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Rules for the Classification of Inland Navigation Vessels

PART C – Machinery, Systems and Electricity

Chapters 1 – 2

NR 217.C1 DNI R02 E April 2009

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MARINE DIVISON
GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine Division (the "Society") is the classification (" Classification ") of any ship or vessel or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- prepares and publishes Rules for classification, Guidance Notes and other documents (“Rules”);
- issues Certificates, Attestations and Reports following its interventions (“Certificates”);
- publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as " Certification ".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as " Services ". The party and/or its representative requesting the services is hereinafter referred to as the " Client ". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

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

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

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

ARTICLE 3

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

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- conducts surveys at the place of their construction;
- classes Units and enters their class in its Register;
- surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

5.2. - The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder, respectively.

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - If the Services of the Society cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee.

The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

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

ARTICLE 7

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

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

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

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

ARTICLE 8

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

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

8.3. - The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit;
- copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, are passed on to IACS (International Association of Classification Societies) according to the association working rules;
- the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

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

ARTICLE 12

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

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

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

ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

RULES FOR INLAND NAVIGATION VESSELS

Part C
Machinery, Systems and Electricity

Chapters **1 2**

April 2009

These Rules apply to inland navigation vessels for which contracts for construction are signed on or after July 1st, 2009.

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

CHAPTER 1
MACHINERY AND SYSTEMS

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CHAPTER 2
ELECTRICAL INSTALLATIONS

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Part C
Machinery, Systems and Electricity

Chapter 1
MACHINERY AND SYSTEMS

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Application

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

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in Part D, for the assignment of the type and service notations and additional class notations.

1.3 Documentation to be submitted

1.3.1 The drawings and documents requested in the relevant Sections of this Chapter are to be submitted to the Society for review / approval.

1.4 Machinery spaces

1.4.1 Machinery spaces are all machinery spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.5 Essential services

1.5.1 Essential services are defined in Pt A, Ch 1, Sec 1, [1.2.16]. They are subdivided in primary and secondary essential services.

1.5.2 Primary essential services

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

Examples of equipment for primary essential services are the following:

- Steering gear
- Actuating systems for controllable pitch propellers
- Scavenging air blowers, fuel oil supply pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for the propulsion
- Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps
- Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- Electric generators and associated power sources supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety devices/systems for equipment for primary essential services
- Speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion.

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

1.5.3 Secondary essential services

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

Examples of equipment for secondary essential services are the following:

- Thrusters
- Starting air and control air compressors
- Bilge pumps
- Fire pumps and other fire-extinguishing medium pumps
- Ventilation fans for engine rooms
- Services considered necessary to maintain dangerous cargo in a safe condition
- Navigation lights, aids and signals
- Internal safety communication equipment
- Fire detection and alarm systems
- Electrical equipment for watertight closing appliances
- Electric generators and associated power supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety for cargo containment systems
- Control, monitoring and safety devices/systems for equipment for secondary essential services.

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 NR 216 Materials and Welding and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding the requirements given in [2.2.2] apply.

2.2.2 Welded machinery components

Welding processes are to be approved and welders certified by the Society in accordance with NR 216 Materials and Welding.

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

Joints transmitting loads are to be either:

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

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

T-joints on scalloped edges are not permitted.

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

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

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

2.3 Vibrations

2.3.1 Special consideration (see Ch 1, Sec 9) is to be given to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

2.4 Operation in inclined position

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

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

Table 1 : Permanent inclination of vessel

Installations, components	Angle of inclination (degrees) **(1)**	
	Athwartship	Fore and aft
Main and auxiliary machinery **(2)**	12	5

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) Higher angle values may be required depending on vessel operating conditions

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.

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +40 (+45 in tropical zone) **(1)**
On machinery components, boilers In spaces subject to higher or lower temperatures	According to specific local conditions
On exposed decks	between -20 and +40 (+45 in tropical zone)

WATER TEMPERATURE	
Coolant	Temperature (°C)
River water or, if applicable, river water at charge air coolant inlet	up to +25 in general up to +32 in tropical zone

(1) Different temperatures may be accepted by the Society in the case of vessels intended for restricted service.

2.6 Approved fuels

2.6.1 The flash point of liquid fuels for the operation of machinery and boiler installations must be above 55°C.

2.6.2 Liquid fuel must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

2.7 Power of machinery

2.7.1 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.

2.8 Astern power

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

The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the maximum ahead revolutions for a period of at least 10 min.

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

During the river trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also Ch 1, Sec 15, [3.2]).

2.9 Safety devices

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

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

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

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

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.

3.3.2 Chocking resins are to be type approved.

3.4 Safety devices on moving parts

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

3.5 Gauges

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

3.6 Ventilation in machinery spaces

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

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

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

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

3.7 Hot surfaces and fire protection

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

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material (see Ch 1, Sec 14, [1.4.2] for definition) or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

Fire protection, detection and extinction is to comply with the requirements of Ch 1, Sec 14.

3.8 Machinery remote control, alarms and safety systems

3.8.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, see Ch 2, Sec 13, [2.7] and Pt D, Ch 2, Sec 8, for additional class notation **AUT-UMS.**

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter 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 is to be informed in advance and the tests are to be carried out in accordance with the requirements of NR 216 Materials and Welding relative to incomplete tests.

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

4.2 Tests on board

4.2.1 Trials on board of machinery are detailed in Ch 1, Sec 15.

SECTION 2 INTERNAL COMBUSTION ENGINES

1 General

1.1 Scope

1.1.1 The Rules contained in this Article apply to internal combustion engines used as main propulsion units and auxiliary units.

For the purpose of these Rules, internal combustion engines are diesel engines.

1.2 Rated power

1.2.1 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.

1.2.2 In determining the power of all engines used on board inland waterway vessels with unlimited range of service, the ambient conditions given in Tab 1 are to be used.

