	245
240	415	353	291
300	475	404	333

Table 9 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 80°C (ambient temperature 45°C)

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1	15	13	11
1,5	19	16	13
2,5	26	22	18
4	35	30	25
6	45	38	32
10	63	54	44
16	84	71	59
25	110	94	77
35	140	119	98
50	165	140	116
70	215	183	151
95	260	221	182
120	300	255	210
150	340	289	238
185	390	332	273
240	460	391	322
300	530	450	371

Table 10 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 85°C (ambient temperature 45°C)

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1	16	14	11
1,5	20	17	14
2,5	28	24	20
4	38	32	27
6	48	41	34
10	67	57	47
16	90	77	63
25	120	102	84
35	145	123	102
50	180	153	126
70	225	191	158
95	275	234	193
120	320	272	224
150	365	310	256
185	415	353	291
240	490	417	343
300	560	476	392

Table 11 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 95°C (ambient temperature 45°C)

Nominal section mm²	Number of conductors		
	1	2	3 or 4
1	20	17	14
1,5	24	20	17
2,5	32	27	22
4	42	36	29
6	55	47	39
10	75	64	53
16	100	85	70
25	135	115	95
35	165	140	116
50	200	170	140
70	255	217	179
95	310	264	217
120	360	306	252
150	410	349	287
185	470	400	329
240	570	485	399
300	660	560	462

9.9.6 Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service (e.g. mooring winches or bow thruster propellers), the current carrying capacity obtained from Tab 7 to Tab 11 may be increased by applying the corresponding correction factors given in Tab 12.

In no case is a period shorter than 1/2-hour to be used, whatever the effective period of operation.

9.9.7 For supply cables to single services for intermittent loads (e.g. cargo winches or machinery space cranes), the current carrying capacity obtained from Tab 6 to Tab 10 may be increased by applying the correction factors given in Tab 13.

The correction factors are calculated with rough approximation for periods of 10 minutes, of which 4 minutes with a constant load and 6 minutes without load.

9.10 Minimum nominal cross-sectional area of conductors

9.10.1 In general the minimum allowable conductor cross-sectional areas are those given in Tab 14.

9.10.2 The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm². In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

9.10.3 For the nominal cross-sectional area of:

- earthing conductors, see Sec 12, [2]
- earthing connections for distribution systems, see Sec 12, [2].

9.11 Choice of cables

9.11.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

9.11.2 The nominal cross-sectional area of each cable is to be sufficient to satisfy the following conditions with reference to the maximum anticipated ambient temperature:

- the current carrying capacity is to be not less than the highest continuous load carried by the cable
- the voltage drop in the circuit, by full load on this circuit, is not to exceed the specified limits
- the cross-sectional area calculated on the basis of the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

9.11.3 The highest continuous load carried by a cable is to be calculated on the basis of the power requirements and of the diversity factor of the loads and machines supplied through that cable.

9.11.4 When the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard busbars to any point in the installation is not to exceed 6% of the nominal voltage.

For battery circuits with supply voltage less than 55 V, this value may be increased to 10%.

For the circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.

Table 12 : Correction factors for various ambient air temperatures

Maximum conductor temperature, in °C	Correction factors for ambient air temperature of :										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
60	1,29	1,15	1,00	0,82	-	-	-	-	-	-	-
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	-	-	-	-
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	-	-	-
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	-	-
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 13 : Correction factors for short-time loads

½ -hour service		1-hour service		Correlation factor
Sum of nominal cross-sectional areas of all conductors in the cable, in mm²		Sum of nominal cross-sectional areas of all conductors in the cable, in mm²		
Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	
up to 20	up to 75	up to 80	up to 230	1,06
21-41	76-125	81-170	231-400	1,10
41-65	126-180	171-250	401-600	1,15
66-95	181-250	251-430	601-800	1,20
96-135	251-320	431-600	-	1,25
136-180	321-400	601-800	-	1,30
181-235	401-500	-	-	1,35
236-285	501-600	-	-	1,40
286-350	-	-	-	1,45

Table 14 : Correction factors for intermittent service

Sun of nominal cross selectionel areas of all conductors in the cable, in mm²		Correction factor
Cables with metallic sheath and armoured cables	Cables without metallic sheath and non-amoured cables	
	S ≤ 5	1,10
	5 < S ≤ 8	1,15
	8 < S ≤ 16	1,20
S ≤ 4	16 < S ≤ 825	1,25
4 < S ≤ 7	25 < S ≤ 42	1,30
7 < S ≤ 17	42 < S ≤ 72	1,35
17 < S ≤ 42	72 < S ≤ 140	1,40
42 < S ≤ 110	140 < S	1,45
110 < S	-	1,50

10 Electrical installations in hazardous areas

10.1 Electrical equipment

10.1.1 No electrical equipment is to be installed in hazardous areas unless the Society is satisfied that such equipment is:

- essential for operational purposes,
- of a type which will not ignite the mixture concerned,
- appropriate to the space concerned, and
- appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

10.1.2 Where electrical equipment of a safe type is permitted in hazardous areas it is to be selected with due consideration to the following:

a) risk of explosive dust concentration; see see Sec 12, [5.2]:
- degree of protection of the enclosure
- maximum surface temperature

b) risk of explosive gas atmosphere; see Sec 12, [5.1]:
- explosion group
- temperature class.

10.1.3 Where electrical equipment is permitted in hazardous areas, all switches and protective devices are to interrupt all poles or phases and, where practicable, to be located in a non-hazardous area unless specifically permitted otherwise.

Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

10.1.4 For electrical equipment installed in Zone 0 hazardous areas, only the following types are permitted:

- certified intrinsically-safe apparatus Ex(ia)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category “ia” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority
- equipment specifically designed and certified by the appropriate authority for use in Zone 0.

Table 15 : Minimum nominal cross-sectional areas

Service	Nominal cross-sectional area	
	external wiring mm^2	internal wiring mm^2
Power, heating and lighting systems	1,0	1,0
Control circuits for power plant	1,0	1,0
Control circuits other than those for power plant	0,75	0,5
Control circuits for telecommunications, measurement, alarms	0,5	0,2
Telephone and bell equipment, not required for the safety of the ship or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

10.1.5 For electrical equipment installed in Zone 1 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 0
- certified intrinsically-safe apparatus Ex(ib)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category "ib" not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority
- certified flameproof Ex(d)
- certified pressurised Ex(p)
- certified increased safety Ex(e)
- certified encapsulated Ex(m)
- certified sand filled Ex(q)
- certified specially Ex(s)
- through runs of cable.

10.1.6 For electrical equipment installed in Zone 2 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 1
- tested specially for Zone 2 (e.g. type "n" protection)
- pressurised, and accepted by the appropriate authority
- encapsulated, and accepted by the appropriate authority
- the type which ensures the absence of sparks and arcs and of "hot spots" during its normal operation (minimum class of protection IP55).

10.1.7 When apparatus incorporates a number of types of protection, it is to be ensured that all are suitable for use in the zone in which it is located.

10.2 Electrical cables

10.2.1 Electrical cables are not to be installed in hazardous areas except as specifically permitted or when associated with intrinsically safe circuits.

10.2.2 All cables installed in Zone 0, Zone 1 and weather exposed areas classified Zone 2 are to be sheathed with at least one of the following:

a) a non-metallic impervious sheath in combination with braiding or other metallic covering

b) a copper or stainless steel sheath (for mineral insulated cables only).

10.2.3 All cables installed in non-weather exposed Zone 2 areas are to be provided with at least a non-metallic external impervious sheath.

10.2.4 Cables of intrinsically safe circuits are to have a metallic shielding with at least a non-metallic external impervious sheath.

10.2.5 The circuits of a category "ib" intrinsically safe system are not to be contained in a cable associated with a category "ia" intrinsically safe system required for a hazardous area in which only category "ia" systems are permitted.

10.3 Electrical installations in battery rooms

10.3.1 Only intrinsically safe apparatus and certified safe type lighting fittings may be installed in compartments assigned solely to large vented storage batteries; see Sec 11.

The associated switches are to be installed outside such spaces.

Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

10.3.2 Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

10.3.3 Where vented (see Note 1) type batteries replace valve-regulated sealed (see Note 2) types, the requirements of Sec 11 are to be complied with.

Note 1: A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

Note 2: A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

10.4 Electrical equipment allowed in paint stores and in enclosed spaces leading to paint stores

10.4.1 Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services.

Certified safe type equipment of the following type is acceptable:

a) intrinsically safe Exi

b) flameproof Exd

c) pressurised Exp

d) increased safety Exe

e) special protection Exs

Cables (through-runs or terminating cables) of armoured type or installed in metallic conduits are to be used.

10.4.2 The minimum requirements for certified safe type equipment are as follows:

- explosion group II B
- temperature class T3.

10.4.3 Switches, protective devices and motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and are preferably to be located in a non-hazardous space.

10.4.4 In areas on open deck within 1m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets, the following electrical equipment may be installed:

- electrical equipment with the type of protection as permitted in paint stores or
- equipment of protection class Exn or
- appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature or
- appliances with simplified pressurised enclosures or vapour-proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature
- cables as specified in [10.4.1].

10.4.5 The enclosed spaces giving access to the paint store may be considered as non-hazardous, provided that :

- the door to the paint store is a gas-tight door with self-closing devices without holding back arrangements
- the paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area
- warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

Note 1: The paint stores and inlet and exhaust ventilation ducts under 10.4.4 are classified as Zone 1 and areas on open deck under 10.4.4 as Zone 2, as defined in IEC standard 60092-502, Electrical Installation in ships-part 502: Tankers-special features.

Note 2: A watertight door may be considered as being gas-tight.

10.5 Electrical installations in stores for welding gas (acetylene) bottles

10.5.1 The following equipment may be installed in stores for welding gas bottles provided that it is of a safe type appropriate for Zone 1 area installation:

- lighting fittings
- ventilator motors where provided.

10.5.2 Electrical cables other than those pertaining to the equipment arranged in stores for welding gas bottles are not permitted.

10.5.3 Electrical equipment for use in stores for welding gas bottles is to have minimum explosion group IIC and temperature class T2.

10.6 Special ships

10.6.1 For installations in hazardous areas in:

- oil tankers, chemical tankers and liquefied gas carriers, see Pt E.
- ships arranged with spaces for the carriage of vehicles, see Pt E.

11 Recording of the Type, Location and Maintenance Cycle of Batteries

11.1 Battery schedule

11.1.1 Where batteries are fitted for use for essential and emergency services, a schedule of such batteries is to be compiled and maintained. The schedule, required in Sec 1, Tab 1, is to include at least the following information regarding the battery(ies):

- type and Manufacturer's type designation
- voltage and ampere-hour rating
- location
- equipment and/or system(s) served
- maintenance/replacement cycle dates
- date(s) of last maintenance and/or replacement
- for replacement batteries in storage, the date of manufacture and shelf life.

Note 1: Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

SECTION 4 ROTATING MACHINES

1 Constructional and operational requirements for generators and motors

1.1 Mechanical construction

1.1.1 Insulating materials, insulated windings and construction of electrical machines are to conform to the relevant requirements of Sec 2, [3] and Sec 2, [4].

1.1.2 Shafts are to be made of material complying with the provisions of Pt D, Ch 2, Sec 3 and, where rolled products are allowed in place of forgings, with those of Pt D, Ch 2, Sec 1.

1.1.3 Where welded parts are foreseen on shafts and rotors, the provisions of Part D, Chapter 5 are to apply.

1.1.4 Sleeve bearings are to be efficiently and automatically lubricated at all running speeds.

Provision is to be made for preventing the lubricant from gaining access to windings or other insulated or bare current carrying parts.

1.1.5 Means are to be provided to prevent bearings from being damaged by the flow of currents circulating between them and the shaft. According to the Manufacturer's requirements, electrical insulation of at least one bearing is to be considered.

1.1.6 For surface-cooled machines with an external fan installed on the open deck, adequate protection of the fan against icing is to be provided.

1.1.7 When liquid cooling is used, the coolers are to be so arranged as to avoid entry of water into the machine, whether by leakage or condensation in the heat exchanger, and provision is to be made for the detection of leakage.

1.1.8 Rotating machines whose ventilation or lubrication system efficiency depends on the direction of rotation are to be provided with a warning plate.

1.2 Sliprings, commutators and brushes

1.2.1 Sliprings and commutators with their brushgear are to be so constructed that undue arcing is avoided under all normal load conditions.

1.2.2 The working position of brushgear is to be clearly and permanently marked.

1.2.3 Sliprings, commutators and brushgear are to be readily accessible for inspection, repairs and maintenance.

1.3 Terminal connectors

1.3.1 Suitable, fixed terminal connectors are to be provided in an accessible position for connection of the external cables.

1.3.2 All terminal connectors are to be clearly identified with reference to a diagram.

1.3.3 The degree of protection of terminal boxes is to be adequate to that of the machine.

1.4 Electrical insulation

1.4.1 Insulating materials for windings and other current carrying parts are to comply with the requirements of Sec 2, [3.2] and Sec 2, [3.3].

2 Special requirements for generators

2.1 Prime movers, speed governors and overspeed protection

2.1.1 Prime movers for generators are to comply with the relevant requirements of Ch 1, Sec 2.

2.1.2 When generators are to operate in parallel, the characteristics of speed governors are to comply with the provisions of [2.2].

2.2 A.c. generators

2.2.1 Alternators are to be so constructed that, when started up, they take up the voltage without the aid of an external electrical power source.

Where these provisions are not complied with, the external electrical power source is to be constituted by a battery installation in accordance with the requirements for electrical starting systems of auxiliary machinery (see Ch 1, Sec 2).

2.2.2 The voltage wave form is to be approximately sinusoidal, with a maximum deviation from the sinusoidal fundamental curve of 5% of the peak value.

2.2.3 Each alternator is to be provided with automatic means of voltage regulation.

2.2.4 For a.c. generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

2.2.5 For a.c. generating sets intended to operate in parallel, means are to be provided to regulate the governor so as to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

2.2.6 When a.c. generators are operated in parallel, the reactive loads of the individual generating sets are not to differ from their proportionate share of the total reactive load by more than 10% of the rated reactive power of the largest machine, or 25% of that of the smallest machine, whichever is the lesser.

2.3 A.c. generators

2.3.1 The following solutions can be arranged for the supply of d.c. power to the vessel:

- Regulated single or 3-phase a.c. generators connected to a rectifier
- Compound-wound generators
- Shunt generators with automatic voltage regulator.

2.3.2 Generators are to be designed so that, even with the battery disconnected, their voltage characteristic and harmonic content remain within the prescribed limits over the whole load range and they themselves suffer no damage.

They are to be so designed that a short-circuit at the terminals produces a current not less than three times the rated current. They are to be able to withstand the sustained short-circuit current for 1 second without suffering damage.

Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short-circuits in the vessel's network is assured at even lower sustained short-circuit currents, possibly in conjunction with a parallel-connected power supply battery.

The regulator characteristic of the generators is to ensure that connected power supply batteries are without fail fully charged over the whole load range and overcharging is avoided.

3 Testing of rotating machines

3.1 General

3.1.1 All machines are to be tested by the Manufacturer

Table 1 : Tests to be carried out on electrical rotating machines

No.	Tests	a.c. Generators		Motors	
		Type test **(1)**	Routine test **(2)**	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection	X	X	X	X
2	Insulation resistance measurement	X	X	X	X
3	Winding resistance measurement	X	X	X	X
4	Verification of the voltage regulation system	X	X **(3)**		
5	Rated load test and temperature rise measurement	X		X	
6	Overload/overcurrent test	X	X **(4)**	X	X **(4)**
7	Verification of steady short-circuit conditions **(5)**	X			
8	Overspeed test	X	X	X **(6)**	X **(6)**
9	Dielectric strength test	X	X	X	X
10	No load test	X	X	X	X
11	Verification of degree of protection	X		X	
12	Verification of bearings	X	X	X	X

(1) Type tests on prototype machine or tests on at least the first of a batch of machines.
(2) The report on routinely tested machines is to contain the Manufacturer's serial number of the machine which has been type tested and the test result.
(3) Only functional test of voltage regulator system.
(4) Only applicable for machine of essential services rated above 100kW/kVA.
(5) Verification of steady short circuit condition applies to synchronous generators only.
(6) Not applicable for squirrel cage motors.

Table 2 : Minimum insulation resistance

Rated voltage U_n, in V	Minimum test voltage, in V	Minimum insulation resistance, in MΩ
$U_n = 250$	2 U_n	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	U_n/1000 + 1
$7200 < U_n \leq 15000$	5000	U_n/1000 + 1

3.1.2 All tests are to be carried out according to IEC Publication 60092-301.

3.1.3 All a.c. generators having rated power of 100 kVA and above, all d.c. generators having rated power of 100 kW and above, and all a.c./d.c. motors having rated power of 100 kW and above, intended for essential services are to be surveyed by the Society during testing and, if appropriate, during manufacturing.

Note 1: An alternative inspection scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

3.1.4 For generators and electric motors having rated power less than 50 kW. not tested in the presence of a Surveyor, works' test certificates are to be submitted.

3.2 Shaft material

3.2.1 Shaft material for other machines is to be in accordance with recognised international or national standards (see [1.1.2]).

3.3 Tests

3.3.1 Type tests are to be carried out on a prototype machine or on the first of a batch of machines, and routine tests carried out on subsequent machines in accordance with Tab 1.

Note 1: Test requirements may differ for shaft generators, special purpose machines and machines of novel construction.

4 Description of the test

4.1 Examination of the technical documentation, as appropriate, and visual inspection

4.1.1 Examination of the technical documentation

Technical documentation of machines rated at 100kW (kVA) and over is to be available for examination by the Surveyor.

4.1.2 Visual inspection

A visual examination of the machine is to be made to ensure, as far as is practicable, that it complies with the technical documentation.

4.2 Insulation resistance measurement

4.2.1 Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth,
b) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Tab 2. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

4.3 Winding resistance measurement

4.3.1 The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

4.4 Verification of the voltage regulation system

4.4.1 The alternating current generator, together with its voltage regulation system, is to be verified in such a way that, at all loads from no load running to full load, the rated voltage at the rated power factor is maintained under steady conditions within ± 2.5%. These limits may be increased to ± 3.5% for emergency sets.

4.4.2 When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage

4.4.3 The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1.5 s. For emergency sets, these values may be increased to plus or minus 4% in not more than 5 s.

4.4.4 In the absence of precise information concerning the maximum values of the sudden loads, the following conditions may be assumed: 60% of the rated current with a power factor of between 0.4 lagging and zero to be suddenly switched on with the generator running at no load, and then switched off after steady - state conditions have been reached.

4.5 Rated load test and temperature rise measurements

4.5.1 The temperature rises are to be measured at the rated output, voltage and frequency and for the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC Publication 60034-1, or by means of a combination of other tests.

The limits of temperature rise are those specified in Table 6 of IEC Publication 60034-1 adjusted as necessary for the ambient reference temperatures specified in Sec 2.

4.6 Overload/overcurrent tests

4.6.1 Overload test is to be carried out as a type test for generators as proof of overload capability of generators and the excitation system, for motors as proof of momentary excess torque as required in IEC Publication 60034-1. The overload test can be replaced at a routine test by an overcurrent test. The overcurrent test is to be proof of the current capability of the windings, wires, connections etc. of each machine. The overcurrent test can be performed at reduced speed (motors) or at short-circuit (generators).

4.6.2 In the case of machines for special uses (e.g. for windlasses), overload values other than the above may be considered.

4.7 Verification of steady short-circuit conditions

4.7.1 It is to be verified that under steady state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

4.8 Overspeed test

4.8.1 Machines are to withstand the overspeed test as specified in IEC Publication 60034-1. This test is not applicable for squirrel cage motors.

4.9 Dielectric strength test

4.9.1 New and completed rotating machines are to withstand a dielectric test as specified in IEC Publication 60034-1.

4.9.2 When it is necessary to perform an additional high voltage test, this is to be carried out after any further drying, with a test voltage of 80% of that specified in IEC Publication 60034-1.