Table 1 : Ambient conditions

Barometric pressure	1000 mbar
Suction air temperature	• 40°C, in general • 45°C, in tropical zone
Relative humidity	60%
Raw water temperature (inlet temperature of charge air coolant)	• 25°C, in general • 32°C, in tropical zone

1.2.3 Continuous power is understood to mean the net brake power which an engine is capable of delivering continuously, provided that the maintenance prescribed by the engine manufacturer is carried out, between the maintenance intervals stated by the engine manufacturer.

1.2.4 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.

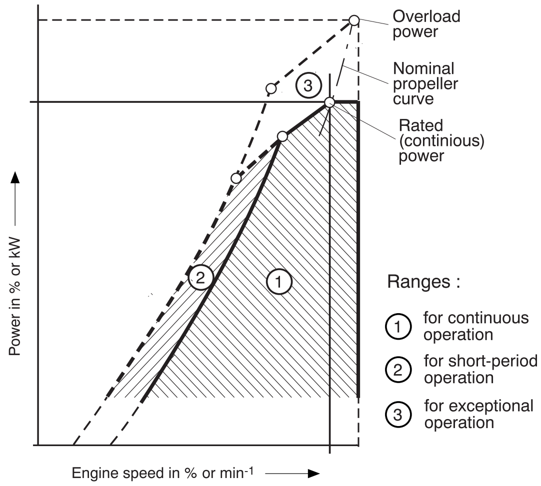
1.2.5 After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.

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

1.2.7 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.

1.2.8 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



1.3 Fuels

1.3.1 The use of liquid fuels is subject to the Rules contained in Ch 1, Sec 1, [2.6].

For fuel systems, see Ch 1, Sec 10, [7].

1.4 Accessibility of engines

1.4.1 Engines are to be so arranged in the engine room that all the erection holes and inspection ports provided by the engine manufacturer for inspections and repairs are accessible or easily be made accessible (see Ch 1, Sec 1, [3.1].

1.5 installation and mounting of engines

1.5.1 Engines are to be mounted and secured to their shipboard foundations in conformity with the Society's Rules.

1.6 Documents for review / approval

1.6.1 For each engine type, one or three copies, as specified, of the drawings and documents listed in Tab 2 shall, wherever applicable, be submitted for review / approval (A) or information (R).

The type specification of an internal combustion engine is defined by the following data:

- manufacturer's type designation
- cylinder bore
- stroke
- injection system (direct or indirect injection)
- working cycle (4-stroke, 2-stroke)
- scavenging system (naturally aspirated or supercharged)
- rated power per cylinder at rated speed and maximum mean effective working pressure
- supercharging system (pulsating pressure system or constant pressure system)
- charge air cooling system (with or without intercooler, number of cooling stages)
- cylinder arrangement (in-line, vee).

Following initial approval of an engine type by the Society, only those documents listed in Tab 2 require to be resubmitted for examination which embody important design modifications.

2 Crankshaft design

2.1 Design methods

2.1.1 Crankshafts are to be designed to withstand the stresses occurring when the engine runs at rated power. Calculations are to be based on the Society's Rules for Machinery. Other methods of calculation may be used provided that they do not result in crankshaft dimensions smaller than those specified in the most recent edition of the aforementioned Society's Rules.

Outside the end bearings, crankshafts designed according to the Society's Rules may be adapted to the diameter of the adjoining shaft by a generous fillet ($r \geq 0,06.d$) or a taper.

Design methods for application to crankshafts of special construction and to the crankshafts of engines of special type are to be agreed with the Society.

2.2 Split crankshaft

2.2.1 Fitted bolts or equivalent fastenings are to be used for assembling split crankshafts.

2.3 Torsional vibration, critical speed

2.3.1 See Ch 1, Sec 9.

Table 2 : Documents for review

Serial N°	A / R	Description	Quantity	Remarks
1	R	Details required on Society forms when applying for review / approval of a internal combustion engine	1	
2	R	Engine transverse cross section	1	
3	R	Engine longitudinal section	1	
4	R	Bedplate or crankcase	1	
5	R	Engine block	1	
6	R	Tie rod	1	
7	R	Cylinder cover assembly	1	
8	R	Cylinder liner	1	**(1)**
9	A	Crankshaft details, for each number of cylinders	3	
10	A	Crankshaft assembly, for each number of cylinders	3	
11	A	Counterweights including fastening bolts	3	
12	A	Connecting rod, details	3	
13	R	Connecting rod assembly	1	**(1)**
14	R	Piston assembly	1	
15	R	Camshaft drive assembly	1	
16	A	Material specifications of main components	3	
17	A	Arrangement of foundation bolts (for main engines only)	3	
18	A	Schematic diagram of engine control and safety system	3	
19	R	Shielding and insulation of exhaust pipes - assembly	1	
20	A	Shielding of high-pressure fuel pipes - assembly	3	**(2)**
21	A	Arrangement of crankcase explosion relief valves	3	**(3)**
22	R	Operation and service manuals	1	

(1) Only necessary if sufficient details are not shown on the transverse cross section and longitudinal section
(2) For attended engine: only engines with a cylinder bore of ≥ 250 mm
(3) Only for engines with a cylinder diameter of > 200 mm, or a crankcase volume exceeding 0,6 m^3

3 Materials

3.1 Approved materials

3.1.1 The mechanical characteristics of materials used for the components of diesel engines must conform to NR 216 Materials and Welding. The materials approved for the various components are shown in Tab 4 together with their minimum required characteristics.

Materials with properties deviating from those specified may be used only with the Society's consent.

3.2 Testing of materials

3.2.1 For the following components:

- crankshaft
- crankshaft coupling flange (non-integral) for main power transmission
- crankshaft coupling bolts
- connecting rods.

Evidence is to be supplied that the materials used meet the requirements of NR 216 Materials and Welding. This evidence may take the form of a workshop certificate.

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

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

4 Tests and trials

4.1 Pressure tests

4.1.1 Appointed components of internal combustion engines are to be subjected at the works to pressure tests at the test pressures indicated in Tab 3 or to equivalent tests.

Table 3 : Pressure tests

Component		Test pressure, p_P **(1)**
Cylinder cover, cooling water space		7 bar
Cylinder liner, over whole length of cooling water space		7 bar
Cylinder jacket, cooling water space		4 bar, at least $1,5.p_{e,zul}$
Exhaust valve, cooling water space		4 bar, at least $1,5.p_{e,zul}$
Piston, cooling water space (after assembly with piston rod, if applicable)		7 bar
Fuel injection system	Pump body, delivery side	$1,5.p_{e,zul}$ or $p_{e,zul}$ + 300 bar (whichever is less)
	Valves Pipes	$1,5.p_{e,zul}$ or $p_{e,zul}$ + 300 bar (whichever is less)
Exhaust gas turbocharger, cooling water space		4 bar, at least $1,5.p_{e,zul}$
Exhaust gas line, cooling water space		4 bar, at least $1,5.p_{e,zul}$
Main engine-driven compressor: Cylinder, cover, intercooler	Air side	$1,5.p_{e,zul}$
Aftercooler	Water side	4 bar, at least $1,5.p_{e,zul}$
Cooler, both sides (charge air cooler only on water side)		4 bar, at least $1,5.p_{e,zul}$
Main engine-driven pumps (Oil, water, fuel and bilge pumps)		4 bar, at least $1,5.p_{e,zul}$
Starting and control air system		$1,5.p_{e,zul}$ before installation

(1) Component shall normally by hydraulically tested. Other equivalent test methods may be accepted.
$p_{e,zul}$: Maximum permissible working pressure of component concerned, in bar

Table 4 : Approved materials

Minimum required characteristics	Components
Forged steel $R_m \geq 360$ N/mm²	Crankshafts Connecting rods Tie rods Bolts and studs
Rolled steel rounds $R_m \geq 360$ N/mm²	Tie rods Bolts and studs
Nodular cast iron, preferably ferritic grades	Engine blocks Bedplates Cylinders covers Flywheels Valve bodies and similar parts
Lamellar cast iron $R_m \geq 200$ N/mm²	Engine blocks Bedplates Cylinder covers Liners Flywheels
Shipbuilding steel All grade D for plates ≤ 25 mm thick	Welded bedplates Welded engine blocks
Shipbuilding steel All grade D for plates > 25 mm thick or equivalent structural steel, cast in the fully killed condition and normalized	
Weldable cast steel	Bearing transverse girders

4.2 Test bed trials

4.2.1 In general, engines are to be subjected under the Society's supervision to a test bed trial of the scope stated below. Exceptions to this require the agreement of the Society.

Main engines for direct propeller drive:

a) 100% power (rated power)

at rated speed n_0: 60 minutes

b) 100% power

at n = 1,032 n_0: 45 minutes

c) 90%, 75%, 50% and 25% power in accordance with the nominal propeller curve.

In each case the measurements shall not be carried out until the steady operating condition has been achieved.

d) Starting and reversing manoeuvres

e) Test of governor and independent overspeed protection device

f) Test of engine shutdown devices.

For main engines for indirect propeller devices, the test is to be performed at rated speed with a constant governor setting under conditions of:

a) 100% power

(rated power): 60 minutes

b) 110% power: 45 minutes

c) 75%, 50% and 25% power and idle run

In each case the measurements shall not be carried out until the steady operating condition has been achieved.

d) Start-up tests

For auxiliary driving engines and engines driving electric generators, tests are to be performed in accordance with hereabove paragraph (main engines for indirect propeller devices). The manufacturer's test bed reports are acceptable for auxiliary driving engines rated at ≤ 100 kW.

5 Safety devices

5.1 Speed control and engine protection against overspeed

5.1.1 Main and auxiliary engines

Each diesel engine not used to drive an electric generator must be equipped with a speed governor or regulator so adjusted that the engine speed cannot exceed the rated speed by more than 15%.

In addition to governor, each main engine with a rated power of 220 kW or over which can be declutched in service or which drives a variable pitch propeller must be fitted with an additional overspeed device so adjusted that the engine speed cannot exceed the rated speed by more than 20%.

5.1.2 Engine driving electric generators

Each diesel engine used to drive electric generator must be fitted with a governor which, in the event of the sudden complete removal of the load, prevents any transient speed variation (δ_{rs}) in excess of 10% of the rated speed. The permanent speed variation (δ_r) may not exceed 5%.

In addition to the governor, each diesel engine with a rated power of 220 kW or over must be equipped with an overspeed protection device independent of the normal governor which prevents the engine speed from exceeding the rated speed by more than 15%.

Unless other requirements have been agreed with the Society regarding the connection of loads, the speed variations specified above shall not be exceeded when the engine, running on no-load, is suddenly loaded to 50% of its rated power followed by the remaining 50%.

Generating sets of different capacities operating in parallel are required to run within the limits specified in Ch 2, Sec 2, [6].

The speed must be stabilized within five seconds, inside the permissible range specified for the permanent speed variation δ_r.

Generator sets which are installed to serve stand-by circuits must satisfy these requirements even when the engine is cold. The start-up and loading sequence is to be concluded in about 45 seconds.

Emergency generator sets must satisfy the above governor conditions even when their total consumer load is applied suddenly.

The governors of the engines mentioned above must enable the rated speed to be adjusted over the entire power range with a maximum deviation of 5%.

The rate of speed variation of the adjusting mechanisms must permit satisfactory synchonization in a sufficiently short time. The speed characteristic should be as linear as possible over the whole power range. The permanent deviation from the theoretical linearity of the speed characteristic may, in the case of generating sets intended for parallel operation, in no range exceed 1% of the rated speed.

Note 1: The rated power and the corresponding rated speed relate to the conditions under which the engines are operated in the system concerned.

Note 2: Additional overspeed protection device means a system all of whose component parts, including the drive, function independently of the governor.