4.9.3 Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.

4.9.4 Partially rewound windings are to be tested at 75% of the test voltage required for new machines. Prior to the test, the old part of the winding is to be carefully cleaned and dried.

4.9.5 Following cleaning and drying, overhauled machines are to be subjected to a test at a voltage equal to 1,5 times the rated voltage, with a minimum of 500 V if the rated voltage is less than 100 V, and with a minimum of 1000 V if the rated voltage is equal to or greater than 100 V.

4.9.6 A repetition of the high voltage test for groups of machines and apparatus is to be avoided if possible, but if a test on an assembled group of several pieces of new apparatus, each of which has previously passed its high voltage test, is performed, the test voltage to be applied to such assembled group is 80% of the lowest test voltage appropriate for any part of the group.

Note 1: For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

4.10 No load test

4.10.1 Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor while generators are to be driven by a suitable means and excited to give rated terminal voltage.

During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.11 Verification of degree of protection

4.11.1 As specified in IEC Publication 60034-5.

4.12 Verification of bearings

4.12.1 Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by the Surveyor, to establish that the shaft is correctly seated in the bearing shells.

SECTION 5 TRANSFORMERS

1 Constructional and operational requirements

1.1 Construction

1.1.1 Transformers, except those for motor starting, are to be double wound (two or more separate windings).

1.1.2 As a general principle, the primary and secondary windings of transformers are to be separated electrically. For the adjustment of the secondary voltage, taps are to be provided corresponding to ± 2,5% of the rated voltage.

1.1.3 Transformers are normally to be of the dry, air-cooled type.

1.1.4 When a forced air cooling system is used, an alarm is to be activated in the event of its failure.

1.1.5 Liquid-cooled transformers may be used provided that:

- the liquid is non-toxic and of a type which does not readily support combustion
- the construction is such that the liquid is not spilled in inclined position
- temperature and pressure relief devices with an alarm are installed
- drip trays or other suitable arrangements for collecting the liquid from leakages are provided
- a liquid gauge indicating the normal liquid level range is fitted.

1.1.6 Transformers are to have enclosures with a degree of protection in accordance with Sec 3, Tab 3.

2 Testing

2.1 Tests on transformers

2.1.1 Power transformers are to be tested according to IEC 60076.

Transformers with a power rating of 50 kVA or more are to undergo a test at the Manufacturer's works in the presence of a Surveyor. Individual tests may be replaced by tests carried out by the Manufacturer on his own responsibility.

2.1.2 The Manufacturer is to fit to transformers/reactors a name and date plate containing the serial number of the unit and all essential operating data.

SECTION 6 SEMICONDUCTOR CONVERTORS

1 Constructional and operational requirements

1.1 Construction

1.1.1 Semiconductor convertors are generally to comply with the requirements for switchgear assemblies (see Sec 8).

1.1.2 For liquid-cooled convertors the following provisions are to be satisfied:

- liquid is to be non-toxic and of low flammability
- drip trays or other suitable means are to be provided to contain any liquid leakages
- the resistivity of the cooling fluid in direct contact with semiconductor or other current carrying parts is to be monitored and an alarm initiated if the resistivity is outside the specified limits.

1.1.3 Where forced cooling is used, the temperature of the heated cooling medium is to be monitored.

If the temperature exceeds a preset value an alarm is to be given and the shutdown of the convertor is to be activated.

1.1.4 Where forced (air or liquid) cooling is provided, it is to be so arranged that the convertor cannot be or remain loaded unless effective cooling is maintained.

Alternatively, other effective means of protection against overtemperature may be provided.

1.1.5 Stacks of semiconductor elements, and other equipment such as fuses, or control and firing circuit boards etc., are to be so arranged that they can be removed from equipment without dismantling the complete unit.

1.1.6 Semiconductor convertors are to be rated for the required duty having regard to the peak loads, system transient and overvoltage and to be dimensioned so as to withstand the maximum short-circuit currents foreseen at the point of installation for the time necessary to trip the protection of the circuits they supply.

1.2 Protection

1.2.1 Semiconductor elements are to be protected against short-circuit by means of devices suitable for the point of installation in the network.

1.2.2 Overcurrent and overvoltage protection is to be installed to protect the convertor. When the semiconductor convertor is designed to work as an inverter supplying the network in transient periods, precautions necessary to limit the current are to be taken.

1.2.3 Semiconductor convertors are not to cause distortion in the voltage wave form of the power supply at levels exceeding the voltage wave form tolerances at the other user input terminals (see Sec 2).

1.2.4 An alarm is to be provided for tripping of protective devices against overvoltages and overcurrents in electric propulsion convertors and for convertors for the emergency source of power.

1.3 Parallel operation with other power sources

1.3.1 For convertors arranged to operate in parallel with other power sources, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1.4 Temperature rise

1.4.1 The permissible limit of temperature rise of the enclosure of the semiconductors is to be assessed on the basis of an ambient air temperature of 45°C or sea water temperature of 32°C for water-cooled elements, taking into account its specified maximum permissible temperature value.

1.4.2 The value of the maximum permissible temperature of the elements at the point where this can be measured (point of reference) is to be stated by the Manufacturer.

1.4.3 The value of the mean rated current of the semiconductor element is to be stated by the Manufacturer.

1.5 Insulation test

1.5.1 The test procedure is that specified in IEC Publication 60146.

1.5.2 The effective value of the test voltage for the insulation test is to be as shown in Tab 1.

Table 1 : Test voltages for high voltage test on static convertors

$\frac{U_m}{\sqrt{2}} = U$ in V **(1)**	Test voltage V
$U \le 60$	600
$60 < U \le 90$	900
$90 < U$	2U + 1000 (at least 2000)

(1) U_m: highest crest value to be expected between any pair of terminals.

2 Testing

2.1 General

2.1.1 Convertors intended for essential services are to be subjected to the tests stated in [2.2].

2.1.2 The Manufacturer is to issue a test report giving information on the construction, type, serial number and all technical data relevant to the convertor, as well as the results of the tests required.

Note 1: An alternative inspection scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

2.1.3 In the case of convertors which are completely identical in rating and in all other constructional details, it will be acceptable for the rated current test and temperature rise measurement stipulated in [2.2] not to be repeated.

2.1.4 The tests and, if appropriate, manufacture of convertors of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

2.2 Tests on convertors

2.2.1 Convertors are to be subjected to tests in accordance with Tab 2.

Type tests are the tests to be carried out on a prototype convertor or the first of a batch of convertors, and routine tests are the tests to be carried out on subsequent convertors of a particular type.

2.2.2 Final approval of convertors is to include complete function tests after installation on board, performed with all ship's systems in operation and in all characteristic load conditions.

Table 2 : Tests to be carried out on static convertors

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Light load function test to verify all basic and auxiliary functions	X	X
3	Rated current test	X	
4	Temperature rise measurement	X	
5	Insulation test (dielectric strength test and insulation resistance measurement)	X	X
6	Protection of the convertors in case of failure of forced cooling system	X	X

(1) Type test on prototype convertor or test on at least the first batch of convertors.
(2) The certificates of convertors routine tested are to contain the manufacturer's serial number of the convertor which has been type tested and the test result.
(3) A visual examination is to be made of the convertor to ensure, as far as practicable, that it complies with technical documentation.

SECTION 7 STORAGE BATTERIES, CHARGERS AND UNINTERUPTIBLE POWER SYSTEMS

1 Constructional requirements for batteries

1.1 General

1.1.1 The requirements of this Section apply to permanently installed storage batteries (not to portable batteries).

1.1.2 *(1/3/2019)*

Storage batteries may be of the lead-acid or nickel-alkaline type, due consideration being given to the suitability for any specific application.

The use of batteries other than Lead-acid or alkaline batteries is allowed subject to the compliance of the battery system and its installation to the requirements given in Pt C, Ch 2, App 2 of the Rules for the Classification of Ships.

Other types of storage batteries of satisfactorily proven design (e.g. silver/zinc) may be accepted provided they are suitable for shipboard use to the satisfaction of the Society.

1.1.3 Cells are to be assembled in suitable crates or trays equipped with handles for convenient lifting.

1.2 Vented batteries

1.2.1 Vented batteries are those in which the electrolyte can be replaced and freely releases gas during periods of charge and overcharge.

1.2.2 Vented batteries are to be constructed to withstand the movement of the ship and the atmosphere (salt mist, oil etc.) to which they may be exposed.

1.2.3 Battery cells are to be so constructed as to prevent spilling of electrolyte at any inclination of the battery up to 40° from the vertical.

1.2.4 It is to be possible to check the electrolyte level and the pH.

1.3 Valve-regulated sealed batteries

1.3.1 Valve-regulated sealed batteries are batteries whose cells are closed under normal conditions but which have an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cells cannot normally receive addition to the electrolyte.

1.3.2 Cell design is to minimise risks of release of gas under normal and abnormal conditions.

1.4 Tests on batteries

1.4.1 The battery autonomy is to be verified on board in accordance with the operating conditions.

2 Constructional requirements for chargers

2.1 Characteristics

2.1.1 Chargers are to be adequate for the batteries for which they are intended and provided with a voltage regulator.

2.1.2 In the absence of indications regarding its operation, the battery charger is to be such that the completely discharged battery can be recharged to 80% capacity within a period of 10 hours without exceeding the maximum permissible charging current.

2.1.3 For floating service or for any other condition where the load is connected to the battery while it is on charge, the maximum battery voltage is not to exceed the safe value of any connected apparatus.

Note 1: Consideration is to be given to the temperature variation of the batteries.

2.1.4 The battery charger is to be designed so that the charging current is set within the maximum current allowed by the manufacturer when the battery is discharged and the floating current to keep the battery fully charged.

2.1.5 Battery chargers are to be constructed to simplify maintenance operation. Indications are to be provided to visualise the proper operation of the charger and for troubleshooting.

2.1.6 Battery chargers are to be constructed to simplify maintenance operation. Indications are to be provided to visualise the proper operation of the charger and for troubleshooting.

2.2 Tests on chargers

2.2.1 Battery chargers are to be subjected to tests in accordance with Tab 1.

Type tests are the tests to be carried out on a prototype charger or the first of a batch of chargers, and routine tests are the tests to be carried out on subsequent chargers of a particular type.

2.2.2 The tests of battery chargers of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

Note 1: An alternative inspection scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

Table 1 : Tests to be carried out on battery chargers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Functional tests (current and voltage regulation, quick, slow, floating charge, alarms)	X	X
3	Temperature rise measurement	X	
4	Insulation test (dielectric strength test and insulation resistance measurement)	X	X

(1) Type test on prototype battery charger or test on at least the first batch of battery chargers.
(2) The certificates of battery chargers routine tested are to contain the manufacturer's serial number of the battery charger which has been type tested and the test result.
(3) A visual examination is to be made of the battery charger to ensure, as far as practicable, that it complies with technical documentation.

3 Location

3.1 General

3.1.1 Storage batteries are to be installed in such a way that they are accessible for cell replacement, inspection, testing, topping-up and cleaning.

The installation of batteries in the accommodation area, cargo holds and wheelhouses is not permissible. Gas-tight batteries can be seen as an exception, e.g. in case of internal power source of emergency lighting fittings.

3.1.2 Storage batteries are not to be installed in locations where they are exposed to unacceptably high or low temperatures, spray or other effects liable to impair their serviceability or reduce their life essentially. They are to be installed in such a way that adjacent equipment is not damaged by the effects of escaping electrolyte vapours.

3.1.3 Lead-acid batteries and alkaline storage batteries are not to be installed in the same room or in the immediate vicinity of each other.

3.1.4 Measures are to be taken to prevent storage batteries from shifting. The devices used are not to impede ventilation.

4 Ventilation

4.1 General

4.1.1 All battery installations in rooms, cabinets and containers are to be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

4.1.2 For the ventilation of storage batteries the total power of the associated charger is to be considered. The charging power is to be calculated from the maximum current of the battery charger and the rated voltage of the battery.

4.1.3 The charging power for automatic IU-charging is to be calculated as follows:

P = U.I

I = 8 x C/100 for Pb - batteries

I = 16 x C/100 for NiCd - batteries

where:

P : Charging power, in W

U : Rated battery voltage, in V

I : Charging current, in A

C : Rated battery capacity, in Ah.

4.2 Charging power up to 0,2 kW

4.2.1 Lead batteries with charging power up to 0,2 kW may be installed without separation from the switchgear, if:

a) the batteries are of valve regulated type (VRL), provided with solid electrolyte
b) the switchboards are not closed completely (IP 2X is suitable)
c) the charger is an automatic IU-charger with a maximum continuous charging voltage of 2,3 V/cell and rated power is limited to 0,2 kW.

4.3 Charging power up to 2 kW

4.3.1 Batteries with charging power up to 2 kW may be installed in ventilated cabinets or containers arranged in ventilated rooms (except in rooms according to [3.1.1] and [3.1.2]). Unenclosed installation (IP 12) is permitted in well-ventilated positions in machinery spaces.

The battery's gassing voltage is not to be exceeded. If several battery sets are to be used, the sum of charging power is to be calculated.

The room's free air volume is to be calculated depending on battery size as follows:

V = 2,5 x Q

where:

V : Free air volume, in m^3

Q : Air quantity, in m^3/h

Q = 0,25 x f x I x n

n : number of battery cells in series connection

f : f = 0,03 for lead batteries (VRL) with solid electrolyte

f = 0,11 for batteries with fluid electrolyte

If several battery sets will be installed in one room, the sum of air quantity is to be calculated. The air ducts for natural ventilation are to have a cross-section as follows, assuming an air speed of 0,5 m/s:

A = 5,6 x Q

where:

A : Cross-section, in cm^2

The required minimum cross-sections of ventilation ducts are shown in Tab 1.

Small air ducts and dimensions of air inlet and outlet openings are to be calculated based on lower air speed (0,5m/s).

Table 2 : Cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU - charging)			
Battey charging power	Cross.section, in cm^2		
[W]	Lead battery solid electrolyte VRL	Load battery fluid electrolyte	Nickel Cadmium battery
< 500	40	60	80
500 < 1000	60	80	120
1000 < 1500	80	120	180
1500 < 2000	80	160	240
2000 < 3000	80	240	forced ventilation
> 3000	forced ventilation		

4.4 Charging power more than 2 kW

4.4.1 If the charging power of batteries exceeds 2 kW, they are to be installed either in closed cabinets, containers or a battery room to be ventilated to the open deck. Lead batteries up to 3 kW may still be ventilated by natural ventilation.

Battery rooms are to exhaust to the open deck area. Forced ventilation is to be used.

Doors to battery rooms are to be gas-tight with self-closing devices without holding back means.

4.5 Ventilation requirements

4.5.1 Ventilation inlet and outlet openings are to be so arranged to ensure that fresh air flows over the surface of the storage battery.

The air inlet openings are to be arranged below and air outlet openings are to be arranged above. If batteries are installed in several floors, the free distance between them is to be at least 50 mm.

Devices which obstruct the free passage of air, e.g. fire dampers and safety screens, are not to be mounted in the ventilation inlet and outlet ducts. If necessary, weathertight closures are to be provided.

Air ducts for natural ventilation are to lead to the open deck directly. Openings are to be at least 0,9 m above the cabinet/container. The inclination of air ducts is not to exceed 45° from vertical.

4.6 Forced ventilation

4.6.1 If natural ventilation is not sufficient or required cross-sections of ducts according to Tab 1 are too large, forced ventilation is to be provided. The air quantity Q is to be calculated according to [4.3]. The air speed is not to exceed 4 m/s.

Where storage batteries are charged automatically, with automatic start of the fan at the beginning of the charging, arrangements are to be made for the ventilation to continue for at least 1 h after completion of charging.

4.6.2 Wherever possible, forced ventilation exhaust fans are to be used. The fan motors are to be either explosion-proof and resistant to electrolyte or, preferably, located outside of the dangerous area.

4.6.3 The fan impellers are to be made of a material which does not create sparks on contact with the housing, and dissipates static charges (see Pt C, Ch 4, Sec 1, paragraph 5 - Non-sparking fans). The ventilation systems for battery roomsare to be independent of the ventilation systems serving other rooms. Air ducts for forced ventilation are to be resistant to electrolyte and lead to the open deck.

5 Electrical equipment in battery spaces

5.1 General

5.1.1 Only explosion protected lamps, switches, fan motors and space heating appliances are to be installed in battery rooms. The following mimimum requirements are to be observed:

- Explosion group II C
- Temperature class T 1.

Other electrical equipment is permitted only with the special approval of the Society.

5.1.2 Where leakage is possible, the inner walls of battery rooms, cabinets and containers are to be protected against the injurious effects of the electrolyte.

6 Starting batteries

6.1 General

6.1.1 Storage batteries for starting internal combustion engines are to be designed to have sufficient capacity for at least six starting operations in 30 minutes without intermediate recharging.

6.1.2 Starter batteries are to be capable of being recharged with the means available on board and may only be used to start engines and supply energy to the monitoring systems relevant to them.

6.1.3 Starting internal combustion engines with the vessel's supply battery is permitted only in emergencies.

6.1.4 Wherever possible, storage batteries used for starting and preheating internal combustion engines are to be located close to the machines.

SECTION 8 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

1 Constructional requirements for main and emergency switchboards

1.1 Construction

1.1.1 Construction is to be in accordance with IEC Publication 60092-302.

1.1.2 Where the framework, panels and doors of the enclosure are of steel, suitable measures are to be taken to prevent overheating due to the possible circulation of eddy currents.

1.1.3 Insulating material for panels and other elements of the switchboard is at least to be moisture-resistant and flame-retardant.

1.1.4 Switchboards are to be of dead front type, with enclosure protection according to Sec 3, Tab 3.

1.1.5 Switchboards are to be provided with insulated handrails or handles fitted in an appropriate position at the front of the switchboard. Where access to the rear is necessary for operational or maintenance purposes, an insulated handrail or insulated handles are to be fitted.

1.1.6 Where the aggregate capacity of generators connected to the main busbars exceeds 100 kVA, a separate cubicle for each generator is to be arranged with flame-retardant partitions between the different cubicles. Similar partitions are to be provided between the generator cubicles and outgoing circuits.

1.1.7 Instruments, handles or push-buttons for switchgear operation are to be placed on the front of the switchboard. All other parts which require operation are to be accessible and so placed that the risk of accidental touching of live parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

1.1.8 Where it is necessary to make provision for the opening of the doors of the switchboard, this is to be in accordance with one of the following requirements:

a) opening is to necessitate the use of a key or tool (e.g. when it is necessary to replace a lamp or a fuse-link)
b) all live parts which can be accidentally touched after the door has been opened are to be disconnected before the door can be opened
c) the switchboard is to include an internal barrier or shutter with a degree of protection not less than IP2X shielding all live parts such that they cannot accidentally be touched when the door is open. It is not to be possible to remove this barrier or shutter except by the use of a key or tool.

1.1.9 All parts of the switchboard are to be readily accessible for maintenance, repair or replacement. In particular, fuses are to be able to be safely inserted and withdrawn from their fuse-bases.

1.1.10 Hinged doors which are to be opened for operation of equipment on the door or inside are to be provided with fixing devices for keeping them in open position.

1.1.11 Means of isolation of the circuit-breakers of generators and other important parts of the installation are to be provided so as to permit safe maintenance while the main busbars are alive.

1.1.12 Where components with voltage exceeding the safety voltage are mounted on hinged doors, the latter are to be electrically connected to the switchboard by means of a separate, flexible protective conductor.

1.1.13 All measuring instruments and all monitoring and control devices are to be clearly identified with indelible labels of durable, flame-retardant material.

1.1.14 The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device (circuit-breaker, thermal relay etc.) for each circuit is to be permanently indicated at the location of the fuse or protective device.

1.2 Busbars and bare conductors

1.2.1 Busbars are to be of copper or of copper-surrounded aluminium alloy if suitable for use in the marine environment and if precautions are taken to avoid galvanic corrosion.

1.2.2 All connections are to be so made as to inhibit corrosion.

1.2.3 Busbars are to be dimensioned in accordance with IEC Publication 60092-302.

The mean temperature rise of busbars is not to exceed 45°C under rated current condition with an ambient air temperature of 45°C (see Sec 2, [1.2.8]) and is not to have any harmful effect on adjacent components. Higher values of temperature rise may be accepted to the satisfaction of the Society.

1.2.4 The cross-section of neutral connection on an a.c. three-phase, four-wire system is to be at least 50% of the cross-section for the corresponding phases.

1.2.5 Bare main busbars, excluding the conductors between the main busbars and the supply side of outgoing units, are to have the minimum clearances and creepage distances given in Tab 1. The values shown apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.

Table 1 : Clearance and creepage distances

Rated insulation voltage a.c. r.m.s. or d.c. V	Minimum clearance mm	Minimum creepage distance mm
≤ 250	15	20
> 250 to ≤ 690	20	25
> 690	25	35

Note 1: Clearance is the distance between two conductive parts along a string stretched the shortest way between such parts. Creepage distance is the shortest distance along the surface of an insulating material between two conductive parts.

1.2.6 Reduced values as specified in IEC Publication 60092-302 may be accepted for type tested and partially type tested assemblies.

The reference values for the evaluation of the minimum clearances and creepage distances for these assemblies are based on the following:

- pollution degree 3 (conductive pollution occurs, or dry non-conductive pollution occurs which becomes conductive due to condensation which is expected)
- overvoltage category III (distribution circuit level)
- inhomogenous field conditions (case A)
- rated operational voltage 1000 V a.c., 1500 V d.c.
- group of insulating material IIIa.

Special consideration is to be given to equipment located in spaces where a pollution degree higher than 3 is applicable, e.g. in diesel engine rooms.

1.2.7 Busbars and other bare conductors with their supports are to be mechanically dimensioned and fixed such that they can withstand the stresses caused by short-circuits.

1.2.8 Busbars and bare conductors are to be protected, where necessary, against falling objects (e.g. tools, fuses or other objects).

1.3 Internal wiring

1.3.1 Insulated conductors for internal wiring of auxiliary circuits of switchboards are to be constructed in accordance with Sec 9, [1.1.5].

1.3.2 All insulated conductors provided for in [1.3.1] are to be of flexible construction and of the stranded type.

1.3.3 Connections from busbars to protective devices are to be as short as possible. They are to be laid and secured in such a way to minimise the risk of a short-circuit.

1.3.4 All conductors are to be secured to prevent vibration and are to be kept away from sharp edges.

1.3.5 Connections leading to indicating and control instruments or apparatus mounted in doors are to be installed such that they cannot be mechanically damaged due to movement of the doors.

1.3.6 Non-metallic trays for internal wiring of switchboards are to be of flame-retardant material.

1.3.7 Control circuits are to be installed and protected such that they cannot be damaged by arcs from the protective devices.

1.3.8 Where foreseen, fixed terminal connectors for connection of the external cables are to be arranged in readily accessible positions.

1.4 Switchgear and controlgear

1.4.1 Switchgear and controlgear are to comply with IEC Publication 60947 series and to be chosen from among that type approved by the Society.

1.4.2 The characteristics of switchgear, controlgear and protective devices for the various consumers are to be in compliance with Sec 3, [7].

1.5 Auxiliary circuits

1.5.1 Auxiliary circuits are to be designed in such a manner that, as far as practicable, faults in such circuits do not impair the safety of the system. In particular, control circuits are to be designed so as to limit the dangers resulting from a fault between the control circuit and earth (e.g. inadvertent operation or malfunction of a component in the installation), also taking account of the earthing system of their supply.

1.5.2 Auxiliary circuits of essential systems are to be independent of other auxiliary circuits.

1.5.3 Common auxiliary circuits for groups of consumers are permitted only when the failure of one consumer jeopardises the operation of the entire system to which it belongs.

1.5.4 Auxiliary circuits are to be branched off from the main circuit in which the relevant switchgear is used.

1.5.5 The supply of auxiliary circuits by specifically arranged control distribution systems will be specially considered by the Society.

1.5.6 Means are to be provided for isolating the auxiliary circuits as well when the main circuit is isolated (e.g. for maintenance purposes).

1.5.7 For the protection of auxiliary circuits see Sec 3, [7.13].

1.6 Instruments

1.6.1 The upper limit of the scale of every voltmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.6.2 The upper limit of the scale of every ammeter is to be not less than 130% of the normal rating of the circuit in which it is installed.

1.6.3 The upper limit of the scale of every wattmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.6.4 Wattmeters for use with a.c. generators which may be operated in parallel are to be capable of indicating 15% reverse power.

1.6.5 For wattmeters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.

1.6.6 The rated value of the measure read, at full load, is to be clearly indicated on the scales of instruments.

1.6.7 Frequency meters are to have a scale at least ± 5% of the nominal frequency.

1.6.8 The secondary windings of instrument transformers are to be earthed.

1.6.9 Each a.c. generator not operated in parallel is to be provided with:

- 1 voltmeter
- 1 frequency meter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read
- 1 three-phase wattmeter in the case of generators rated more than 50 kVA.

1.6.10 Each a.c. generator operated in parallel is to be provided with:

- 1 three-phase wattmeter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read.

1.6.11 For paralleling purposes the following are to be provided:

- 2 voltmeters
- 2 frequency meters
- 1 synchroscope and synchronising indicating lamps or equivalent means.

A switch is to be provided to enable one voltmeter and one frequency meter to be connected to each generator before the latter is connected to the busbars.

The other voltmeter and frequency meter are to be permanently connected to the busbars.

1.6.12 Each secondary distribution system is to be provided with one voltmeter.

1.6.13 Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems as stipulated in Sec 3, [3.2.1].

1.6.14 The main switchboard is to be fitted with a voltmeter or signal lamp indicating that the cable between the shore-connection box and the main switchboard is energised.

1.6.15 For each d.c. power source (e.g. converters, rectifiers and batteries), one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices (e.g. starting motor for emergency generator).

2 Constructional requirements for section boards and distribution boards

2.1 Construction

2.1.1 Section boards and distribution boards are to be constructed, insofar as applicable, as specified for main and emergency switchboards.

2.1.2 All parts which require operation in normal use are to be placed on the front.

2.1.3 Distribution switchboards which are provided with two or more supply circuits arranged for automatic standby connection are to be provided with positive indication of which of the circuits is feeding the switchboard.

3 Testing

3.1 General

3.1.1 Switchboards are to be subjected to the tests specified from [3.2] to [3.4].

3.1.2 The Manufacturer is to issue the relative test reports providing information concerning the construction, serial number and technical data relevant to the switchboard, as well as the results of the tests required.

3.1.3 The tests are to be carried out prior to installation on board.

3.1.4 The test procedures are as specified in IEC Publication 60092-302.

3.2 Inspection of equipment, check of wiring and electrical operation test

3.2.1 It is to be verified that the switchboard:

- complies with the approved drawings
- maintains the prescribed degree of protection
- is constructed in accordance with the relevant constructional requirements, in particular as regards creepage and clearance distances.

3.2.2 The connections, especially screwed or bolted connections, are to be checked for adequate contact, possibly by random tests.

3.2.3 Depending on the complexity of the switchboard it may be necessary to carry out an electrical functioning test. The test procedure and the number of tests depend on whether or not the switchboard includes complicated interlocks, sequence control facilities, etc. In some cases it may be necessary to conduct or repeat this test following installation on board.

3.3 High voltage test

3.3.1 The test is to be performed with alternating voltage at a frequency between 25 and 100 Hz of approximately sinusoidal form.

3.3.2 The test voltage is to be applied:

- between all live parts connected together and earth
- between each polarity and all the other polarities connected to earth for the test.

During the high voltage test, measuring instruments, ancillary apparatus and electronic devices may be disconnected and tested separately in accordance with the appropriate requirements.

3.3.3 The test voltage at the moment of application is not to exceed half of the prescribed value. It is then to be increased steadily within a few seconds to its full value. The prescribed test voltage is to be maintained for 1 minute.

3.3.4 The value of the test voltage for main and auxiliary circuits is given in Tab 2 and Tab 3.

3.4 Measurement of insulation resistance

3.4.1 Immediately after the high voltage test, the insulation resistance is to be measured using a device with a direct current voltage of at least 500 V.

3.4.2 The insulation resistance between all current carrying parts and earth (and between each polarity and the other polarities) is to be at least equal to 1 MΩ.

Table 2 : Test voltages for main circuits

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 660$	2500
$660 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500

Table 3 : Test voltage for auxiliary circuits

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \leq 12$	250
$12 < U_i \leq 60$	500
$U_i > 60$	$2 U_i + 1000$ (at least 1500)

SECTION 9 CABLES

1 Constructional requirements

1.1 Construction

1.1.1 Cables manufactured in accordance with the relevant recommendations of IEC Publications 60092-350, 60092-351, 60092-352, 60092-353, 60092-354, 60092-359, 60092-373, 60092-374, 60092-375 and 60092-376 are acceptable to the Society provided that they are tested as specified in this Chapter.

1.1.2 Mineral-insulated cables are to be constructed according to IEC Publication 60702.

1.1.3 Optical fibre cables are to be constructed in accordance with IEC Publication 60794.

1.1.4 Flexible cables constructed according to national standards will be specially considered by the Society.

1.1.5 Cables manufactured and tested to standards other than those specified in [1.1.1] will be accepted provided they are in accordance with an acceptable and relevant international or national standard.

1.1.6 Insulated wiring for auxiliary circuits of switchboards may be constituted by cables with a single conductor of the stranded type for all sections, PVC- or rubber-insulated in accordance with the Publications cited in [1.1.1] and without further protection.

The insulated wiring is to be at least of the flame-retardant type according to IEC Publication 60332-1. Equivalent types of flame-retardant switchboard wires will be specially considered by the Society.

1.2 Conductors

1.2.1 Conductors are to be of annealed electrolytic copper with a resistivity not exceeding 17,241 Ω mm^2/km at 20°C according to IEC 60228.

1.2.2 Individual conductor wires of rubber-insulated cables are to be tinned or coated with a suitable alloy.

1.2.3 All conductors are to be stranded, except for cables of nominal cross-sectional area 2,5 mm^2 and less (provided that adequate flexibility of the finished cable is assured).

1.2.4 For the minimum nominal cross-sectional areas permitted, see Sec 3, [9.10].

1.3 Insulating materials

1.3.1 The materials used for insulation are to comply with IEC Publication 60092-351 and to have the thicknesses specified for each type of cable in the relevant standard. The maximum permissible rated temperature is specified for the various materials.

1.3.2 Materials and thicknesses other than those in [1.3.1] will be specially considered by the Society.

1.4 Inner covering, fillers and binders

1.4.1 The cores of a multicore cable are to be laid up. The spaces between the cores are to be filled so as to obtain an assembly having an essentially circular cross-section. The filling may be omitted in multicore cables having a conductor cross-sectional area not exceeding 4 mm^2.

When a non-metallic sheath is applied directly over the inner covering or the fillers, it may substitute partially for the inner covering or fillers.

1.4.2 The materials used, the binders and the thicknesses of the inner coverings are generally to be in accordance with IEC Publications of the series 60092-3.., in relation to the type of cable.

1.5 Protective coverings (armour and sheath)

1.5.1 Metallic armour, if not otherwise protected against corrosion, is to be protected by means of a coating of protective paint (see Sec 3, [9.3]).

1.5.2 The paint is to be non-flammable and of adequate viscosity. When dry, it is not to flake off.

1.5.3 The materials and construction used for (metal) armour are to be in accordance with IEC Publication 60092-350 and their dimensions are to be those specified for each type of cable in the relevant standard.

1.5.4 The materials used for sheaths are to be in accordance with IEC Publication 60092-359 and are to have the thicknesses specified for each type of cable in the relevant standard.

The quality of the materials is to be adequate to the service temperature of the cable.

1.5.5 Materials other than those in [1.5.3] and [1.5.4] will be specially considered by the Society.

1.6 Identification

1.6.1 Each cable is to have clear means of identification so that the manufacturer can be determined.

1.6.2 Fire non propagating cables are to be clearly labelled with indication of the standard according to which this characteristic has been verified and, if applicable, of the category to which they correspond.

1.6.3
Fire-resisting cables are to be clearly labelled with the indication of the standard according to which this characteristic has been verified.

2 Testing

2.1 Type tests

2.1.1 Type tests are to be in accordance with the relevant IEC 60092-3.. Series Publications and IEC 60332-1, IEC 60332-3 Category A, and IEC 60331 where applicable.

2.2 Routine tests

2.2.1 Every length of finished cable is to be subjected to the tests specified in [2.2.2].

2.2.2 The following routine tests are to be carried out:

a) visual inspection
b) check of conductor cross-sectional area by measuring electrical resistance
c) high voltage test
d) insulation resistance measurement
e) dimensional checks (as necessary).

2.2.3 The manufacturer is to issue a statement providing information on the type and characteristics of the cable, as well as the results of the tests required and the Type Approval Certificates.

2.2.4 The test procedure is as specified in IEC Publication 60092-350.

2.2.5 Power cables for electrical propulsion systems, other than internal wiring in switchboards, are to be type approved and tested for acceptance in the presence of the Surveyor. Acceptance tests are to include at least:

a) a high voltage test
b) insulation resistance measurement.

2.2.6 Where an alternative scheme, e.g. a certified quality assurance system, is recognised by the Society, attendance of the Surveyor may not be required.

SECTION 10 MISCELLANEOUS EQUIPMENT

1 Switchgear and controlgear, protective devices

1.1 General

1.1.1 Switchgear and controlgear are to comply with IEC Publication 60947.

1.1.2 For materials and construction see Sec 2, [3] and Sec 2, [4].

1.2 Circuit-breakers

1.2.1 Power-driven circuit-breakers are to be equipped with an additional separate drive operated by hand.

1.2.2 Power circuit-breakers with a making capacity exceeding 10 kA are to be equipped with a drive which performs the make operation independently of the actuating force and speed.

1.2.3 Where the conditions for closing the circuit-breaker are not satisfied (e.g. if the undervoltage trip is not energised), the closing mechanism is not to cause the closing of the contacts.

1.2.4 All circuit-breakers rated more than 16 A are to be of the trip-free type, i.e. the breaking action initiated by overcurrent or undervoltage releases is to be fulfilled independently of the position of the manual handle or other closing devices.

1.3 Protection devices

1.3.1 Short-circuit releases are generally to be independent of energy supplied from circuits other than that to be protected. Tripping due to short-circuit is to be reliable even in the event of a total loss of voltage in the protected circuit.

1.3.2 Short-circuit releases for generators are to be equipped with reclosing inhibitors and are to be delayed for selective tripping.

1.3.3 Overload releases or relays are to operate reliably at any voltage variation of the supply voltage in the protected circuit.

1.3.4 Undervoltage relays or releases are to cause the circuit-breaker to open if the voltage drops to 70%-35% of the rated voltage.

1.3.5 Shunt releases are to ensure the disconnection of the circuit-breaker even when the supply voltage of the release drops to 85% of the rated supply voltage.

1.3.6 The reverse power protection device is to respond to the active power regardless of the power factor, and is to operate only in the event of reverse power.

1.3.7 Single-phase failure devices in three-phase circuits are to operate without a time lag.

1.3.8 Insulation monitoring devices are to continuously monitor the insulation resistance to earth and trigger an alarm should the insulation resistance fall below a predetermined value.

The measuring current of such devices is not to exceed 30 mA in the event of a total short to earth.

2 Lighting fittings

2.1 Applicable requirements

2.1.1 Lighting fittings are to comply with IEC Publications 60598 and 60092-306.

Lighting fittings complying with other standards will be specially considered by the Society.

2.2 Construction

2.2.1 The temperature of terminals for connection of supplying cables is not to exceed the maximum conductor temperature permitted for the cable (see Sec 3, [9.9]).

Where necessary, luminaires are to be fitted with terminal boxes which are thermally insulated from the light source.

2.2.2 Wires used for internal connections are to be of a temperature class which corresponds to the maximum temperature within the luminaire.

2.2.3 The temperature rise of parts of luminaires which are in contact with the support is not to exceed 50°C. The rise is not to exceed 40°C for parts in contact with flammable materials.

2.2.4 The temperature rise of surface parts which can easily be touched in service is not to exceed 15°C.

2.2.5 High-power lights with higher surface temperatures than those in [2.2.2] and [2.2.3] are to be adequately protected against accidental contact.

3 Accessories

3.1 Applicable requirements

3.1.1 Accessories are to be constructed in accordance with the relevant IEC Publications, and in particular with Publication 60092-306.

3.2 Construction

3.2.1 Enclosures of accessories are to be of metal having characteristics suitable for the intended use on board, or of flame-retardant insulating material.

3.2.2 Terminals are to be suitable for the connection of stranded conductors, except in the case of rigid conductors for mineral-insulated cables.

4 Plug-and-socket connections

4.1 Applicable requirements

4.1.1 Plug-and-socket connections are to comply with IEC Publication 60092-306 and with the following additional standards in relation to their use:

- in accommodation spaces, day rooms and service rooms (up to 16 A, 250 V a.c.): IEC Publication 60083 or 60320, as applicable
- for power circuits (up to 250 A, 690 V a.c.): IEC Publication 60309
- for electronic switchgear: IEC Publications, e.g. 60130 and 60603
- for refrigerated containers: ISO 1496-2.

5 Heating and cooking appliances

5.1 Applicable requirements

5.1.1 Heating and cooking appliances are to comply with the relevant IEC Publications (e.g. those of series 60335), with particular attention to IEC 60092-307.

5.2 General

5.2.1 Heating elements are to be enclosed and protected with metal or refractory material.

5.2.2 The terminals of the power supply cable are not to be subjected to a higher temperature than that permitted for the conductor of the connection cable.

5.2.3 The temperature of parts which are to be handled in service (switch knobs, operating handles and the like) is not to exceed the following values:

- 55°C for metal parts
- 65°C for vitreous or moulded material.

5.3 Space heaters

5.3.1 The casing or enclosure of heaters is to be so designed that clothing or other flammable material cannot be placed on them.

5.3.2 The temperature of the external surface of space heaters is not to exceed 60°C.

5.3.3 Space heaters are to be provided with a temperature limiting device without automatic reconnection which automatically trips all poles or phases not connected to earth when the temperature exceeds the maximum permissible value.

5.4 Cooking appliances

5.4.1 Live parts of cooking appliances are to be protected such that any foods or liquids which boil over or spill do not cause short-circuits or loss of insulation.

5.5 Fuel oil and lube oil heaters

5.5.1 In continuous-flow fuel oil and lube oil heaters, the maximum temperature of the heating elements is to be below the boiling point of the oil.

5.5.2 Each oil heater is to be provided with a thermostat maintaining the oil temperature at the correct level.

5.5.3 In addition to the thermostat in [5.5.2], each oil heater is to be provided with a temperature limiting device without automatic reconnection, and with the sensing device installed as close as possible to the heating elements and permanently submerged in the liquid.

5.6 Water heaters

5.6.1 Water heaters are to be provided with a thermostat and safety temperature limiter.

6 Cable trays/protective casings made of plastics materials

6.1 General requirement

6.1.1 Cable trays/protective casings (see Note 1) made of plastic (see Note 2) materials are to be type tested (See Note 3).

Note 1: "Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

Note 2: "Plastics" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fibre reinforced plastics - FRP.

Note 3: Cable trays/protective casings made of plastic materials are to be type tested in accordance with IACS REC 73.

6.2 Installation Requirements

6.2.1 Cable trays/protective casings made of plastics materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note 1: When plastic cable trays/protective casings are used on open deck, they are additionally to be protected against UV light.

6.2.2 The load on the cable trays/protective casings is to be within the Safe Working Load (SWL). The support spacing is to be not greater than the Manufacturer's recommendation or in excess of the spacing at the SWL test. In general it is not to exceed 2 metres.