5.1.3 Use of electrical / electronic governors

Use of electrical / electronic governors

The electrical / electronic governors used must have been type-tested by the Society.

In the case of engines with electrical starters, the governor may be supplied direct from the starter battery allocated to each engine.

For each engine without an electric starter, the governor must be supplied from the floating shipboard supply battery or from a permanently assigned battery of suitable capacity.

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

When an engine is taken out of service, the supply to its governor shall cut out automatically.

5.2 Cylinder overpressure warning device

5.2.1 All the cylinders of engines with a cylinder bore > 230 mm are to be fitted with cylinder overpressure control valves. The response threshold of these valves shall be set at not more than 40% above the combustion pressure at rated power.

The cylinder overpressure control valves may be replaced by efficient acoustic or visual cylinder overpressure warning devices. These must have been type-tested by the Society.

5.3 Crankcase airing and venting

5.3.1 The airing of crankcases is not allowed.

Crankcases are to be equipped with venting systems with a clear opening not larger than is strictly necessary.

The crankcase vent pipes of engines having a swept volume of more than 50 dm^3 per row of cylinders are to be led into the open and protected to prevent the entry of water.

Engine with a swept volume of up to 50 dm^3 per row of cylinders are to be fitted with vent pipes which are to be covered over to prevent the entry of foreign matter and which may not terminate at hot points.

Where provision has been made for extracting the lubricating oil vapours, e.g. for monitoring the oil vapour concentration, the negative pressure in the crankcase may not exceed 2,5 mbar.

Joining together the crankcase vent pipes of two or more engines is not permitted.

5.4 Crankcase safety devices

5.4.1 Safety valves to safeguard against overpressure in the crankcase are to be fitted to all engines with a cylinder bore of > 200 mm or a crankcase volume of > 0,6 m^3.

All other spaces communicating with the crankcase, e.g. gear or chain casings for camshafts or similar drives, are to be equipped with additional safety valves if the volume of these spaces like-wise exceeds 0,6 m^3.

5.4.2 Engines with a cylinder bore of > 200 mm ≤ 250 mm must be equipped with at least one safety valve at each end of the crankcase. If the crankshaft has more than 8 throws, an additional safety valve is to be fitted near the middle of the crankcase.

5.4.3 Engines with a cylinder bore of > 250 mm < 300 mm must have at least one safety valve close to every second crank throw, subject to a minimum number of two.

5.4.4 Engines with a cylinder bore of > 300 mm must have at least one safety valve close to each crank throw.

5.4.5 Each safety valve must have a free cross sectional area of at least 45 cm^2.

The total free sectional area of the safety valves fitted to an engine to safeguard against overpressure in the crankcase may not be less than 115 cm^2 / m^3 of crankcase volume.

Note 1: In estimating the gross volume of the crankcase, the volume of the fixed parts which it contains may be deducted.

Note 2: A space communicating with the crankcase via a total free cross sectional area of > 115 cm^2 / m^3 of the volume need not be considered as a separate space. In calculating the total free cross sectional area, individual sections of < 45 cm^2 are to be disregarded.

Note 3: Each safety valve required may be replaced by not more than two safety valves of smaller cross sectional area provided that the free cross sectional area of each safety valve is not less than 45 cm^2.

5.4.6 The safety devices must take the form of flaps or valves of proven design. In service they must be oiltight when closed and must prevent air from flowing in into the crankcase. The gas flow caused by the response of the safety device must be deflected in such a way as not to endanger persons standing nearby.

Safety device shall respond to as low an overpressure in the crankcase as possible (maximum 0,2 bar).

5.4.7 Covers of crankcase openings must be so dimensioned as not to suffer permanent deformation due to the pressure occurring during the response of the safety equipment.

5.4.8 A warning sign is to be mounted on the engine control platform or, if appropriate, on both sides of the engine dra wing attention to the fact that the crankcase may not be opened immediately following stoppage of the hot run engine, but only after a sufficient cooling period has elapsed.

5.5 Safety devices in the starting air system

5.5.1 The following equipment is to be fitted to safeguard main starting air lines against explosions due to failure of starting valves:

a) An isolation non-return valve is to be fitted to the starting air line serving each engine.

b) Engines with cylinder bore of > 230 mm are to be equipped with flame arresters as follows:
   - On directly reversible engines, in front of each startup valve of each cylinder.
   - On non-reversing engines, in the main starting air line to each engine.

c) Equivalent safety devices may be approved by the Society.

5.6 Safety devices in the lubricating oil system

5.6.1 If the lubricating oil pressure falls below the minimum level specified by the engine manufacturer, thereby necessitating the immediate shutdown of the main engine, an audible and visual alarm must be given which is clearly perceptible throughout the engine room and the control stand.

This alarm must be clearly distinguishable from the alarm required under Ch 1, Sec 1, [3.8].

6 Pipes and filters

6.1 General

6.1.1 The general engine piping system is subject to the requirements of Ch 1, Sec 10.

6.2 Fuel lines

6.2.1 Only pipe connections with metal sealing surfaces or equivalent pipe connections of approved design may be used for fuel injection lines.

On all main and auxiliary engines, the high-pressure fuel injection lines are to be shielded and secured in such a way that, should a fuel line rupture, no fuel or fuel mist can ignite at the engine or at any hot components located in the vicinity.

If pressure variations of > 20 bar occur in the fuel return lines, these are also to be shielded.

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.

6.3 Filters

6.3.1 Lubricating oil filters for main engines

Lubricating oil lines are to be fitted with lubricating oil filters located in the main oil flow on the delivery side of the pumps.

Steps are to be taken to ensure that main flow filters can be cleaned without interrupting operation. This requirement is considered to be satisfied by switch-over duplex filters, automatic filters or equivalent devices of approved design.

On main engines with a rated power of up to 220 kW, fitted with a lubricating oil line supplied from the engine oil sump, simplex filters may be fitted provided that they are equipped with a pressure alarm behind the filter and provided also that the filter can be changed during operation. For this purpose, a by-pass with manually operated shutoff valves is to be provided.

The switch positions must be clearly recognizable.

6.3.2 Lubricating oil filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

6.3.3 Fuel filters for main engines

The supply lines to fuel-injection pumps are to be fitted with switch-over duplex filters or automatic filters.

6.3.4 Fuel filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

6.3.5 Filter arrangements

Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in immediate proximity of hot components.

Where the arrangement stated here before is unfeasible, the rotating parts and the hot components are to be sufficiently shielded.

Drip pans of suitable size are to be mounted under fuel filters. The same applies to lubricating oil filters if oil can escape when the filter is opened.

Switch-over filters with two or more filter chambers are to be fitted with devices ensuring a safe relief of pressure before opening and venting when a chamber is placed in service. Shutoff valves shall normally be used for this purpose. It must be clearly discernible which filter chambers are in service and which are out of operation at any time.

6.4 Exhaust gas lines

6.4.1 Exhaust gas pipes from engines are to be installed separately from each other with regard to structural fire protection.

The pipes must be so installed that no exhaust gases can penetrate into accommodation spaces.

Account is to be taken of thermal expansion when laying out and suspending the lines.

Where exhaust gas lines discharge near water level, provisions are to be taken to prevent water from entering the engines.

Exhaust gas lines are to be insulated and/or cooled in such a way that the surface temperature cannot exceed 220°C at any point. Insulating materials must be non-combustible.

Exhaust gas lines are to be provided with suitable protection, e.g. sheet metal cladding or approved hard sheathing, to prevent leaking oil from seeping into the insulation.

The exhaust gas lines of main and auxiliary engines are to be fitted with efficient silencers.

7 Starting equipment

7.1 Electric starting equipment

7.1.1 Where main engines are started electrically, one independent set of starter batteries is to be provided for each engine. The set of batteries must enable the main engine to be started from cold.

7.1.2 The capacity of the starter set of batteries must be sufficient for at least 6 start-up operations within 30 minutes without recharging.

7.1.3 Electrical starters for auxiliary engines are to be provided with independent batteries. The capacity of the batteries must be sufficient for at last 3 start-up operations within 30 minutes.

7.1.4 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.

7.1.5 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.

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

7.2 Starting with compressed air

7.2.1 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 must be driven independently of the main engine and must supply at least 50% of the total capacity required.

7.2.2 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.

7.2.3 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.

7.2.4 The total volume of the starting air receivers shall be such that it can be proved during the river trials that the quantity of air available is sufficient for at least 6 start-up operations with non-reversible main engines and at least 12 start-up operations with reversible main engines. Recharging of the starting air receivers during the execution of the start-ups is not allowed.

7.2.5 Multi-engine propulsion plants

For multi-engine propulsion plants, the capacity of the starting air receivers is to be sufficient to ensure at least 3 consecutive starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

7.2.6 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.

7.2.7 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.

7.3 Air compressor equipment

7.3.1 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 must be fitted with safety valves or rupture discs of sufficient cross sectional area.

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

Every compressor stage must be equipped with a suitable safety valve which cannot be blocked and which prevents the maximum permissible working pressure from exceeded by more than 10% even when the delivery line has been shutoff. The setting of the safety valve must be secured to prevent unauthorized alteration.

Each compressor stage must be fitted with a suitable pressure gauge, the scale of which must indicate the relevant maximum permissible working pressure.

8 Control equipment

8.1 Main engines room control platform

8.1.1 As a minimum requirement, the engine room control platform is to be equipped with the following main engine indicators, which are to be clearly and logically arranged:

- engine speed indicator
- lubricating oil pressure at engine inlet
- cylinder cooling water pressure
- starting air pressure
- charge air pressure
- control air pressure at engine inlet
- shaft revolution indicator.

Indicators are to be provided for the following on the control platform and/or directly on the engine:

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

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

On the pressure gauges the permissible pressures, and on the tachometers any critical speed ranges, are to be indicated in red.

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

See also Ch 2, Sec 13, Tab 1.

8.2 Main engines control from the bridge

8.2.1 The vessel's control stand is to be fitted with indicators, easily visible to the operator, showing the starting and manoeuvring air pressure as well as the direction of rotation and revolutions of the propeller shaft.

In addition, the alarm system required under last paragraph of [8.1.1] is to signal faults on the bridge. Faults may be signalled in accordance with Ch 1, Sec 1, [3.8]. An indicator in the engine room and on the bridge shall show that the alarm system is operative.

8.3 Auxiliary engines

8.3.1 Instruments or equivalent devices mounted in a logical manner on the engine shall indicate at least:

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

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

See also Ch 2, Sec 13, Tab 1.

9 Auxiliary systems

9.1 Lubricating oil system

9.1.1 General requirements relating to lubricating oil systems are contained in Ch 1, Sec 10, [8]; for filters, see [6.3.1].

Engines whose sumps serve as oil reservoirs must be so equipped that the oil level can be established and, if necessary, topped up during operation. Means must be provided for completely draining the oil sump.

The combination of the oil drainage lines from the crankcases of two or more engines is not allowed.

Main lubricating oil pumps driven by the engine are to be designed to maintain the supply of lubricating oil over the entire operating range of the engine.

9.2 Cooling system

9.2.1 General requirements relating to the design of cooling water systems are contained in Ch 1, Sec 10, [9].

Main cooling water pumps driven by the engine are to be designed to maintain the supply of cooling water over the entire operating range of the engine.

If cooling air is drawn from the engine room, the design of the cooling system is to be based on a room temperature of at least 40°C.

The exhaust air of air-cooled engines may not cause any unacceptable heating of the spaces in which the plant is installed. The exhaust air is normally to be led to the open air through special ducts.

See also Ch 1, Sec 1, [3.6].