The selection and spacing of cable tray/protective casing supports are to take into account:

- dimensions of cable trays/protective casings;
- mechanical and physical properties of their material;
- mass of cable trays/protective casings;
- loads due to weight of cables, external forces, thrust forces and vibrations;
- maximum accelerations to which the system may be subjected;
- combination of loads.

6.2.3 The sum of the cables' total cross-sectional area, based on the cables' external diameter, is not to exceed 40% of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

SECTION 11 LOCATION

1 General

1.1 Location

1.1.1 The degree of protection of the enclosures and the environmental categories of the equipment are to be appropriate to the spaces or areas in which they are located; see Sec 3, Tab 3, Sec 3, Tab 5 and Sec 2, [4.2.2].

1.2 Areas with a risk of explosion

1.2.1 Except where the installation of equipment for explosive gas atmosphere is provided for by the Rules, electrical equipment is not to be installed where flammable gases or vapours are liable to accumulate; see Sec 3, [10].

2 Main electrical system

2.1 Location in relation to the emergency system

2.1.1 The arrangement of the emergency electrical system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated converting equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render inoperative the main electric lighting system and the other primary essential services.

2.2 Main switchboard

2.2.1 The main switchboard shall be so placed relative to one main generating station that, as far as is practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space.

2.2.2 An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating switchboards from generators.

2.2.3 The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads.

2.2.4 Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided that there is access between the spaces.

2.2.5 The main switchboard is to be located as close as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries.

2.2.6 Where essential services for steering and propulsion are supplied from section boards, these and any transformers, convertors and similar appliances constituting an essential part of the electrical supply system are also to satisfy the above provisions.

2.2.7 A non-required subdivision bulkhead, with sufficient access, located between the switchboard and generators, or between two or more generators, is not to be considered as separating the equipment.

3 Emergency electrical system

3.1 Spaces for the emergency source

3.1.1 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard shall be located above the uppermost continuous deck and shall be readily accessible from the open deck.

They are not to be located forward of the collision bulkhead.

3.1.2 The spaces containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of Category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

Where this is not practicable, the contiguous boundaries are to be Class A60.

3.2 Location in relation to the main electrical system

3.2.1 The location of the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard shall be such as to ensure to the satisfaction of the Society that a fire or other casualty in the space containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of Category A will not interfere with the supply, control and distribution of emergency electrical power.

3.2.2 The arrangement of the main electrical system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated converting equipment, if any, the main switchboard and the main lighting switchboard will not render inoperative the emergency electric lighting system and the other emergency services other than those located within the spaces where the fire or casualty has occurred.

3.3 Emergency switchboard

3.3.1 The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

3.3.2 Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3.4 Emergency battery

3.4.1 No accumulator battery fitted in accordance with the provisions of Sec 3, [2.3] shall be installed in the same space as the emergency switchboard.

3.4.2 Accumulator batteries fitted in accordance with the provisions of Sec 3, [2.3] and connected to a charging device of power of 2 kW or less may be accepted in the same space as the emergency switchboard but outside the emergency switchboard to the satisfaction of the Society.

4 Distribution boards

4.1 Distribution boards for cargo spaces and similar spaces

4.1.1 Distribution boards containing multipole switches for the control of power and lighting circuits in bunkers and cargo spaces are to be situated outside such spaces.

4.2 Distribution board for navigation lights

4.2.1 The distribution board for navigation lights is to be placed in an accessible position on the bridge.

5 Cable runs

5.1 General

5.1.1 Cable runs are to be selected so as to be as far as practicable accessible, with the exception of single cables, situated behind walls or ceilings constructed of incombustible materials, supplying lighting fittings and socket-outlets in accommodation spaces, or cables enclosed in pipes or conduits for installation purposes.

5.1.2 Cable runs are to be selected so as to avoid action from condensed moisture and from dripping of liquids.

5.1.3 Connection and draw boxes are to be accessible.

5.1.4 Cables are generally not to be installed across expansion joints.

Where this is unavoidable, however, a loop of cable of length proportional to the expansion of the joint is to be provided (see Sec 12, [7.2.2]).

5.2 Location of cables in relation to the risk of fire and overheating

5.2.1 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are, so far as is practicable, to be routed clear of galleys, laundries, machinery spaces of Category A and their casings and other high fire risk areas, except for supplying equipment in those spaces.

5.2.2 When it is essential that a circuit functions for some time during a fire and it is unavoidable to carry the cable for such a circuit through a high fire risk area (e.g. cables connecting fire pumps to the emergency switchboard), the cable is to be of a fire-resistant type or adequately protected against direct exposure to fire.

5.2.3 Main cable runs (see Note 1) and cables for the supply and control of essential services are, as far as is practicable, to be kept away from machinery parts having an increased fire risk (see Note 2) unless:

- the cables have to be connected to the subject equipment,
- the cables are protected by a steel bulkhead or deck, or
- the cables in that area are of the fire-resisting type.

Note 1: Main cable runs are for example:

- cable runs from generators and propulsion motors to main and emergency switchboards
- cable runs directly above or below main and emergency switchboards, centralised motor starter panels, section boards and centralised control panels for propulsion and essential auxiliaries.

Note 2: Machinery, machinery parts or equipment handling combustibles are considered to present an increased fire risk.

5.2.4 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are to be arranged, as far as practicable, in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

5.2.5 Cables are to be arranged as remote as possible from sources of heat such as hot pipes, resistors, etc. Where installation of cables near heat sources cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields are to be installed, or other precautions to avoid overheating are to be taken, for example use of ventilation, heat insulation materials or special heat-resisting cables.

5.3 Location of cables in relation to electromagnetic interference

5.3.1 For the installation of cables in the vicinity of radio equipment or of cables belonging to electronic control and monitoring systems, steps are to be taken in order to limit the effects of unwanted electromagnetic interference (see Ch 3, Sec 5).

5.4 Services with a duplicate feeder

5.4.1 In the case of essential services requiring a duplicate supply (e.g. steering gear circuits), the supply and associated control cables are to follow different routes which are to be as far apart as practicable, separated both vertically and horizontally.

5.5 Emergency circuits

5.5.1 Cables supplying emergency circuits are not to run through spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, except for cables supplying emergency equipment located within such spaces (see [3.2.2]).

SECTION 12 INSTALLATION

1 General

1.1 Protection against injury or damage caused by electrical equipment

1.1.1 All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.

1.1.2 All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.

1.1.3 For protective earthing as a precaution against indirect contact, see [2].

1.1.4 Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

1.2 Protection against damage to electrical equipment

1.2.1 Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, steam, oil or oil vapours.

1.2.2 The air supply for internal ventilation of electrical equipment is to be as clean and dry as practicable; cooling air for internal ventilation is not to be drawn from below the floor plates in engine and/or boiler rooms.

1.2.3 Equipment is to be so mounted that its enclosing arrangements and the functioning of the built-in equipment will not be affected by distortions, vibrations and movements of the ship's structure or by other damage liable to occur.

1.2.4 If electrical fittings, not of aluminium, are attached to aluminium, suitable provision is to be made to prevent galvanic corrosion.

1.3 Accessibility

1.3.1 Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts (see [6.1.3]).

2 Earthing of non-current carrying parts

2.1 Parts which are to be earthed

2.1.1 Exposed metal parts of both fixed and portable electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live and similar metal parts inside non-metallic enclosures are to be earthed unless the machines or equipment are:

a) supplied at a voltage not exceeding 50 V direct current or 50 V, root mean square between conductors, achieved without the use of auto-transformers (safety voltage); or

b) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying one consuming device only; or

c) constructed in accordance with the principle of double insulation.

2.1.2 To minimise shock from high frequency voltage induced by the radio transmitter, handles, handrails and other metal elements on the bridge or upper decks are to be in electrical connection with the hull or superstructures.

2.2 Methods of earthing

2.2.1 Metal frames or enclosures of apparatus and electrical machinery may be fixed to, and in metallic contact with, the ship's structure, provided that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together.

2.2.2 For metal frames or enclosures which are not earthed as specified in [2.2.1], earthing connections complying with [2.3] and [2.4] are to be used.

2.2.3 For requirements regarding the earthing of coverings of cables and the mechanical protection of cables, see [7.11] and [7.12].

2.3 Earthing connections

2.3.1 Every earthing connection is to be of copper or other corrosion-resistant material and is to be securely installed and protected, where necessary, against damage and electrolytic corrosion.

2.3.2 The nominal cross-sectional area of each copper earthing connection is to be not less than that required in Tab 1.

Earthing connections of other metals are to have conductance at least equal to that specified for a copper earthing connection.

Table 1 : Cross-sectional area of earth-continuity conductors and earthing connections

<table>
<tr><th colspan="2">Type of earthing connection</th><th>Cross-sectional area of associated current carrying conductor</th><th colspan="2">Minimum cross-sectional area of copper earthing connection</th></tr>
<tr><td>1</td><td>Earth-continuity conductor in flexible cable or flexible cord</td><td>any</td><td colspan="2">Same as current carrying conductor up to and including 16 mm^2 and one half above 16 mm^2 but at least 16 mm^2</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Earth-continuity conductor incorporated in fixed cable</td><td rowspan="3">any</td><td colspan="2">a) for cables having an insulated earth-continuity conductor
• a cross-section equal to the main conductors up to and including 16 mm^2, but minimum 1,5 mm^2
• a cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm^2, but at least 16 mm^2
b) for cables with a bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>Cross-section of main conductor mm^2</td><td>Earthing connection mm^2</td></tr>
<tr><td>1 ÷ 2,5
4 ÷ 6</td><td>1
1,5</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Separate fixed earthing conductor</td><td>≤ 2,5 mm^2</td><td colspan="2">Same as current carrying conductor subject to minimum of 1,5 mm^2 for stranded earthing connection or 2,5 mm^2 for unstranded earthing connection</td></tr>
<tr><td>> 2,5 mm^2 but ≤ 120 mm^2</td><td colspan="2">One half the cross-sectional area of the current carrying conductor, subjected to a minimum of 4 mm^2</td></tr>
<tr><td>> 120 mm^2</td><td colspan="2">70 mm^2</td></tr>
</table>

2.3.3 Metal parts of portable appliances are to be earthed, where required (see [2.1.1]), by means of an earth-continuity conductor in the flexible supply cable or cord, which has the cross-sectional area specified in Tab 1 and which is earthed, for example, through the associated plug and socket.

2.3.4 In no circumstances is the lead sheathing or armour of cables to be relied upon as the sole means of earthing.

2.4 Connection to the ship's structure

2.4.1 Every connection of an earth-continuity conductor or earthing lead to the ship's structure is to be secured by means of a screw of brass or other corrosion-resistant material of diameter not less than 6 mm.

2.4.2 Such earthing connection is not to be used for other purposes.

2.4.3 The connection described in [2.4.1] is to be located in an accessible position where it may readily be checked.

2.5 Earthed distribution systems

2.5.1 The system earthing of earthed distribution systems is to be effected by means independent of any earthing arrangements of non-current carrying parts and is to be connected to the hull at one point only.

2.5.2 In an earthed distribution system in which the earthing connection does not normally carry current, this connection is to conform with the requirements of [2.3], except that the lower limit of 70 mm^2 (see Tab 1) does not apply.

2.5.3 In a distribution system with hull return, the system earthing connection is to have at least the same cross-sectional area as the feeder lines.

2.5.4 The earthing connection is to be in an accessible position where it may readily be inspected and disconnected for insulation testing.

2.6 Aluminium superstructures

2.6.1 When aluminium superstructures are insulated from the steel hull to prevent electrolytic corrosion, they are to be secured to the hull by means of a separate bonding connection.

2.6.2 The connections are to be adequately close together and are to have a resistance less than 0.1 Ω.

2.6.3 The connections are to be located where they may readily be inspected.

3 Rotating machines

3.1

3.1.1 Every rotating machine is preferably to be installed with the shaft in the fore-and-aft direction. Where a rotating machine of 100 kW and over is installed athwartship, or vertically, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in Sec 2, Tab 4.

4 Semiconductor convertors

4.1 Semiconductor power convertors

4.1.1 Naturally air-cooled semiconductor convertors are to be installed such that the circulation of air to and from the stacks or enclosures is not impeded and that the temperature of the cooling inlet air to convertor stacks does not exceed the ambient temperature for which the stacks are specified.

5 Vented type storage batteries

5.1 General

5.1.1 Batteries are to be arranged so that each cell or crate of cells is accessible from the top and at least one side to permit replacement and periodical maintenance.

5.1.2 Cells or crates are to be carried on insulating supports of material non-absorbent to the electrolyte (e.g. treated wood).

5.1.3 Cells are to be securely chocked by means of insulating material non-absorbent to the electrolyte, e.g. strips of treated wood. Special mechanical precautions are to be taken to prevent the emergency battery fron being damaged by the shock due to a collision.

5.1.4 Provision is to be made for the free circulation of air.

5.2 Protection against corrosion

5.2.1 The interior of battery compartments (rooms, lockers, boxes) including all metal parts subject to the electrolyte is to be protected against the deteriorating effect of the latter by electrolyte-resistant coating or other equivalent means, unless corrosion-resistant materials are used.

5.2.2 Interior surfaces of metal shelves for battery cells, whether or not grouped in crates or trays, are to be protected by a lining of electrolyte-resistant material, watertight and carried up to at least 75 mm on all sides. In particular, linings are to have a minimum thickness of 1,5 mm, if of lead sheet for lead-acid batteries, and of 0,8 mm, if of steel for alkaline batteries.

Alternatively, the floor of the room or locker is to be lined as specified above to a height of at least 150 mm.

5.2.3 Battery boxes are to be lined in accordance with [5.2.2] to a height of at least 75 mm.

6 Switchgear and controlgear assemblies

6.1 Main switchboard

6.1.1 The main switchboard is to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel.

6.1.2 An unobstructed space is to be left in front of the switchboard wide enough to allow access for operation; such width is generally about 1 metre.

When withdrawable equipment is contained in the switchboard, the width of the space is to be not less than 0,5 m when the equipment is fully withdrawn.

Reduced widths may be considered for small ships.

6.1.3 Where necessary, an unobstructed space is to be provided at the rear of the switchboard ample to permit maintenance; in general, the width of this passage is to be not less than 0,6 m, except that this may be reduced to 0,5 m in way of stiffeners and frames, and the height sufficient for the operation foreseen.

6.1.4 Where the switchboard is open at the rear, the rear space in [6.1.3] is to form a locked space provided at each end with an access door. The required IP protection for the corresponding location is to be fulfilled.

6.1.5 If necessary, the clear height above the switchboard specified by the manufacturer is to be maintained for pressure relief in the event of a short-circuit.

6.1.6 When the voltage exceeds the safety voltage, non-conducting mats or gratings are to be provided at the front and rear of the switchboard as necessary.

6.1.7 Piping and conduits are not to be installed directly above or in the vicinity of switchboards and controlgear assemblies.

Where this is unavoidable, pipes and conduits are to have welded joints only or to be provided with protection against spray from steam or pressurised liquids or dripping.

6.2 Emergency switchboard

6.2.1 For the installation of the emergency switchboard, the same requirements apply as given in [6.1] for the installation of the main switchboard.

6.3 Section boards and distribution boards

6.3.1 For the installation of section and distribution boards, the same requirements apply, as far as applicable, as given in [6.1] for the installation of the main switchboard.

7 Cables

7.1 General

7.1.1 Cables having insulating materials with different maximum permissible conductor temperatures are not to be bunched together.

Where this is not practicable, the cables are to be so installed that no cable reaches a temperature higher than its rating.

7.1.2 Cables having a protective covering which may damage the covering of more vulnerable cables are not to be bunched with the latter.

7.1.3 Cables having a bare metallic sheath (e.g. of copper) or braid or armour are to be installed in such a way that galvanic corrosion by contact with other metals is prevented.

7.1.4 All cables and wiring external to equipment are to be so installed as not to impair their original flame-retarding properties.

To this end, the following methods may be used:

a) the use of cables which have been tested in accordance with IEC Publication 332-3 Category A or an equivalent test procedure for cables installed in bunches, or

b) the use of fire stops having at least B0 penetrations fitted as follows (see Fig 1, Fig 2, Fig 3 and Fig 4):
   - cable entries at the main and emergency switchboard
   - where cables enter engine control rooms
   - cable entries at centralised control panels for propulsion machinery and essential auxiliaries
   - at each end of totally enclosed cable trunks
   - at every second deck or approximately 6 metres for verticals runs and every 14 metres for horizontal runs in enclosed and semi-enclosed spaces
   - at the boundaries of the spaces in cargo areas.

c) the use of fire protection coating applied to at least 1 metre in every 14 metres on horizontal cable runs and over the entire length of vertical cable runs for cables installed in enclosed and semi-enclosed spaces.

The cable penetrations are to be installed in steel plates of at least 3 mm thickness extending all around to twice the largest dimension of the cable run for vertical runs and once for horizontal runs, but need not extend through ceilings, decks, bulkheads or solid sides of trunks. These precautions apply in particular to bunches of 5 or more cables in areas with a high fire risk (such as Category A machinery spaces, galleys etc.) and to bunches of more than 10 cables in other areas.

7.2 Radius of bend

7.2.1 The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the Manufacturer.

Its value is generally to be not less than the figure given in Tab 2.

7.2.2 Where the installation of cables across expansion joints is unavoidable, the minimum internal radius of the loop at the end of the travel of the expansion joint is to be not less than 12 times the external diameter of the cable.