9.3 Exhaust gas turbochargers

9.3.1 Exhaust gas turbochargers may exhibit no critical speed ranges over the entire operating range of the engine.

The lubricating oil supply must also be ensured during start-up and run-down of the exhaust gas turbochargers.

Even at low engine speeds, main engines must be supplied with charge air in a manner to ensure reliable operation.

Emergency operation must be possible in the event of the failure of an exhaust gas turbocharger.

9.4 Charge air cooling

9.4.1 Means are to be provided for regulating the temperature of the charge air within the temperature range specified by the engine manufacturer.

The charge air lines of engines with charge air coolers are to be provided with sufficient means of drainage.

SECTION 3 PRESSURE VESSELS, BOILERS AND THERMAL OIL HEATERS

1 Pressure vessels

1.1 General

1.1.1 Scope

The following rule requirements apply to pressure vessels for the operation of the main propulsion plant and its auxiliary machinery. They also apply to pressure vessels and equipment necessary for the operation of the inland waterway vessel and to independent cargo tanks if these are subjected to internal or external pressure in service.

Cargo tanks and containers with design temperatures of < 0°C are subject to Pt D, Ch 3, Sec 2.

These Rules do not apply to pressure vessels with permitted working pressures of up to 1,0 bar and with a total capacity of not more than 1000 litres or to pressure vessels with working pressures of > 1 bar where the product of pressure (bar) x capacity (litres) is ≤ 200.

Manufacture and inspection of these pressure vessels are subject to the rules of good engineering practice.

Pressure vessels manufactured to recognized standards can be accepted if they have been subjected in the manufacturer's works to tests conforming to the standard.

1.1.2 Division into classes

Pressure vessels are to be assigned to classes in accordance with the operating conditions indicated in Tab 1.

Pressure vessels filled partly with liquids and partly with air or gases or which are blown out with air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, are to be classified as pressure vessels containing air or gas.

1.1.3 Documents for review/approval

Drawings of pressure vessels and equipment containing all the data necessary for their safety assessment are to be submitted to the Society, at least in triplicate, for review/approval. The following details, in particular, are to be specified:

- Intended use, volume of the individual spaces
- Substance to be contained in the pressure vessel, working pressures and temperatures
- Materials to be used, details of welding techniques and heat treatment.

1.2 Materials

1.2.1 General requirements

The materials of pressure-containing parts must be suitable for the intended use and comply with NR 216 Materials and Welding.

Parts such as ribs or girths, holders, supports, brackets etc. welded directly to pressure vessel walls are to be made of material compatible with that of the wall and of guaranteed weldability.

Welded structures are also subject to applicable requirements of NR 216 Materials and Welding.

1.2.2 Testing of materials

Tests in accordance with NR 216 Materials and Welding are prescribed for materials belonging to pressure vessel classes I and II used for:

a) All surfaces under pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter ≤ DN 32 mm, together with forged or rolled steel valve heads for compressed air receivers

b) Forged flanges for service temperatures > 300°C and for service temperatures ≤ 300°C if the product of the maximum allowable working pressure, PB, in bar, by the nominal diameter, DN, in mm, is < 2500 or the nominal diameter DN is > 250

c) Bolts and nuts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm², or more than 600 N/mm² in the case of nuts, and alloy or heat-treated steel bolts above M 16.

Table 1 : Pressure vessel classes

Operating medium	Design pressure p_C, in bar Design temperature t, in °C		
Liquefied gases (propane, butane, etc.), toxic gas cargo	all	NA	NA
Steam, Compressed air, Gases, Thermal oil	$p_C > 16$ or $t > 300$	$p_C \le 16$ and $t \le 300$	$p_C \le 7$ and $t \le 170$
Liquid fuels	$p_C > 16$ or $t > 150$	$p_C \le 16$ and $t \le 150$	$p_C \le 7$ and $t \le 60$
Water and oils	$p_C > 40$ or $t > 300$	$p_C \le 40$ and $t \le 300$	$p_C \le 16$ and $t \le 200$
Pressure vessel class	I	II	III
NA : Not applicable			

1.2.3 For class II parts subject to mandatory testing, proof of material quality may take the form of works inspection certificates 3.1 according to EN 10204 provided that the test results certified therein comply with the Society's Rules for Materials and Welding.

Works inspection certificates may also be recognized for series-manufactured class I parts made of unalloyed steels, e.g. hand- and manhole covers, and for branch pipes where the product of PB × DN ≤ 2500 and the nominal bore DN ≤ 250 mm for service temperatures of < 300°C.

1.2.4 For all parts not subject to testing of materials by the Society, alternative proof of the characteristics of the material is to be provided, e.g. a works certificate or manufacturer's guarantee as to the properties of the materials used.

1.3 Manufacturing principles

1.3.1 Manufacturing processes applied to materials

Manufacturing processes must be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold working are to undergo heat treatment in accordance with the Society's Rules for Materials and Welding.

1.3.2 Welding

The execution of welding work, the approval of welding shops and the qualification testing of welders are to be in accordance with the Society's Rules for Materials and Welding.

1.3.3 Reinforcement of openings

Due account is to be taken of the weakening of walls caused by openings and, where necessary, reinforcement is to be provided.

1.3.4 End plates

The flanges of dished ends may not be unduly hindered in their movement by any kind of fixtures, e.g. fastening plates or stiffeners. Supporting legs may only be attached to dished ends which have been adequately dimensioned for this purpose.

Where covers or ends are secured by hinged bolts, the latter are to be safeguarded against slipping off.

1.3.5 Branch pipes

The wall thickness of branch pipes must be so dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes should be appropriate to the wall thickness of the part into which they are welded. The walls must be effectively welded together.

Pipe connections in accordance with Ch 1, Sec 10 are to be provided for the attachment of piping.

1.3.6 Tube plates

Tube holes must be carefully drilled and deburred. Bearing in mind the tube-expansion procedure and the combination of materials involved, the ligament width must be such as to ensure the proper execution of the expansion process and the sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.