Figure 1 : Totally enclosed trunks

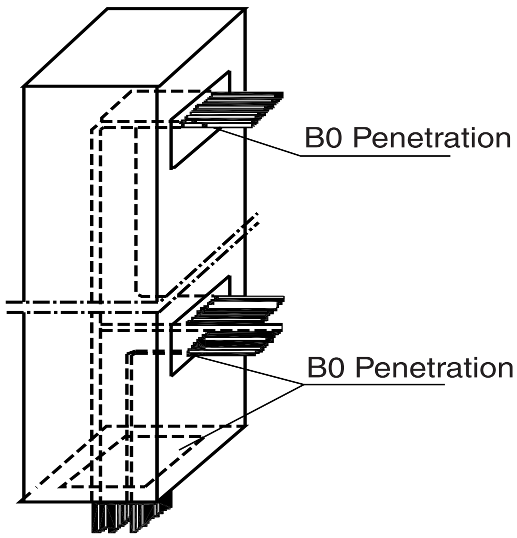


Table 2 : Bending radii

Cable construction		Overall diameter of cable (D)	Minimum internal radius of bend
Insulation	Outer covering		
Thermoplastic or thermosetting with circular copper conductors	Unarmoured or unbraided	≤ 25 mm	4 D
		> 25 mm	6 D
	Metal braid screened or armoured	Any	6 D
	Metal wire armoured Metal tape armoured or metal-sheathed	Any	6 D
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with shaped copper conductors	Any	Any	8 D

Figure 2 : Non-totally enclosed trunks, vertical

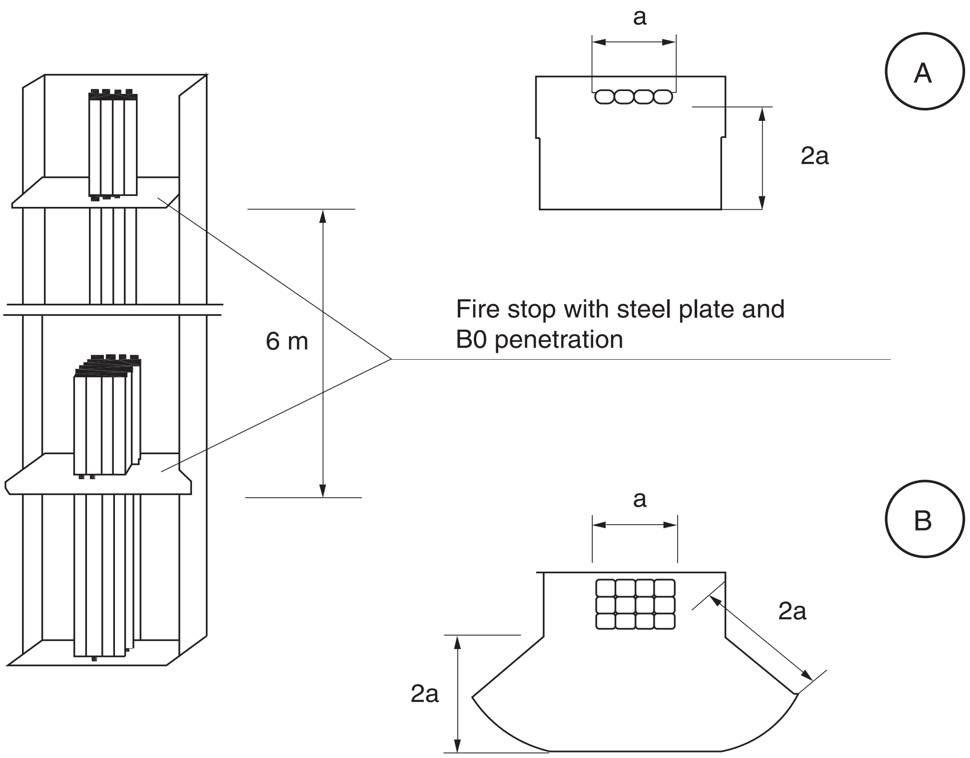


Figure 3 : Non-totally enclosed trunks, horizontal

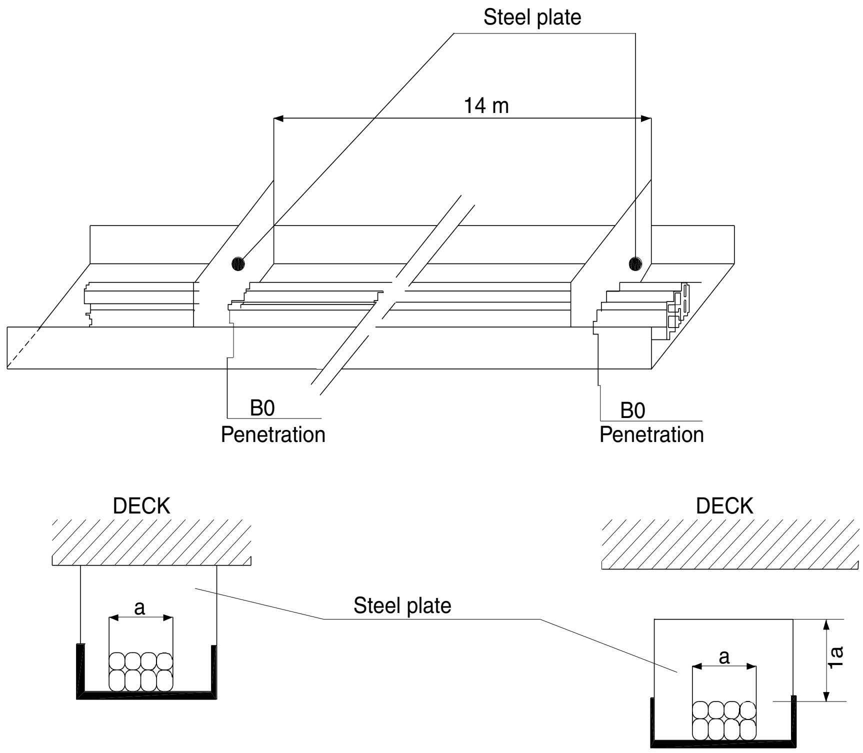
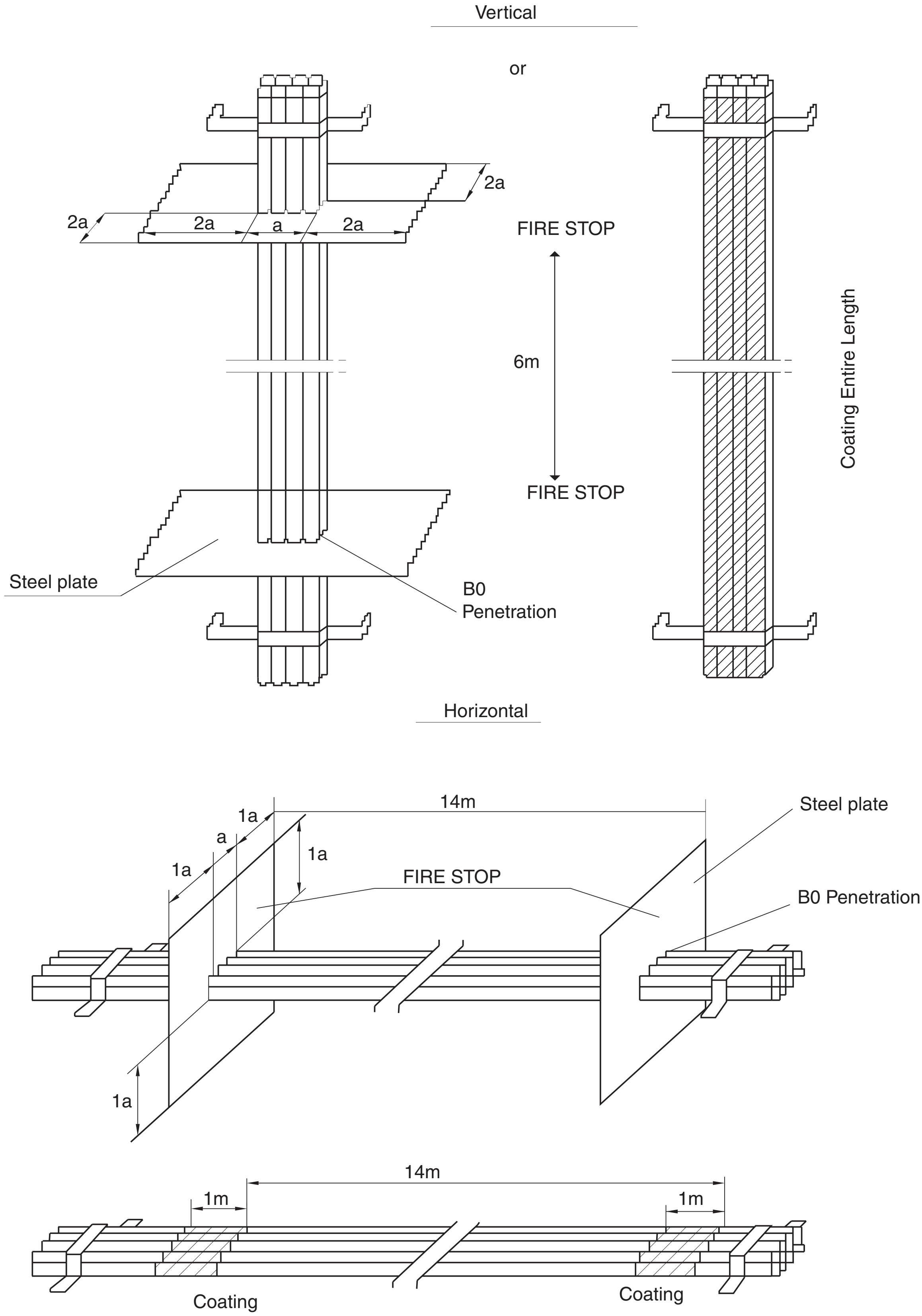


Figure 4 : Open cables runs



7.3 Fixing of cables

7.3.1 Cables are to be installed and supported in such a manner as to avoid chafing or other damage.

7.3.2 The supports (tray plates, separate support brackets or hanger ladders) and the corresponding accessories are to be of robust construction and of corrosion-resistant material or suitably treated before erection to resist corrosion.

When cables are installed directly on aluminium structures, fixing devices of aluminium or suitably treated steel are to be used.

For mineral-insulated cables with copper sheath, fixing devices in contact with the sheath are to be of copper alloy.

7.3.3 With the exception of cables installed in pipes, conduits, trunkings or special casings, cables are to be fixed by means of clips, saddles or straps of suitable material, in order to tighten the cables without their coverings being damaged.

7.3.4 Cable clips or straps made from a material other than metal are to be manufactured of a flame-retardant material.

7.3.5 The distances between fastenings and between supports are to be suitably chosen according to the type and number of cables and the probability of vibration.

7.3.6 When cables are fixed by means of clips or straps made from a material other than metal and these cables are not laid on top of horizontal cable supports (e.g. in the case of vertical installation), suitable metal clips or saddles spaced not more than 1 metre apart are to be used in addition in order to prevent the release of cables during a fire.

7.3.7 Suspended cables of fire-resisting type are to be fixed by means of steel straps spaced not more than 500 mm apart.

7.4 Mechanical protection

7.4.1 Cables exposed to risk of mechanical damage are to be protected by metal casing, profiles or grids or enclosed in metal pipes or conduits, unless the cable covering (e.g. armour or sheath) provides adequate mechanical protection.

7.4.2 In situations where there would be an exceptional risk of mechanical damage, e.g. in holds, storage spaces, cargo spaces, etc., cables are to be protected by metal casing, trunkings or conduits, even when armoured, if the ship's structure or attached parts do not afford sufficient protection for the cables.

7.4.3 For the protection of cables passing through decks, see [7.5.3].

7.4.4 Metal casing used for mechanical protection of cables is to be effectively protected against corrosion.

7.5 Penetrations of bulkheads and decks

7.5.1 If cables have to pass without adequate support through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes are to be fitted with glands or bushings of suitable material.

7.5.2 If cables have to pass through a watertight bulkhead or deck, the penetration is to be effected in a watertight manner.

Either suitable individual watertight glands for single cables or boxes containing several cables and filled with a flame-retardant packing may be used for this purpose.

Whichever type of penetration is used, the watertight integrity of the bulkheads or deck is to be maintained.

7.5.3 Cables passing through decks and continuing vertically are to be protected against mechanical damage to a suitable height above the deck.

7.5.4 Where cables pass through bulkheads or decks separating areas with a risk of explosion, arrangements are to be such that hazardous gas or dust cannot penetrate through openings for the passage of cables into other areas.

7.5.5 Where cables pass through a bulkhead or deck which is required to have some degree of fire integrity, penetration is to be so effected as to ensure that the required degree of fire integrity is not impaired.

7.6 Expansion joints

7.6.1 If there is reason to fear that a tray plate, pipe or conduit may break because of the motion of the ship, different load conditions and temperature variations, appropriate expansion joints are to be provided.

This may apply in particular in the case of cable runs on the weather deck.

7.7 Cables in closed pipes or conduits

7.7.1 Closed pipes or conduits are to have such internal dimensions and radius of bend as will permit the easy drawing in and out of the cables which they are to contain; the internal radius of bend is to be not less than that permitted for cables and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe where this value is greater.

7.7.2 Closed pipes and conduits are to be suitably smooth on the interior and are to have their ends shaped or bushed in such a way as not to damage the cable covering.

7.7.3 The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional areas of the pipe or conduit) is to be not greater than 0,4.

7.7.4 If necessary, openings are to be provided at the highest and lowest points so as to permit air circulation and ensure that the heat from the cables can be dissipated, and to obviate the possibility of water accumulating at any part of the pipe or conduit.

7.7.5 Vertical trunking for electrical cables is to be so constructed as not to jeopardise the required passive fire protection between the spaces.

7.7.6 Metal pipes or conduits are to be protected against corrosion.

7.7.7 Non-metallic pipes or conduits are to be flame-retardant.

7.8 Cables in casings or trunking and conduits with removable covers

7.8.1 Covers are to be removable and when they are open, cables are to be accessible.

7.8.2 Materials used are to comply with [7.7.6] and [7.7.7].

7.8.3 If the fixing of covers is by means of screws, the latter are to be of non-rusting material and arranged so as not to damage the cables.

7.8.4 Means are to be provided to ensure that the heat from the cables can be dissipated and water accumulation is avoided (see [7.7.4]).

7.9 Cable ends

7.9.1 Terminations in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding properties of the cable.

7.9.2 Where mechanical clamps are not used, the ends of all conductors having a cross-sectional area greater than 4 mm^2 are to be fitted with soldering sockets or compression-type sockets of sufficient size to contain all the strands of the conductor.

7.9.3 Cables not having a moisture-resistant insulation (e.g. mineral-insulated) are to have their ends effectively sealed against ingress of moisture.

7.10 Joints and tappings (branch circuit)

7.10.1 Cable runs are normally not to include joints. Where absolutely necessary, cable joints are to be carried out by a junction method with rebuilding of the insulation and protective coverings.

7.10.2 Joints in all conductors are to be so made as to retain the original electrical (continuity and isolation), mechanical (strength and protection), flame-retarding and, where necessary, fire-resisting properties of the cable.

7.10.3 Tappings (branch circuits) are to be made via suitable connections or in suitable boxes of such design that the conductors remain adequately insulated and protected from atmospheric action and are fitted with terminals or busbars of dimensions appropriate to the current rating.

7.10.4 Cables for safety voltages are not to terminate in the same connection boxes as cable for higher voltages unless separated by suitable means.

7.11 Earthing and continuity of metal coverings of cables

7.11.1 All metal coverings of cables are to be electrically connected to the metal hull of the ship.

7.11.2 Metal coverings are generally to be earthed at both ends of the cable, except for [7.11.3] and [7.11.4].

7.11.3 Single-point earthing is admitted for final sub-circuits (at the supply end), except for those circuits located in areas with a risk of explosion.

7.11.4 Earthing is to be at one end only in those installations (mineral-insulated cables, intrinsically safe circuits, control circuits (see Ch 3, Sec 5), etc) where it is required for technical or safety reasons.

7.11.5 Metal coverings of single-core a.c. cables and special d.c. cables with high "ripple" content (e.g. for thyristor equipment) are to be earthed at one point only (e.g. at the mid-point).

7.11.6 The electrical continuity of all metal coverings of cables throughout the length of the latter, particularly at joints and tappings, is to be ensured.

7.11.7 The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands are to be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with these requirements.

7.11.8 The metal covering of cables may also be earthed by means of clamps or clips of corrosion-resistant material making effective contact with the covering and earthed metal.

7.12 Earthing and continuity of metal pipes, conduits and trunking or casings

7.12.1 Metal casings, pipes, conduits and trunking are to be effectively earthed.

7.12.2 Pipes or conduits may be earthed by being screwed into a metal enclosure, or by nuts on both sides of the wall of a metallic enclosure, provided the surfaces in contact are clean and free from rust, scale or paint and that the enclosure is in accordance with these requirements on earthing.

The connection is to be painted immediately after assembly in order to inhibit corrosion.

7.12.3 Pipes and conduits may be earthed by means of clamps or clips of corrosion-resistant metal making effective contact with the earthed metal.

7.12.4 Pipes, conduits or trunking together with connection boxes of metallic material are to be electrically continuous.

7.12.5 All joints in metal pipes and conduits used for earth continuity are to be soundly made and protected, where necessary, against corrosion.

7.12.6 Individual short lengths of pipes or conduits need not be earthed.

7.13 Precautions for single-core cables for a.c.

7.13.1 For the earthing of metal coverings see [7.11.5].

7.13.2 Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 A, the requirements of [7.13.3] to [7.13.7] are to be complied with.

7.13.3 Conductors belonging to the same circuit are to be contained within the same pipe, conduit or trunking, unless this is of non-magnetic material.

7.13.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

7.13.5 In the installation of 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 event, the distance between the external covering of two adjacent cables is to be not greater than one diameter.

7.13.6 When single-core cables having a current rating greater than 250 A are installed near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.13.7 Magnetic material is not to be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit are to pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material is to be no less than 75 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.14 Cables in refrigerated spaces

7.14.1 For the types of cables permitted in refrigerated spaces, see Sec 3, [9.4].

7.14.2 Power cables installed in refrigerated spaces are not to be covered by thermal insulation. Moreover, such cables are not to be placed directly on the face of the refrigerated space unless they have a thermoplastic or elastomeric extruded sheath.

7.14.3 Power cables entering a refrigerated space are to pass through the walls and thermal insulation at right angles, in tubes sealed at each end and protected against oxidation.

7.15 Cables in areas with a risk of explosion

7.15.1 For the types of cables permitted in areas with a risk of explosion, see Sec 3, [10.2].

7.15.2 For penetration of bulkheads or decks separating areas with a risk of explosion, see [7.5.4].

7.15.3 Cables of intrinsically safe circuits are to be separated from the cables of all other circuits (minimum 50 mm).

7.16 Cables in the vicinity of radio equipment

7.16.1 All cables between antennas and transmitters are to be routed separately of any other cable.

7.16.2 Where it is necessary to use single-core cables, the arrangement of conductors is to be such as to avoid complete or partial loops.

7.17 Cables for submerged bilge pumps

7.17.1 See Sec 3, [9.7].

8 Various appliances

8.1 Lighting fittings

8.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

Note 1: Where the temperature of terminals of lighting fittings exceeds the maximum conductor temperature permitted for the supplied cable (see Sec 3, [9.9]), special installation arrangements, such as terminal boxes thermally insulated from the light source, are to be provided.

8.1.2 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

8.1.3 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

8.2 Heating appliances

8.2.1 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

Note 1: To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself.

8.2.2 Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

8.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

8.3 Heating cables and tapes or other heating elements

8.3.1 Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials.

Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

SECTION 13 ELECTRIC PROPULSION PLANT

1 General

1.1 Applicable requirements

1.1.1 The following requirements apply to ships for which the main propulsion plants are provided by at least one electric propulsion motor and its electrical supply. All electrical components of the propulsion plants are to comply with these requirements.

1.1.2 Prime movers are to comply with the requirements of Ch 1, Sec 2.

1.1.3 For the torsional vibration characteristics of the electric propulsion plant, the provisions of Ch 1, Sec 7 apply.

1.1.4 Cooling and lubricating oil systems are to comply with the requirements of Ch 1, Sec 8.

1.2 Operating conditions

1.2.1 The normal torque available on the electric propulsion motors for manoeuvring is to be such as to enable the vessel to be stopped or reversed when sailing at its maximum service speed.

1.2.2 When an electric generating plant has a continuous rating greater than the electric propulsion motor rating, means are to be provided to limit the continuous input to the motor. This value is not to exceed the continuous full load torque for which motor and shafts are designed.

1.2.3 The plant as a whole is to have sufficient overload capacity to provide the torque, power and reactive power needed during starting and manoeuvring conditions.

Locked rotor torque which may be required in relation to the operation of the vessel (e.g. for navigation in ice) is to be considered.

1.2.4 The electric motors and shaftline are to be constructed and installed so that, at any speed reached in service, all the moving components are suitably balanced.

2 Design of the propulsion plant

2.1 General

2.1.1 The electrical power for the propulsion system may be supplied from generating sets, dedicated to the propulsion system, or from a central power generation plant, which supplies the ship's services and electric propulsion.

The minimum configuration of an electric propulsion plant consists of one prime mover, one generator and one electric motor. When the electrical production used for propulsion is independent of the shipboard production, the diesel engines driving the electric generators are to be considered as main engines.

2.1.2 For plants having only one propulsion motor controlled via a static convertor, a standby convertor which it is easy to switch over to is to be provided. Double stator windings with one convertor for each winding are considered as an alternative solution.

2.1.3 In electric propulsion plants having two or more constant voltage propulsion generating sets, the electrical power for the ship's auxiliary services may be derived from this source. Additional ship's generators for auxiliary services need not be fitted provided that effective propulsion and the services mentioned in Sec 3, [2.1] are maintained with any one generating set out of service.

Where transformers are used to supply the ship's auxiliary services, see Sec 5.

2.1.4 Plants having two or more propulsion generators, two or more static convertors or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically, without affecting the operation of the others.

2.2 Power supply

2.2.1 Where the plant is intended exclusively for electric propulsion, voltage variations and maximum voltage are to be maintained within the limits required in Sec 2.

2.2.2 In special conditions (e.g. during crash-stop manoeuvres), frequency variations may exceed the limits stipulated in Sec 2 provided that other equipment operating on the same network is not unduly affected.