1.3.7 Compensation for expansion

The design of pressure vessels and equipment is to take account of possible thermal expansion, e.g. between the shell and nest of heating tubes.

1.3.8 Corrosion protection

Pressure vessels and equipment exposed to accelerated corrosion owing to the medium which they contain must be protected in a suitable manner.

1.3.9 Cleaning and inspection

Pressure vessels and equipment are to be provided with inspection and access openings which should be as large as possible and conveniently located. For the minimum dimensions of these, see [2.3].

Pressure vessels over 2,0 m long must have inspection openings at each end at least. Where the pressure vessel can be entered, one access opening is sufficient.

Pressure vessels with an inside diameter of more than 800 mm must be capable of being entered.

In order to provide access with auxiliary or protective gear, a manhole diameter of at least 600 mm is generally required. The diameter may be reduced to 500 mm where the pipe socket height to be traversed does not exceed 250 mm.

Inspection openings may be dispensed with where experience has proved the unlikelihood of corrosion or deposits, e.g. in steam jackets.

Where pressure vessels and equipment contain dangerous substances (e.g. liquefied or toxic gases), the covers of inspection and access openings shall not be secured by crossbars but by bolted flanges.

Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

1.3.10 Mountings

Wherever necessary, strengthening elements are to be fitted at mountings and supports to prevent excessive stress increases in the pressure vessel shell due to vibration.

1.3.11 Identification and marking

Each pressure vessel is to be provided with a plate or permanent inscription indicating the manufacturer, the serial number, the year of manufacture, the capacity, the maximum allowable working pressure of the pressurized parts and the identification of the inspection body. On smaller items of equipment, an indication of the working pressures is sufficient.

1.4 Design

1.4.1 General

Design calculations, are to be performed according to existing Society's Rules or to international codes such as AD-Merkblätter, ASME, CODAP, British Standards or harmonized European Standards accepted by the Society, taking into consideration the special requirements for pressure vessels installed on inland waterway vessels.

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

1.5 Equipment and installation

1.5.1 Shutoff devices

Shutoff devices must be fitted in pressure lines as close as possible to the pressure vessel. Where several pressure vessels are grouped together, it is not necessary that each pressure vessel should be capable of being shut off individually and means need only be provided for shutting off the group. In general, not more than three pressure vessels should be grouped together. Starting air receivers and other pressure vessels which are opened in service must be capable of being shut off individually. Devices incorporated in piping, e.g. water and oil separators, do not require shutoff devices.

1.5.2 Pressure gauges

Each pressure vessel which can be shut off and every group of pressure vessels with a shutoff device must be equipped with a pressure gauge, also capable of being shut off, suitable for the medium contained in the pressure vessels. The measuring range and calibration must extend to the test pressure with a red mark to indicate the maximum working pressure.

Equipment need only be fitted with pressure gauges when these are necessary for its operation.

1.5.3 Safety equipment

Each pressure vessel which can be shut off or every group of pressure vessels with a shut off device must be equipped with a spring-loaded safety valve which cannot be shut off and which closes again reliably after blow off.

Appliances for controlling pressure and temperature are no substitute for relief valves.

Safety valves must be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10 %. Means must be provided to prevent the unauthorized alteration of the safety valve setting. Valves cones must be capable of being lifted at all times. Means of drainage which cannot be shut off are to be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities must be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out must be drained off via an open funnel.

Steam-filled spaces are to be fitted with a safety valve if the steam pressure inside them is liable to exceed the maximum allowable working pressure.

Heated spaces which can be shut off on both the inlet and the outlet side are to be fitted with a safety valve which will prevent an inadmissible pressure increase should the contents of the space undergo dangerous thermal expansion or the heating elements fail.

Besides a temperature controller, electrically heated appliances are also to be equipped with a safety thermal cutout.

Pressure water tanks are to be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with provided that the air pressure supplied to the tank cannot exceed its maximum allowable working pressure. Calorifiers are to be fitted at the cold water inlet with a diaphragm safety valve.

Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the product of the pressure (bar) x capacity (litres) $PB \times I \leq 200$.

1.5.4 Draining and venting

Pressure vessels and equipment must be capable of being depressurized and completely emptied or drained. Particular attention is to be given to the adequate drainage facilities of compressed air pressure vessels.

Suitable connections and a vent at the uppermost point must be provided for the execution of hydraulic pressure tests.

1.5.5 Installation

Pressure vessels and equipment are to be installed in such a way as to provide for maximum all-round visual inspection and to facilitate the execution of periodic tests. Where necessary, ladders or steps are to be fitted inside pressure vessels.

Wherever possible, horizontal compressed air receivers should be installed at an angle and parallel to the fore-and-aft line of the inland waterway vessel. The angle should be at least 10° (with the valve head at the top.) Where pressure vessels are installed athwartships, the angle should be greater.

Where necessary, compressed air receivers are to be so marked on the outside that they can be installed on board inland waterway vessels in the position necessary for complete venting and drainage.

1.5.6 Cargo tanks for liquefied gases

For the equipment and installation of cargo tanks for liquefied gases, see Pt D, Ch 3, Sec 2.

1.6 Tests

1.6.1 Constructional test and pressure tests

On completion, pressure vessels and equipment are to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the loads specified in Tab 2 may not be exceeded.

For Group I pressure vessels and equipment, the test pressure is generally 1,5 times the permitted working pressure subject to a minimum of p + 1 bar.

For pressure vessels and equipment of Groups II and III, the test pressure is 1,3 times the permitted working pressure subject to a minimum of p + 1 bar. For working pressures below atmospheric pressure, the test pressure is 2 bar excess pressure.

Air coolers (e.g. charge air coolers) are to be tested on the water side at 1,5 times the permitted working pressure subject to a minimum of 4 bar.

In special cases the use of media other than water for the pressure tests may be agreed.