2.2.3 The electric plant is to be so designed as to prevent the harmful effects of electromagnetic interference generated by semiconductor convertors, in accordance with Sec 2.

2.3 Auxiliary machinery

2.3.1 Propeller/thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution board or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

2.3.2 When the installation has one or more lubrication systems, devices are to be provided to ensure the monitoring of the lubricating oil return temperature.

2.3.3 Propelling machinery installations with a forced lubrication system are to be provided with alarm devices which will operate in the event of oil pressure loss.

2.4 Electrical Protection

2.4.1 Automatic disconnections of electric propulsion plants which adversely affect the manoeuvrability of the ship are to be restricted to faults liable to cause severe damage to the equipment.

2.4.2 The following protection of convertors is to be provided:

- protection against overvoltage in the supply systems to which convertors are connected
- protection against overcurrents in semiconductor elements during normal operation
- short-circuit protection.

2.4.3 Overcurrent protective devices in the main circuits are to be set sufficiently high so that there is no possibility of activation due to the overcurrents caused in the course of normal operation, e.g. during manoeuvring or in heavy seas.

2.4.4 Overcurrent protection may be replaced by automatic control systems ensuring that overcurrents do not reach values which may endanger the plant, e.g. by selective tripping or rapid reduction of the magnetic fluxes of the generators and motors.

2.4.5 In the case of propulsion plants supplied by generators in parallel, suitable controls are to ensure that, if one or more generators are disconnected, those remaining are not overloaded by the propulsion motors.

2.4.6 In three-phase systems, phase-balance protective devices are to be provided for the motor circuit which deexcite the generators and motors or disconnect the circuit concerned.

2.5 Excitation of electric propulsion motor

2.5.1 Each propulsion motor is to have its own exciter.

2.5.2 For plants where only one generator or only one motor is foreseen, each machine is to be provided with a standby static electronic exciter, which it is easy to switch over to.

2.5.3 In the case of multi-propeller propulsion ships, one standby static electronic exciter which it is easy to switch over to is to be provided.

2.5.4 For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened. Alternatively, the induced voltage when the field circuits are opened is to be maintained at the nominal design voltage.

2.5.5 In excitation circuits, there is to be no overload protection causing the opening of the circuit, except for excitation circuits with semiconductor convertors.

3 Construction of rotating machines and semiconductor convertors

3.1 Ventilation

3.1.1 Where electrical machines are fitted with an integrated fan and are to be operated at speeds below the rated speed with full load torque, full load current, full load excitation or the like, the design temperature rise is not to be exceeded.

3.1.2 Where electrical machines or convertors are force-ventilated, at least two fans, or other suitable arrangements, are to be provided so that limited operation is possible in the event of one fan failing.

3.2 Protection against moisture and condensate

3.2.1 Machines and equipment which may be subject to the accumulation of moisture and condensate are to be provided with effective means of heating. The latter is to be provided for motors above 500 kW, in order to maintain the temperature inside the machine at about 3°C above the ambient temperature.

3.2.2 Provision is to be made to prevent the accumulation of bilge water, which is likely to enter inside the machine.

3.3 Rotating machines

3.3.1 Electrical machines are to be able to withstand the excess speed which may occur during operation of the ship.

3.3.2 The design of rotating machines supplied by static convertors is to consider the effects of harmonics.

3.3.3 The winding insulation of electrical machines is to be capable of withstanding the overvoltage which may occur in manoeuvring conditions.

3.3.4 The design of a.c. machines is to be such that they can withstand without damage a sudden short-circuit at their terminals under rated operating conditions.

3.3.5 The obtainable current and voltage of exciters and their supply are to be suitable for the output required during manoeuvring and overcurrent conditions, including short-circuit in the transient period.

3.4 Semiconductor convertors

3.4.1 The following limiting repetitive peak voltages U_{RM} are to be used as a base for each semiconductor valve:

- when connected to a supply specifically for propeller drives:

  $U_{RM} = 1,5\ U_P$

- when connected to a common main supply:

  $U_{RM} = 1,8\ U_P$

  where

  U_P : is the peak value of the rated voltage at the input of the semiconductor convertor.

3.4.2 For semiconductor convertor elements connected in series, the values in [3.4.1] are to be increased by 10%. Equal voltage distribution is to be ensured.

3.4.3 For parallel-connected convertor elements, an equal current distribution is to be ensured.

3.4.4 Means are to be provided, where necessary, to limit the effects of the rate of harmonics to the system and to other semiconductor convertors. Suitable filters are to be installed to keep the current and voltage within the limits given in Sec 2.

4 Control and monitoring

4.1 General

4.1.1 The control and monitoring systems, including computer based systems, are to be type approved, according to Ch 3, Sec 6.

4.2 Power plant control systems

4.2.1 The power plant control systems are to ensure that adequate propulsion power is available, by means of automatic control systems and/or manual remote control systems.

4.2.2 The automatic control systems are to be such that, in the event of a fault, the propeller speed and direction of thrust do not undergo substantial variations.

4.2.3 Failure of the power plant control system is not to cause complete loss of generated power (i.e. blackout) or loss of propulsion.

4.2.4 The loss of power plant control systems is not to cause variations in the available power; i.e. starting or stopping of generating sets is not to occur as a result.

4.2.5 Where power-aided control (for example with electrical, pneumatic or hydraulic aid) is used for manual operation, failure of such aid is not to result in interruption of power to the propeller, any such device is to be capable of purely manual operation.

4.2.6 The control system is to include the following main functions:

- monitoring of the alarms: any event critical for the proper operation of an essential auxiliary or a main element of the installation requiring immediate action to avoid a breakdown is to activate an alarm
- speed or pitch control of the propeller
- shutdown or slow down when necessary.

4.2.7 Where the electric propulsion system is supplied by the main switchboard together with the ship's services, load shedding of the non-essential services and /or power limitation of the electric propulsion is to be provided. An alarm is to be triggered in the event of power limitation or load shedding.

4.2.8 The risk of blackout due to electric propulsion operation is to be eliminated. At the request of the Society, a failure mode and effects analysis is to be carried out to demonstrate the reliability of the system.

4.3 Indicating instruments

4.3.1 Instruments indicating consumed power and power available for propulsion are to be provided at each propulsion remote control position.

4.3.2 The instruments specified in [4.3.3]and [4.3.4] in relation to the type of plant are to be provided on the power control board or in another appropriate position.

4.3.3 The following instruments are required for each propulsion alternator:

- an ammeter on each phase, or with a selector switch to all phases
- a voltmeter with a selector switch to all phases
- a wattmeter
- a tachometer or frequency meter
- a power factor meter or a var-meter or a field ammeter for each alternator operating in parallel
- a temperature indicator for direct reading of the temperature of the stator windings, for each alternator rated above 500 kW.

4.3.4 The following instruments are required for each a.c. propulsion motor:

- an ammeter on the main circuit
- an embedded sensor for direct reading of the temperature of the stator windings, for motors rated above 500 kW
- an ammeter on the excitation circuit for each synchronous motor
- a voltmeter for the measurement of the voltage between phases of each motor supplied through a semiconductor frequency convertor.

4.3.5 Where a speed measuring system is used for control and indication, the system is to be duplicated with separate sensor circuits and separate power supply.

4.3.6 An ammeter is to be provided on the supply circuit for each propulsion semiconductor bridge.

4.4 Alarm system

4.4.1 An alarm system is to be provided, in accordance with the requirements of Chapter 3. The system is to give an indication at the control positions when the parameters specified in [4.4] assume abnormal values or any event occurs which can affect the electric propulsion.

4.4.2 Where an alarm system is provided for other essential equipment or installations, the alarms in [4.4.1] may be connected to such system.

4.4.3 Critical alarms for propulsion may be grouped, but are to be indicated to the bridge separately from other alarms.

4.4.4 The following alarms are to be provided, where applicable:

- high temperature of the cooling air of machines and semiconductor convertors provided with forced ventilation (see Note 1)
- reduced flow of primary and secondary coolants of machines and semiconductor convertors having a closed cooling system with a heat exchanger
- leakage of coolant inside the enclosure of machines and semiconductor convertors with liquid-air heat exchangers
- high winding temperature of generators and propulsion motors, where required (see [4.3])
- low lubricating oil pressure of bearings for machines with forced oil lubrication
- tripping of protective devices against overvoltages in semiconductor convertors (critical alarm)
- tripping of protection on filter circuits to limit the disturbances due to semiconductor convertors
- tripping of protective devices against overcurrents up to and including short-circuit in semiconductor convertors (critical alarm)
- voltage unbalance of three-phase a.c. systems supplied by semiconductor frequency convertors
- earth fault for the main propulsion circuit (see Note 2)
- earth fault for excitation circuits of propulsion machines (see Note 3).

Note 1: As an alternative to the air temperature of convertors or to the airflow, the supply of electrical energy to the ventilator or the temperature of the semiconductors may be monitored.

Note 2: In the case of star connected a.c. generators and motors with neutral points earthed, this device may not detect an earth fault in the entire winding of the machine.

Note 3: This may be omitted in brushless excitation systems and in the excitation circuits of machines rated up to 500 kW. In such cases, lamps, voltmeters or other means are to be provided to detect the insulation status under operating conditions.

4.5 Reduction of power

4.5.1 Power is to be automatically reduced in the following cases:

- low lubricating oil pressure of bearings of propulsion generators and motors
- high winding temperature of propulsion generators and motors
- fan failure in machines and convertors provided with forced ventilation, or failure of cooling system
- lack of coolant in machines and semiconductor convertors
- load limitation of generators or inadequate available power.

4.5.2 When power is reduced automatically, this is to be indicated at the propulsion control position (critical alarm).

4.5.3 Switching-off of the semiconductors in the event of abnormal service operation is to be provided in accordance with the manufacturer’s specification.

5 Installation

5.1 Ventilation of spaces

5.1.1 Loss of ventilation to spaces with forced air cooling is not to cause loss of propulsion. To this end, two sets of ventilation fans are to be provided, one acting as a standby unit for the other. Equivalent arrangements using several independently supplied fans may be considered.

5.2 Cable runs

5.2.1 Where there is more than one propulsion motor, all cables for any one machine are to be run as far as is practicable away from the cables of other machines.

5.2.2 Cables which are connected to the sliprings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during manoeuvring.

6 Tests

6.1 General

6.1.1 A quality assurance plan is to be submitted to the Society.

6.1.2 Tests of machines, static converters, switchgear, equipment and cables are to be carried out at the Manufacturer's works in accordance with the applicable requirements of Ch 2, Sec 4 to Ch 2, Sec 10.

6.1.3 Shaft material for generators and propulsion motors

Tests of the shaft material for generators and propulsion motors are to be carried out. Steel and iron materials are to be tested according to the vessel's shafting requirements.

6.1.4 The testing of other important forgings and castings for main electric propulsion plants, e.g. rotors and pole shoe bolts, is to be agreed on with the Society.

6.2 Tests after installation

6.2.1 Newly constructed or enlarged plants require testing and trials on board. The scope of the trials is to be agreed on with the Society.

6.2.2 Dock trial

For the scope and extent of dock trials, see Ch 1, Sec 12.

6.2.3 River trial

For the river trial program, see Ch 1, Sec 12.

SECTION 14 TESTING

1 General

1.1 Rule application

1.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service, the electrical equipment is to be tested in accordance with [3], [4] and [5] to the satisfaction of the Surveyor in charge.

1.2 Insulation-testing instruments

1.2.1 Insulation resistance may be measured with an instrument applying a voltage of at least 500 V. The measurement will be taken when the deviation of the measuring device is stabilised.

Note 1: Any electronic devices present in the installation are to be disconnected prior to the test in order to prevent damage.

2 Type approved components

2.1

2.1.1 The following components are to be type tested or type approved or in accordance with [2.1.2]:

- electrical cables (internal wiring of equipment excluded)
- transformers
- electric motors
- electrical convertors
- circuit-breakers, contactors and overcurrent protective devices (fuses excluded)
- sensors, alarm panels, electronic protective devices, automatic and remote control equipment, actuators, safety devices for installations intended for essential services (steering, controllable pitch propellers, propulsion machinery, etc.), electronic speed regulators for main or auxiliary engines, electronic devices for alarm, safety and control of electrical convertors for primary essential services
- computers used for tasks essential to safety.

2.1.2 Case by case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of the Society.

3 Insulation resistance

3.1 Lighting and power circuits

3.1.1 The insulation resistance between all insulated poles (or phases) and earth and, where practicable, between poles (or phases), is to be at least 1 MΩ in ordinary conditions.

The installation may be subdivided to any desired extent and appliances may be disconnected if initial tests give results less than that indicated above.

3.2 Internal communication circuits

3.2.1 Circuits operating at a voltage of 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 MΩ.

3.2.2 Circuits operating at voltages below 50 V are to have an insulation resistance between conductors and between each conductor and earth of at least 0,33 MΩ.

3.2.3 If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

3.3 Switchboards

3.3.1 The insulation resistance between each busbar and earth and between each insulated busbar and the busbar connected to the other poles (or phases) of each main switchboard, emergency switchboard, section board, etc. is to be not less than 1 MΩ.

3.3.2 The test is to be performed before the switchboard is put into service 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.

3.4 Generators and motors

3.4.1 The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded.

3.4.2 The test is to be carried out with the machine hot immediately after running with normal load.

3.4.3 The insulation resistance of generator and motor connection cables, field windings and starters is to be at least 1 MΩ.

4 Earth

4.1 Electrical constructions

4.1.1 Tests are to be carried out, by visual inspection or by means of a tester, to verify that all earth-continuity conductors and earthing leads are connected to the frames of apparatus and to the hull, and that in socket-outlets having earthing contacts, these are connected to earth.

4.2 Metal-sheathed cables, metal pipes or conduits

4.2.1 Tests are to be performed, by visual inspection or by means of a tester, to verify that the metal coverings of cables and associated metal pipes, conduits, trunking and casings are electrically continuous and effectively earthed.

5 Operational tests

5.1 Generating sets and their protective devices

5.1.1 Generating sets are to be run at full rated load to verify that the following are satisfactory:

- electrical characteristics
- commutation (if any)
- lubrication
- ventilation
- noise and vibration level.

5.1.2 Suitable load variations are to be applied to verify the satisfactory operation under steady state and transient conditions (see Sec 4, [2]) of:

- voltage regulators
- speed governors.

5.1.3 Generating sets intended to operate in parallel are to be tested over a range of loading up to full load to verify that the following are satisfactory:

- parallel operation
- sharing of the active load
- sharing of the reactive load (for a.c. generators).

Synchronising devices are also to be tested.

5.1.4 The satisfactory operation of the following protective devices is to be verified:

- overspeed protection
- overcurrent protection (see Note 1)
- load-shedding devices
- any other safety devices.

For sets intended to operate in parallel, the correct operation of the following is also to be verified:

- reverse-power protection for a.c. installations (or reverse-current protection for d.c. installations)
- minimum voltage protection.

Note 1: Simulated tests may be used to carry out this check where appropriate.

5.1.5 The satisfactory operation of the emergency source of power and of the transitional source of power, when required, is to be tested. In particular, the automatic starting and the automatic connection to the emergency switchboard, in case of failure of the main source of electrical power, are to be tested.

5.2 Switchgear

5.2.1 All switchgear is to be loaded and, when found necessary by the attending Surveyor, the operation of overcurrent protective devices is to be verified (see Note 1).

Note 1: The workshop test is generally considered sufficient to ensure that such apparatus will perform as required while in operation.

5.2.2 Short-circuit tests may also be required at the discretion of the Society in order to verify the selectivity characteristics of the installation.

5.3 Consuming devices

5.3.1 Electrical equipment is to be operated under normal service conditions (though not necessarily at full load or simultaneously) to verify that it is suitable and satisfactory for its purpose.

5.3.2 Motors and their starters are to be tested under normal operating conditions to verify that the following are satisfactory:

- power
- operating characteristics
- commutation (if any)
- speed
- direction of rotation
- alignment.

5.3.3 The remote stops foreseen are to be tested.

5.3.4 Lighting fittings, heating appliances etc. are to be tested under operating conditions to verify that they are suitable and satisfactory for their purposes (with particular regard to the operation of emergency lighting).

5.4 Communication systems

5.4.1 Communication systems, order transmitters and mechanical engine-order telegraphs are to be tested to verify their suitability.

5.5 Installations in areas with a risk of explosion

5.5.1 Installations and the relevant safety certification are to be examined to ensure that they are of a type permitted in the various areas and that the integrity of the protection concept has not been impaired.

5.6 Voltage drop

5.6.1 Where it is deemed necessary by the attending Surveyor, the voltage drop is to be measured to verify that the permissible limits are not exceeded (see Sec 3, [9.11.4]).

APPENDIX 1 INDIRECT TEST METHOD FOR SYNCHRONOUS MACHINES

1 General

1.1 Test method

1.1.1 The machine is to subjected to the three separate running tests specified below (see Fig 1) when it is completed (with covers, heat exchangers, all control devices and sensors), the exciter circuit is connected to its normal supply or to a separate supply having the same characteristics, and the supply is fitted with the necessary measuring instruments:

- Test N° 1: No load test at rated voltage and current on rotor, stator winding in open circuit. The temperature rise of the stator winding depends, in such case, on the magnetic circuit losses and mechanical losses due to ventilation, where:
  - Δt_{s1} is the stator temperature rise
  - Δt_{r1} is the rotor temperature rise
- Test N° 2: Rated stator winding current with the terminals short-circuited. The temperature of the stator winding depends on the thermal Joule losses and mechanical losses, as above, where:
  - Δt_{s2} is the stator temperature rise
  - Δt_{r2} is the rotor temperature rise, which for test N° 2 is negligible
- Test N° 3: Zero excitation. The temperature of all windings depends on the mechanical losses due to friction and ventilation, where:
  - Δt_{s3} is the stator temperature rise
  - Δt_{r3} is the rotor temperature rise.

Note 1: The synchronous electric motor is supplied at its rated speed by a driving motor. The temperature balance will be considered as being obtained, when the temperature rise does not vary by more than 1°C per hour.

1.1.2 Temperature measurements of the stator winding can be based on the use of embedded temperature sensors or measurement of winding resistance. When using the resistance method for calculation of the temperature rise, the resistance measurement is to be carried out as soon as the machine is shut down.

The rotor temperature rise is obtained by calculation of rotor resistance, $R_{rotor} = (U/I)_r$, where U and I are the voltage and current in the magnetic field winding.

The following parameters are recorded, every 1/2 hour:

- temperature sensors as well as the stator current and voltage
- the main field voltage and current
- the bearing temperatures (embedded sensor or thermometer), and the condition of cooling of the bearings, which are to be compared to those expected on board.

1.1.3 The tests described above allow the determination of the final temperature rise of stator and rotor windings with an acceptable degree of accuracy.

- The temperature rise of the stator winding is estimated as follows:

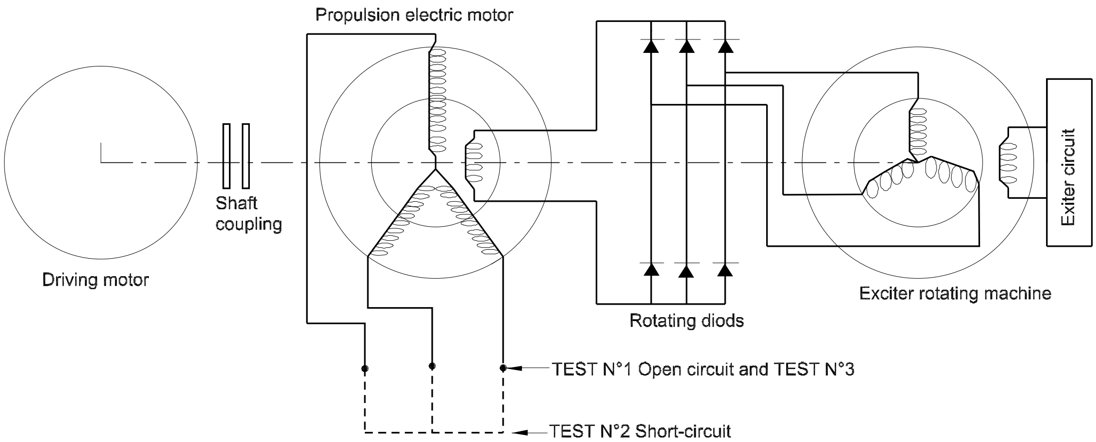
  $\Delta t_{stator} = \Delta t_{s1} + \Delta t_{s2} - \Delta t_{s3}$

  Δt_{stator} winding is to be corrected by the supplementary temperature rise due to current harmonics evaluated by the manufacturer
- Considering that in test N° 1 the magnetic field winding current Irt is different from the manufacturer's estimated value Ir (due to the fact that the cos φ in operation is not equal to 1), the temperature rise of the rotor is to be corrected as follows:

  $\Delta t_{rotor} = (\Delta t_{r1} - \Delta t_{r3})$ x (rated loading conditions Ir/ test loading conditions Irt)^2 + Δt_{r3}

1.1.4 In the indirect method, a possible mutual influence of the temperature rise between the stator and the rotor is not taken into consideration. The test results may be representative of the temperature rise on board ship, but a margin of 10 to 15°C is advisable compared with the permitted temperature of the Rules and the measure obtained during tests.

Figure 1 : Schematic diagram used for the test



Part C

Machinery, Systems and Fire Protection

Chapter 3

FIRE PROTECTION, DETECTION AND EXTINCTION

SECTION 1 REQUIREMENTS FOR FIRE PROTECTION, DETECTION AND EXTINCTION

1 General

1.1 Application

1.1.1 The requirements of this Chapter are not applicable for the purpose of classification, except where Tasneef carries out surveys relevant to fire protection statutory requirements on behalf of the flag Administration.

In such cases, fire protection statutory requirements are considered a matter of class and therefore compliance with these requirements is also verified by Tasneef for classification purposes.

1.1.2 This Section contains:

a) requirements applicable to fire protection equipment

b) requirements relevant to fire protection that Tasneef applies to cargo ships with steel hulls engaged in inland navigation.

c) depending from the ship' s service the additional requirements of Part F are to be applied

2 Documentation to be submitted

2.1

2.1.1 The following documents are to be submitted by the Interested Party to the Society if applicable:

- general water fire-extinguishing systems
- CO_2 extinguishing systems
- other gas fire-extinguishing systems
- foam extinguishing systems
- fire detection and alarm systems
- fire control plan.

3 Definitions

3.1 Machinery spaces

3.1.1 Machinery spaces are machinery spaces of category A and other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

3.2 Machinery spaces of category A

3.2.1 Machinery spaces of category A are those spaces and trunks to such spaces which contain either:.

- internal combustion machinery used for main propuls
- internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or
- any oil fired boiler or oil fuel unit, or any oil fired equipment other than boilers, such as inert gas generators, incinerators, etc.

3.3 Accommodation spaces

3.3.1 Accommodation spaces are those spaces used for public spaces, corridors, stairs, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

3.4 Central control station

3.4.1 A central control station is a control station in which the following control and indicator functions are centralised:

a) fixed fire detection and alarm systems;

b) automatic sprinklers, fire detection and alarm systems;

c) fire door indicator panels;

d) fire door closures;

e) watertight door indicator panels;

f) watertight door closures;

g) ventilation fans;

h) general/fire alarms.

3.5 Cargo area

3.5.1 The cargo area is that part of the ship that contains cargo holds, cargo tanks, slop tanks and cargo pump rooms including pump rooms, cofferdams, ballast and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the abovementioned spaces.

For the definition of the cargo area of chemical tankers and gas carriers, refer to Pt E, Ch 1, Sec 13 and Sec 14, respectively.

3.6 Service spaces

3.6.1 Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

Main pantries and pantries containing cooking appliances may contain:

- toasters, induction heaters, microwave ovens and similar appliances each of them with a maximum power of 5 kW;
- electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 2 kW and a surface temperature not above 150°C;
- water boilers, regardless of their electrical power;
- coffee automats, and non-cooking appliances such as dishwashers, water boilers, ice-cube machines and fridges without any restriction on their power. A dining room containing such appliances is not to be regarded as a pantry.

Spaces containing any electrically heated cooking plate or hot plate for keeping food warm, with a power of more than 2 kW, or toasters, induction heaters, microwave ovens and similar appliances each of them with power greater than 5 kW are to be regarded as galleys.

3.7 Fire Test Procedures Code

3.7.1 The International Code for the Application of Fire Test Procedures adopted under Resolution MSC.61(67) by the Maritime Safety Committee of the IMO.

3.8 Cargo ship

3.8.1 Cargo ship is any ship which is not a passenger ship.

3.9 Passenger ship

3.9.1 A passenger ship is a ship which carries more than twelve passengers.

3.10 Tanker

3.10.1 A tanker is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of an inflammable nature.

3.11 A class divisions

3.11.1 Divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material or alternative forms of construction to be in compliance with the requirements of this Section;

b) they are suitably stiffened;

c) they are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:
   - class "A-60" ....60 min
   - class "A-30" ....30 min
   - class "A-15"..15 min
   - class "A-0"...0 min

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one hour standard fire test; Tasneef will require a test of a pro-totype bulkhead or deck in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity or temperature rise. The prod-ucts indicated in Tab 1 may be installed without testing or approval;

Table 1

Classification	Product description
class “A-0” bulkhead	A steel bulkhead with dimension not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 60 x 60 x 5 mm spaced at 600 mm or structural equivalent
class “A-0” deck	A steel deck with dimension not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 95 x 65 x 7 mm spaced at 600 mm or structural equivalent

3.12 B class divisions

3.12.1 Divisions formed by bulkheads, decks, ceilings or linings that comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials entering into the construction and erection of "B" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet the other appropriate requirements of this Chapter;

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140° C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225° C above the original temperature, within the time listed below:
   - class "B-15"..15 min
   - class "B-0"...0 min

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test;

Tasneef will require a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity or temperature rise.

3.13 Combustible material

3.13.1 Any material other than a non-combustible material;

3.14 Continuous B class ceilings and linings

3.14.1 B class ceilin.s or linings which terminate at an A or B class division.

3.15 Continuously manned central control station

3.15.1 A continuously manned central control station is a central control station which is continuously manned by a responsible member of the crew.

3.16 Control stations

3.16.1 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 centralised.

3.17 Low flame spread

3.17.1 Low flame spread means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the "Fire Test Procedures Code".
Non-combustible materials are considered as low flame spread. However, due consideration will be given by Tasneef to the method of application and fixing

3.18 Non combustible material

3.18.1 Non-combustible material is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the "Fire Test Procedures Code".

In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

3.19 Not readily ignitable material

3.19.1 Not readily ignitable materials mean a material which will not give rise to smoke or toxic and explosive hazards at elevated temperatures (see Note 1).

Note 1: Reference is made to the Fire Test Procedure Code, Annex 1, Part 6, adopted by IMO by Resolution MSC.61 (67).

3.20 Working stations

3.20.1 An area where members of the crew carry out their duties, including gangway, derrick and ship's boat.

4 Type approved products

4.1

4.1.1 The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which acceptance may be given for individual ships on the basis of suitable documentation or ad hoc tests:

a) Flexible pipes and expansion bellows of non-conventional material for any type of fluid
b) Nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces and boiler rooms
c) Sensing heads for automatic fire alarm and fire detection systems.
d) Fixed fire detection and fire alarm systems
e) Explosive mixture detecting systems
f) Portable explosive mixture detecting apparatus
g) Fixed instruments for measuring the oxygen content for inert gas systems serving cargo tanks
h) Portable instruments for measuring the oxygen content for inert gas systems serving cargo tanks.

5 Non-sparking fans

5.1 General

5.1.1 Where non-sparking fans are required by the Rules, the provisions of [5.2] and [5.3] are also to be complied with.

5.2 Design criteria

5.2.1

a) The air gap between the impeller and the casing is to be not less than 0,1 of the shaft diameter in way of the impeller bearing and in any case not less than 2 mm, but need not exceed 13 mm.
b) Protective screens with square mesh of not more than 13 mm are to be fitted to the inlet and outlet of ventilation openings on the open deck to prevent objects entering the fan housing.

5.3 Materials

5.3.1

a) Except as indicated in the fourth bullet of item 3) below, the impeller and the housing in way of the impeller are to be made of spark-proof materials which are recognised as such by means of an appropriate test to the satisfaction of the Society.
b) Electrostatic charges, both in the rotating body and the casing, are to be prevented by the use of antistatic materials. Furthermore, the installation on board of ventilation units is to be such as to ensure their safe bonding to the hull.

c) Tests may not be required for fans having the following material combinations:
   - impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
   - impellers and housings of non-ferrous materials
   - impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous material is fitted in way of the impeller
   - any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.

d) The following impeller and housing combinations are considered as sparking and therefore are not permitted:
   - impellers of an aluminium alloy or a magnesium alloy and a ferrous housing, regardless of tip clearance
   - housings made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
   - any combination of ferrous impeller and housing with less than 13 mm design tip clearance.

e) Complete fans are to be tested in accordance either with the Society's requirements or national or international standards accepted by the Society.

6 Engine exhaust systems

6.1

6.1.1 The exhaust gases are to be completely ducted out of the vessel. All suitable measures are to be taken to avoid ingress of the exhaust gases into the various compartments. Exhaust pipes passing through accommodation or the wheelhouse are, within these, to be covered by protective gas-tight sheathing. The gap between the exhaust pipe and this sheathing is to be open to the outside air. The exhaust pipes are to be arranged and protected in such a way that they cannot cause a fire. The exhaust pipes are to be suitably insulated or cooled in the engine rooms. Protection against physical contact is to be adequate outside the engine rooms.

7 Engine and boilers installation

7.1

7.1.1 General

a) Engine or boiler rooms are to be arranged in such a way that the equipment therein can be operated, serviced and maintained easily and safely. The liquid fuel or lubricant bunkers and passenger areas and accommodation may not have any common surfaces which are under the static pressure of the liquid when in normal service.

b) Engine room, boiler room and bunker bulkheads, ceilings and doors are to be made of steel or another equivalent non-combustible material. Insulation material used in engine rooms is to be protected against the intrusion of fuel and fuel vapours. All openings in walls, ceilings and doors of engine rooms, boiler rooms, and bunker rooms are to be such that they can be closed from outside the room. The locking devices are to be made from steel or an equivalently non-combustible material.

c) Engine and boiler rooms and other premises in which flammable or toxic gases are likely to escape are to be capable of being adequately ventilated.

d) Companionways and ladders providing access to engine and boiler rooms and bunkers are to be firmly attached and be made of steel or another shock-resistant and non-combustible material.

e) The maximum permissible sound pressure level in the engine rooms is to be 110 dB(A). The measuring points are to be selected as a function of the maintenance work needed during normal operation of the plant located therein.

8 Fuel oil system and ventilation means of closing

8.1

8.1.1 A quick-closing valve is to be provided on the fuel oil supply to the engines or to the burners of each boiler, arranged to be easily operated in case of emergency, either directly or by remote control.

Air ducts to engine and boilers rooms are to be fitted with gas-tight means of closure made of non-combustible material, which can be closed from the deck. Engine room skylights are also to be closed from the outside.

9 Escapes

9.1 Ladders, steps and similar devices

9.1.1

a) Stairs and ladders are to be securely fixed. Stairs are to be not less than 0,60 m wide and the clear width between handrails is to be not less than 0,60 m; steps are to be not less than 0,15 m deep; steps are to have non-slip surfaces and stairs with more than three steps are to be fitted with handrails.

b) Ladders and separately attached rungs are to have a clear width of not less than 0,30 m; rungs are to be not more than 0,30 m apart and the distance between rungs and structures is to be not less than 0,15 m.

c) Ladders and separately attached rungs are to be clearly recognisable from above and are to be equipped with safety handles above exit openings.

d) Movable ladders are to be at least 0,40 m wide, and at least 0,50 m wide at the base; it is to be possible to ensure that they will not topple or skid; the rungs are to be securely fixed in the uprights.

e) Companionways and ladders providing access to engine and boiler rooms and bunkers are to be firmly attached and be made of steel or another shock-resistant and non-combustible material.

9.2 Ladders, steps and similar devices

9.2.1

a) The number, arrangement and dimensions of exits, including emergency exits, are to be in keeping with the purpose and dimensions of the relevant space. Where one of the exits is an emergency exit, it is to be clearly marked as such.

b) Emergency exits or windows or the covers of skylights to be used as emergency exits are to have a clear opening of not less than 0,36 m^2, and the smallest dimension is to be not less than 0,50 m.

9.3 Machinery spaces escapes

9.3.1

a) Engine and boiler rooms are to have two exits of which one may be an emergency exit.

The second exit may be dispensed with if:

1) the total floor area (average length x average width at the level of the floor plating) of the engine or boiler room does not exceed 35 m^2; and
2) the path between each point where servicing or maintenance operations are to be carried out and the exit, or foot of the companionway near the exit providing access to the outside, is not longer than 5 m; and
3) a fire extinguisher is located at the servicing point that is furthest removed from the exit door and also where the installed power of the engines does not exceed 100 kW.

9.4 Accommodation escapes

9.4.1

a) Living and sleeping quarters are to have at least two exits which are as far apart from each other as possible and which serve as escape routes. One exit may be designed as an emergency exit. This does not apply to rooms with an exit leading directly onto the deck or into a corridor which serves as an escape route, provided the corridor has two exits apart from each other leading to port and starboard. Emergency exits, which may include skylights and windows, are to have a clear opening of at least 0,36 m^2 and a shortest side no less than 0,50 m and permit rapid evacuation in an emergency. Insulation and cladding of escape routes are to be made of flame-retardant materials and the usability of escape routes is to be guaranteed at all times by appropriate means such as ladders or separately attached rungs.

b) Doors are to have an opening whose upper edge is at least 1,90 m above deck or above the floor and a clear width of at least 0,60 m. The prescribed height may be achieved by means of sliding or hinged covers or flaps. Doors are to open to the outside and it is to be possible to open them from either side. Sills are to be not more than 0,40 m high, but are to nonetheless comply with the provisions of other safety regulations.

c) Stairways are to be permanently fixed and safely negotiable. They are to be deemed to be so when:

1) they are at least 0,60 m wide;
2) the tread is at least 0,15 m deep;
3) the steps are non-slip;
4) stairways with more than three steps are fitted with at least one handrail or handle.

10 Suppression of fire - detection and alarm

10.1 Fire-extinguishing arrangements in machinery spaces

10.1.1 Application

Machinery spaces and pump rooms are to be protected with a gas fire-extinguishing system in compliance with these Rules.

Machinery spaces of cargo ships not carrying dangerous goods having a Rule Length not more than 40 m and with the hull made in steel need not to be provided with the above fire-extinguishing system.

Fire-extinguishing systems not dealt with in these Rules are to comply with the relevant Tasneef provisions.

10.1.2 Permanently installed fire-fighting systems *(1/3/2019)*

a) Extinguishing agents

For protecting machinery spaces and pump rooms, the following extinguishing agents may be used in permanently installed fire-fighting systems:

1) CO_2 (carbon dioxide);
2) HFC 227ea (heptafluoropropane - FM 200);
3) IG-541 (52% nitrogen, 40% argon, 8% carbon dioxide);
4) FK-5-1-12 (Dodecafluoro-2-methylpentane-3-on);
5) water.

b) Ventilation, air intake

1) Combustion air for the propulsion engines is not to be extracted from rooms that are to be protected by permanently installed fire-fighting systems. This is not to apply where there are two mutually independent and hermetically separated main engine rooms or if next to the main engine room there is a separate engine room with a bow thruster, ensuring that the vessel can continue to make steerageway under its own power in the event of fire in the main engine room.
2) Any forced ventilation present in the room to be protected is to switch off automatically if the fire-fighting system is triggered.
3) There are to be devices available with which all apertures which can allow air to enter or gas to escape from the room to be protected can be

quickly closed. It is to be clearly recognisable whether they are open or closed.

4) The air escaping from relief valves in the compressed air tanks installed in engine rooms is to be conveyed to the open air.

5) Over- or under-pressure resulting from the inflow of extinguishing agent is not to destroy the components of the surrounding partitions of the room to be protected. It is to be possible for the pressure to equalise without danger.

6) Protected rooms are to have a facility for extracting the extinguishing agent and the combustion gases. Such facilities are to be capable of being operated from positions outside the protected rooms and which would not be made inaccessible by a fire within such spaces. If there are permanently installed extractors, it is not to be possible for these to be switched on while the fire is being extinguished.

c) Fire alarm system

When by this rules a fire alarm system is to be fitted it shall be Tasneef type approval.

The space to be protected is to be monitored by means of an appropriate type approved fire detection system. The alarm is to be noticeable in the wheelhouse, the accommodation spaces and the room to be protected.

d) Piping system

1) The extinguishing agent is to be conveyed to the room to be protected and distributed there by means of a fixed piping system. Inside the room to be protected the piping and associated fittings are to made of steel. Tank connecting pipes and expansion joints are to be exempt from this, provided the materials used have equivalent properties in case of fire. Pipes are to be both internally and externally protected against corrosion.

2) Outlet nozzles are to be dimensioned and fitted such that the extinguishing agent is evenly distributed. In particular the extinguishing agent shall also be effective beneath the floor plates.

e) Triggering device

1) Fire-fighting systems with automatic triggering are not permissible.

2) It is to be possible to trigger the fire-fighting system from a suitable place outside the room to be protected.

3) Triggering devices are to be installed in such a way that they can be operated even in the event of a fire and such that, in the event of damage by fire or explosion in the room to be protected, the necessary quantity of extinguishing agent can still be con-veyed.

Non-mechanical triggering devices are to be powered from two different mutually independent energy sources.

These energy sources are to be located outside the room to be protected. Control lines in the room to be protected are to be designed so as to remain functional for at least 30 minutes in the event of fire. This requirement is to be fulfilled in the case of electrical wiring if it complies with IEC Standard 60331-21:1999.

If triggering devices are installed in such a way that they are out of sight. the panel covering them is to be identified by the 'fire-fighting installation' symbol as shown in Figure 1, having a side length of at least 10 cm, and the following text in red lettering on a white background: Fire Fighting system

Figure 1 : Fire-fighting installation

4) If the fire-fighting system is intended for the protection of several rooms, the triggering devices for each room are to be separate and clearly identified.

5) Next to each triggering device, operating instructions in a language the crew can read and understand are to be posted up visibly and indelibly. They are to contain, in particular, instructions regarding:

- triggering of the fire-fighting system;
- the need for checking to ensure that all persons have left the room to be protected;
- action to be taken by the crew when the fire-fighting system is triggered;
- action to be taken by the crew in the case of failure of the fire-fighting system.

6) The operating instructions are to point out that before the fire-fighting system is triggered, combustion engines drawing air from the room to be protected are to be shut down.

f) Warning system

1) Permanently installed fire-fighting systems are to be provided with acoustic and optical warning systems.

2) The warning system is to be set off automatically as soon as the fire-fighting system is first triggered. The warning signal is to sound for an appropriate time

before the extinguishing agent is released and it is not to be possible to switch it off.

3) Warning signals are to be clearly visible in the rooms to be protected and outside the accesses to them and clearly audible even under operating conditions producing the loudest inherent noise. They are to be clearly distinct from all other acoustic and optical signals in the room to be protected.

4) The acoustic warning signals are to be clearly audible in the adjacent rooms even when connecting doors are closed and under operating conditions producing the loudest inherent noise.

5) If the warning system is not self-monitoring as regards short-circuits, wire breaks and voltage drops, it is to be possible to check that it is working properly.

6) At every entrance to a room that can be supplied with extinguishing agent, a clearly visible notice is to be put up bearing the following text in red lettering on a white background:

- warning, fire-fighting installation
- leave the room as soon as the warning signal sounds (description of signal).

g) Pressure tanks, fittings and pressure pipes

1) Pressure tanks, fittings and pressure pipes are to comply with the provisions in force of the competent authority.

2) Pressure tanks are to be installed in accordance with the Manufacturer's instructions.

3) Pressure tanks, fittings and pressure pipes are not to be installed in accommodation spaces.

4) The temperature in cabinets and installation spaces containing pressure tanks is not to exceed 50°C.

5) Cabinets or installation spaces on deck are to be firmly fixed in place and have air vents which are to be arranged in such a way that in the event of a leak in the pressure tank no gas can escape into the interior of the vessel. Direct connections to other rooms are not permitted.

h) Quantity of extinguishing agent

If the quantity of extinguishing agent is intended for protecting more than one room, the total amount of extinguishing agent available does not need to be greater than the quantity necessary for the largest room to be protected.

i) CO_2 fire-fighting systems

Fire-fighting systems using CO_2 as the extinguishing agent are to comply with the following provisions in addition to the requirements under paragraphs 1 to 6:

1) CO_2 containers are to be housed outside the room to be protected in a space or cabinet hermetically separated from other rooms. The doors to these installation spaces and cabinets are to open outwards, be lockable and bear on the outside a symbol for 'General danger warning' in accordance with Figure 4 of Appendix I, at least 5 cm in height, together with the marking 'CO_2' in the same colour and with the same height;

2) installation spaces below decks for CO_2 containers are to be accessible only from the open air. These spaces are to have their own adequate artificial ventilation system with extraction ducts, completely separate from other ventilation systems on board;

3) the CO_2 containers are not to be filled to more than 0,75 kg/l. The specific volume of unpressurised CO_2 gas is to be taken as 0,56 m^3/kg;

4) the volume of CO_2 for the room to be protected is to be at least 40% of its gross volume. It is to be possible to supply this volume within 120 seconds, and to check whether supply has been completed;

5) opening the container valves and operating the flood valve are to be separate control operations;

6) the appropriate time mentioned under paragraph 6(b) is to be at least 20 seconds. There is to be a reliable device to ensure the delay before delivery of the CO_2 gas.

j) HFC-227ea - fire-fighting systems

Fire-fighting systems using HFC-227ea as the extinguishing agent are to comply with the following provisions in addition to the requirements under paragraphs 1 to 8:

1) if there are several rooms to be protected, each with a different gross volume, each room is to be provided with its own fire-fighting system;

2) each container of HFC-227ea that is installed in the room to be protected is to be equipped with an overpressure relief valve. This is to harmlessly release the contents of the container into the room to be protected if the container is exposed to the effects of fire and the fire-fighting system has not been triggered;

3) each container is to be fitted with a device for checking the gas pressure;

4) the containers are not to be filled to more than 1,15 kg/l. The specific volume of the unpressurised HFC-227ea is to be taken as 0,1374 m^3/kg;

5) the volume of HFC-227ea for the room to be protected is to be at least 8% of the room's gross volume. This volume are to be supplied within 10 seconds;

6) the HFC-227ea containers are to be provided with a pressure monitor which triggers an acoustic and optical alarm signal in the wheelhouse in the event of an unauthorised loss of propellant. If there is no wheelhouse, this alarm signal is to be given outside the room to be protected;

7) after flooding, the concentration in the room to be protected is not to exceed 10,5%;

8) the fire-fighting system is not to contain any parts made of aluminium.

k) IG-541 - fire-fighting systems

Fire-fighting systems using IG-541 as the extinguishing agent are to comply with the following provisions in addition to the requirements under paragraphs 1) to 5):

1) if there are several rooms to be protected, each with a different gross volume, each room is to be provided with its own fire-fighting system;

2) each container of IG-541 that is installed in the room to be protected is to be equipped with an overpressure relief valve.

   This is to harmlessly release the contents of the container into the room to be protected if the container is exposed to the effects of fire and the fire-fighting system has not been triggered;

3) each container is to be fitted with a device for checking the contents;

4) the fill

   ing pressure of the container is not to exceed 200 bar at + 15°C;

5) the volume of IG-541 for the room to be protected is to be at least 44% and no more than 50% of the room's gross volume. This volume is to be supplied within 120 seconds.

l) FK-5-1-12 - firefighting systems

Firefighting systems using FK-5-1-12 as the extinguishing agent shall comply with the following provisions in addition to the requirements under paragraphs 1) to 7):

1) if there are several rooms to be protected, each with a different gross volume, each room shall be provided with its own firefighting system;

2) each container of FK-5-1-12 installed in the room to be protected shall be equipped with an overpressure relief valve. The overpressure relief valve shall harmlessly release the contents of the container into the room to be rotected if the container is exposed to the effects of fire and the firefighting system has not been triggered;

3) each container shall be fitted with a device for checking the gas pressure;

4) the containers shall not be filled to more than 1,00 kg/l. The specific volume of the unpressurised FK-5-1-12 is to be taken as 0,0719 m^3/kg;

5) the volume of FK-5-1-12 for the room to be protected shall be at least 5,5 % of the room's gross volume. This volume shall be supplied within 10 seconds;

6) the FK-5-1-12 containers shall be provided with a pressure monitor which triggers an acoustic and optical alarm signal in the wheelhouse in the event of an unauthorised loss of propellant. If there is no wheelhouse, this alarm signal shall be given outside the room to be protected;

7) after flooding, the concentration in the room to be protected shall not exceed 10,0 %.

Fire-fighting systems using water as the extinguishing agent:

Fire-fighting systems using water as the extinguishing agent may only release this agent into the room to be protected in the form of a water mist. The droplet size must be between 5 and 300 microns.

In addition to the requirements laid down in (1) to (7) and (9), (8) applies mutatis mutandis, these fire-fighting systems must comply with the following provisions:

1) The fire-fighting system shall have a type-approval pursuant to MSC/Circ. 11651 (see Note 1) or another Standard recognised by one of the Member States. Type-approval shall be carried out by a recognised classification society or an accredited testing institution. The accredited testing institution shall comply with the European Standard for general requirements for the competence of testing and calibrating laboratories (EN ISO/IEC 17025 : 2005).

Note 1: Circular MSC/Circ. 1165 - Revised guidelines for the approval of equivalent water-based fire-extinguishing systems for machinery spaces and cargo pump-rooms - adopted on 10 June 2005 and as amended by MSC/Circ.1269 , MSC/Circ.1386 and MSC/Circ.1385.

2) The fire-fighting system must be sized according to the largest of the rooms to be protected and must be able to spray water continuously into the room for a minimum of 30 minutes.

3) The pumps, their switching mechanisms and the valves that are required in order for the system to operate should be installed in a room outside the rooms to be protected. The room in which they are installed should be separated from adjacent by at least type A30 partition walls.

4) The fire-fighting system must be completely full of water at all times at least as far as the trip valves and be under the required initial operating pressure. The water supply pumps must be automatically initiated when the system is triggered. The system must feature a continuously operating water supply. Measures must be taken to ensure impurities do not affect system operation.

5) The capacity and design of the system's pipe network must be based on an hydraulic calculation.

6) The number and arrangement of nozzles must ensure sufficient distribution of water in the rooms to be protected. The spray nozzles must be located so as to ensure that the water mist is distributed throughout the room to be protected, especially in those areas where there is a higher risk of fire, including behind the fittings and beneath the floor.

7) The fire-fighting system's electrical components in the room to be protected must at a minimum comply with protection class IP54. The system shall feature two independent energy sources with automatic switching. One of the power sources must be located outside the room to be protected. Each power source should on its own be capable of ensuring the operation of the system.

8) The fire-fighting system must feature redundant pumps.

9) The fire-fighting system must be equipped with a monitoring device which triggers an alarm signal in the wheelhouse in the following cases:
   - drop in water tank level (if fitted),
   - power supply failure,
   - loss of pressure in the low pressure system pipework,
   - loss of pressure in the high pressure circuit,
   - when the system is activated.

10) The documents required for the installation, functional testing and documentation of the installation referred to in (9) must include at a minimum:
   - a schematic diagram of the system showing the sections of pipe work and the types of spray nozzle,
   - a schematic diagram of the system showing the sections of pipe work and the types of spray nozzle,
   - the manufacturer's technical documentation covering all aspects of the installation,
   - the maintenance manual.

m) Fire-fighting systems for protecting objects

For protecting objects in engine rooms, boiler rooms and pump rooms, permanently installed fire-fighting systems are not allowed.

10.2 Automatic Pressure Water-Spraying System

10.2.1 *(1/1/2017)*

When by this rules an automatic water spraying system is required, it is to be in compliance with these Rules.

Fire protection in accommodation spaces, wheelhouses and passenger spaces is to be provided only by suitable automatic pressurised water sprinklers as permanently installed fire-fighting systems.

The automatic pressure spraying system is to be in compliance with the following requirements. According to the space to be protected and considering the fire risk Tasneef may accept different system provided that they are in conformity with the applicable Tasneef Rules.

10.2.2 *(1/3/2019)*

a) The systems are to be made of steel or equivalent non-combustible materials.

b) The systems are to be able to spray water at a rate of at least 5 l/m^2 per minute over the area of the largest room to be protected.

Systems spraying smaller quantities of water shall have a type-approval pursuant to IMO Resolution A.800 (19) (see Note 1) or another Standard recognised by one of the Member States. Type- approval shall be carried out by a recognised classification society or an accredited testing institution. The accredited testing institution shall comply with the European Standard EN ISO/IEC 17025 : 2005.

Note 1: IMO Resolution A.800 (19) adopted on 23 November 1995 - Revised Guidelines for Approval of Sprinkler Systems Equivalent to that referred to in SOLAS Regulation II-2/12.

10.2.3 Pumps and pressure water tanks

Water pressure tanks and water pumps are to be located outside, and at a sufficient distance from, the space to be protected.

The pressure pumps may only be used for supplying water to the pressure water-spraying systems. In the event of a pressure drop in the system, the pump is to start up automatically before the fresh water charge in the pressure water tank has been exhausted. Suitable means of testing are to be provided. The pump is to have a minimum delivery rate of 375l/min. The pump is to be provided with a direct suction connection at the vessel's side. The shut-off device is to be secured in the open position. A suitable raw water filter is to be fitted, the mesh size of which is able to prevent coarse impurities from clogging the nozzles. The pump delivery is to be fitted with a test valve with connecting pipes, the cross-section of which is compatible with the pump capacity at the prescribed head. Pressure water tanks are to be fitted with a safety valve, connected directly without valves to the water compartment, with a water level indicator that can be shut off and is protected against damage, and with a pressure gauge. Furthermore, Ch 1, Sec 3 is to be applied. The volume of the pressure water tank is to be equivalent to at least twice the specified pump delivery per minute. The tank is to contain a standing charge of fresh water equivalent to at least the specified volume delivered by the pump in one minute. The tank is to be fitted with a connection to enable the entire system to be refilled with fresh water. The pressure water tank is to be installed in a frost-proof space. Means are to be provided for replenishing the air cushion in the pressure water tank. The system is to be completely charged with fresh water when not in operation.

In addition to the water supply to the spraying equipment located outside the spaces to be protected, the system is also to be connected to the fire main via a screw-down non-return valve. The equipment is to be kept permanently under pressure and to be ready at all times for immediate, automatic operation. With the test valve at the alarm valve in the fully open position, the pressure at the level of the highest spray nozzles is to still be at least 1,75 bar. At least two mutually independent power sources are to be provided for supplying the pump and the automatic indicating and alarm systems. Each source is to be sufficient to power the equipment.

10.2.4 Piping, valves and fittings

Lines between the suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in Ch 1, Sec 10.

Lines are to be effectively protected against corrosion.

Check valves are to be fitted to ensure that raw water cannot penetrate into the pressure water tank and that water for fire-extinguishing cannot be discharged overboard through pump suction lines.

Hose connections are to be provided at suitable points on the port and starboard sides for supplying the equipment with water from the shore. The connecting valves are to be secured against being opened unintentionally.

Each line leading to a section of the system is to be equipped with an alarm valve (see also [3.1.9]).

Shut-off devices located between the pump delivery and the alarm valves are to be secured in the open position.

10.2.5 Nozzles

The nozzles are to be grouped into sections.

A sprinkler section may extend only over one main fire section or one watertight compartment and may not include more than two vertically adjacent decks.

The spray nozzles are to be so arranged in the upper deck area that a water volume of not less than 5 $l/m^2 \cdot min$ is sprayed over the area to be protected.

Inside accommodation and service spaces the spray nozzles are to be activated within a temperature range from 68°C to 79°C . This does not apply to spaces such as drying rooms with higher temperatures. Here the triggering temperature may be up to 30°C above the maximum temperature in the deck head area.

The nozzles are to be made of corrosion-resistant material.

Nozzles of galvanised steel are not allowed.

10.2.6 Alarm systems

Every spray nozzle section is to be equipped with an alarm valve which, when a nozzle is opened, actuates a visual and audible alarm at one or more suitable positions, at least one of which is to be permanently manned. In addition, each alarm valve is to be fitted with a pressure gauge and a test valve with an I.D. corresponding to a spray nozzle.

At the positions mentioned here above, an automatic indicating device is to be mounted which identifies the actuated sprinkler section.

The electrical installation is to be self-monitoring and capable of being tested separately for each section.

10.2.7 *(1/1/2017)*

According to the space to be protected and considering the fire risk Tasneef may accept different system provided that they are in conformity with the applicable Tasneef Rules.

10.3 Water fire-fighting system

10.3.1 Self-propelled vessels

Self-propelled vessels are to be equipped with a hydrant system.

10.3.2 Hydrant system

a) The system is to consist of:

1) two motor-driven fire-extinguishing pumps of sufficient capacity, at least one of which is permanently installed, with a capacity:

$$Q = (1 + 0,066 \cdot \sqrt{L \times (B + D)})^2 \quad (m^3/h)$$

where:

L = is the length of the ship

B = is the moulded breadth

D = is the moulded depth measured to the bulkhead deck amid ship

The pump is to be driven by a source independent from the propulsion engines. In any case, for vessels having a hull length of not more than 35 m, a fire pump driven by the propulsion engine may be accepted, providing that a suitable additional hand pump is fitted. For vessels of hull length more than 35 m, the additional fire pump is to be mechanically driven by a source independent from the propulsion engines.

2) one fire extinguisher line with a sufficient number of hydrants with permanently connected fire hoses at least 20 m in length and fitted with a nozzle capable of producing both a mist and a jet of water and incorporating a shut-off facility.

b) Hydrant systems are to be designed and dimensioned in such a way that:

1) any point of the vessel can be reached from at least two hydrants in different places, each with a single hose and each with single hose length of not more than 20 m

2) the pressure at the hydrants is at least 300 kPa

3) on all decks a water jet length of at least 6 m can be attained

If a hydrant chest is provided, an 'extinguisher hose' symbol, of at least 10 cm side length, is to be affixed to the outside of the chest.

c) Hydrant valves with screw threads or cocks are to be such that they can be set so that each of the fire hoses can be separated and removed during operation of the fire-extinguishing pumps.

d) Fire extinguisher hoses in the internal area are to be rolled up on an axially connected reel.

e) Materials for fire-fighting equipment are either to be heat-resistant or to be suitably protected against failure to work when subjected to high temperatures.

f) Pipes and hydrants are to be arranged in such a way that the possibility of freezing is avoided.

g) The fire-extinguishing pumps are to:

1) be installed or housed in separate rooms

2) be such that they can be operated independently of each other

3) each be capable, on all decks, of maintaining the necessary pressure at the hydrants and achieving the requisite length of water jet

4) be installed forward of the aft bulkhead.

Fire-extinguishing pumps may also be used for general purposes

10.3.3 Non-self-propelled vessels

Where a non-self-propelled vessel is fitted with a hydrant system, it is to comply with 10.3.2.

10.4 Portable fire extinguisher

10.4.1 *(1/1/2017)*

a) There is to be at least one portable fire extinguisher in accordance with European Standard EN 3:1996 at each of the following places:

   1) in the wheelhouse

   2) close to each entrance from the deck to accommodation spaces

   3) close to each entrance to service spaces which are not accessible from the accommodation spaces and which contain heating, cooking or refrigeration equipment using solid or liquid fuels or liquefied gas

   4) at each entrance to engine rooms and boiler rooms

   5) at suitable points below deck in engine rooms and boiler rooms such that no position in the space is more than 10 metres walking distance from an extinguisher. In any case, for engine rooms where internal combustion engines having a power more than 375 kW but equal to or less than 750 kW are installed, at least 3 fire extinguishers are to be fitted. Where the installed power is more than 750 kW, at least 4 fire extinguishers are to be installed.

b) For the portable fire extinguishers required by paragraph 1, only powder type extinguishers with a content of at least 6 kg or other portable fire extinguishers with the same extinguishing capacity may be used. They are to be suitable for class A, B and C fires and for fires in electrical systems of up to 1000 V.

   For the portable fire extinguishers required by paragraph 1, only powder type extinguishers with a content of at least 6 kg or other portable extinguishers with the same extinguishing capacity may be used. They shall be suitable for Class A, B, C fires.

   By way of derogation on vessels with no liquefied gas installations, spray foam fire extinguishers using aqueous film-forming foam (AFFF-AR)frost proof to minus (-) 20 °C are permissible even if they are unsuitable for Class C fires. These fire extinguishers shall have a minimum capacity of 9 litres.

   All extinguishers shall be suitable to extinguish fires in electrical systems of up to 1 000 V.

c) In addition, powder, water or foam fire extinguishers may be used which are suitable at least for the class of fire most likely to occur in the room for which they are intended.

d) Portable fire extinguishers with CO2 as the extinguishing agent may be used only for extinguishing fires in galleys and electrical installations. The content of these fire extinguishers is to be no more than 1 kg per 15 m^3 of the room in which they are made available for use.

e) Portable fire extinguishers shall be checked at least every two years by a competent person. An inspection label shall be affixed to the fire extinguisher, signed by the competent person and showing the date of the inspection.

f) If portable fire extinguishers are installed in such a way that they are out of sight, the panel covering them is to be identified by a symbol for fire extinguishers as shown in Figure 2 and having a side length of at least 10 cm.

Figure 2 : Fire extinguisher

SECTION 2 ADDITIONAL FIRE APPLIANCES REQUIREMENTS FOR SHIPS CARRYING DANGEROUS GOODS

1 General

1.1 Application

1.1.1 The requirements given in this Section are in addition to those given in Sec 1 and to those given in Pt F, Ch 1, Sec 4 as applicable to vessels carrying dangerous goods with notation DG and type C, type N and type G tankers.

1.1.2 Portable fire extinguishers

In addition to the portable fire extinguishers stated in Sec 1, two portable fire extinguishers having the same capacity are to be fitted in the cargo area. Such portable fire extinguishers are to have the medium agent sized accordingly for fighting fires according to the type of product carried.

1.2 Fire-extinguishing system

1.2.1 A fire-extinguishing system is to be installed on the vessel. This system is to comply with the following requirements:

1.2.2 It is to be supplied by two independent fire or ballast pumps one of which is to be ready for use at any time. These pumps are not to be installed in the same space.

1.2.3 It is to be provided with a water main fitted with at least three hydrants in the protected area above deck. Three suitable and sufficiently long hoses with spray/jet nozzles having a diameter of not less than 12 mm are to be provided.

1.2.4 It is to be possible to reach any point of the deck in the protected area simultaneously with at least two jets of water which do not emanate from the same hydrant.

1.2.5 A spring loaded non-return valve is to be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the protected area

1.2.6 The capacity of the system is to be at least sufficient for a jet of water to reach a distance of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time.

1.3 Fixed fire-extinguishing system

1.3.1 In addition the engine room, the pump room and all spaces containing essential equipment (switchboards, compressors, etc) for the refrigeration equipment, if any, shall be provided with a fixed fire-extinguishing system, in compliance with Sec 1.