Table 2 : Maximum load during hydrostatic tests

For materials with a definite yield point	For materials without a definite yield point
$R_{eH,\,20}$ / 1,1	$R_{m,\,20}$ / 2,0
$R_{eH,\,20}$: Guaranteed yield strength or minimum value of the 0,2 % proof stress at room temperature $R_{m,\,20}$: Guaranteed minimum tensile strength, in Nmm², at room temperature	

1.6.2 Tightness tests

Where pressure vessels and equipment contain hazardous substances (e.g. liquefied gases), the Society reserves the right to call for a special test of gastightness.

1.6.3 Certification of tests

The constructional test and the pressure test are to be performed in the manufacturer's works in the presence of a Surveyor. For pressure vessels and equipment of Group II and III the manufacturer's test certificates are acceptable if the permitted working pressure PB ≤ 1 bar or if the product of the pressure (bar) x capacity (litres) PB × I ≤ 200.

1.6.4 Testing after installation on board

After installation on board the fittings of pressure vessels and equipment and the arrangement and settings of the safety devices are to be checked and, wherever necessary, subjected to a functional test.

2 Steam boilers

2.1 General

2.1.1 Scope

For the purpose of these rule requirements, the term "boiler" includes all closed pressure vessels and piping systems used for:

a) generating steam at pressure above atmospheric (steam generators) or

b) raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators).

The term "steam generator" also includes any equipment directly connected to the aforementioned pressure vessels or piping systems in which the steam is superheated or desuperheated, the circulating line and the casings of circulating pumps serving forced-circulation boilers.

Hot water generators having a maximum permissible discharge temperature of not more than 120°C and all systems incorporating steam or hot water generators which are heated solely by steam or hot liquids are not subject to these Rules, but come under [1].

2.1.2 Other Rules

As regards their construction and installation, steam boiler plants are also required to comply with the applicable statutory requirements and regulations of the inland waterway vessel's country of registration.

2.1.3 Definitions

Steam boiler walls are the walls of the steam and water spaces located between the boiler isolating devices. The bodies of these isolating devices form part of the boiler walls.

The maximum allowable working pressure (design pressure) is the approved steam pressure in bar (gauge pressure) in the saturated steam space prior to entry into the superheater. In continuous-flow boilers, the maximum allowable working pressure is the pressure at the superheater outlet or, in the case of continuous boilers without a superheater, the steam pressure at the steam generator outlet.

The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.:

a) the area in m² measured on the side exposed to fire or exhaust gas, or

b) in the case of electrical heating, the equivalent heating surface, in m²:

$$H = \frac{860N}{18000}$$

where:

N : Electrical power, in kW

The permissible steam output is the maximum quantity of steam (in metric tons/hour or kg/hour) which can be produced continuously by the steam generator operating under the design steam conditions.

The "dropping time" is the time taken by the water level, under conditions of interrupted feed and permissible steam output, to drop from the lowest working level (NW) to the level of the highest point of the gas or flame path (HF), i.e.:

$$t = \frac{I}{Dv'}$$

where:

t : Dropping time, in min

I : Volume, in m³, of water between the lowest level and the highest point of the gas or flame

D : Permissible steam output, in kg/min

v′ : Specific volume of the water at saturation temperature, in m³/kg

2.1.4 Documents for review/approval

Drawings of all boiler parts subject to pressure, such as drums, headers, tubes, manholes and inspection covers etc., are to be submitted to the Society, at least in triplicate, for review/approval. These drawings must contain all the data necessary for strength calculations and design assessment, such as working pressures, superheated steam temperatures, materials to be used and full details of welds including filler materials.

2.2 Materials

2.2.1 General requirements

With respect to their workability during manufacture and their characteristics in subsequent operation, materials used for the manufacture of steam boilers must satisfy the technical requirements, particularly those relating to high-temperature strength and, where appropriate, weldability.

Table 3 : Approved materials

Material and product form	Limits of application	Material grade in accordance with Society's Rules for materials
Steel plates and strips	NA	Steel plates for steam boilers and pressure vessels
Steel tubes	NA	Steel pipes for high temperatures service
Steel forgings and formed parts	NA	Steel forgings for steam boilers and pressure vessels
Steel castings	NA	Steel castings for steam boilers and pressure vessels
Nodular cast iron	≤ 300°C ≤ 40 bar ≤ DN 175 for valves and fittings	Nodular graphite iron castings
Lamellar (grey) cast iron: a) boiler parts only for unheated surfaces and not forthermal oil heaters b) valves and fittings	 ≤ 200°C ≤ 10 bar Φ ≤ 200 ≤ 200°C ≤ 10 bar ≤ DN 175	Grey iron castings
Bolts and nuts	NA	Bolts and nuts for elevated temperature
Valves and fittings of copper alloy castings	≤ 225°C ≤ 25 bar	Copper alloy castings
Φ : Diameter, in mm NA : Not applicable		

2.2.2 Approved materials

The requirements specified in [2.2.1] are recognized as having been complied with if the materials shown in Tab 3 are used.

Materials not specified in NR 216 Materials may be used provided that proof is supplied of their suitability and mechanical properties.

2.2.3 Material testing

The materials of boiler parts subject to pressure must be tested by the Society in accordance with NR 216 Materials and Welding (see Tab 3). Material testing by the Society may be waived in the case of:

a) Small boiler parts made of unalloyed steels, such as stay bolts, stays of ≤ 100 mm diameter, reinforcing plates, handhole and manhole covers, forged flanges and branch pipes up to DN 150 (nominal inside diameter 150 mm) and

b) Smoke tubes (tubes subject to external pressure).

For the parts mentioned in a) and b), the properties of the materials are to be attested by acceptance test certificates.

Special agreements may be made regarding the testing of unalloyed steels to recognized standards.

The materials of valves and fittings must be tested by the Society in accordance with the data specified in Tab 4.

Parts not subject to material testing, such as external supports, lifting brackets, pedestals etc. must be made of materials suitable for the intended purpose and in accordance with accepted engineering practice.

Table 4 : Testing of materials for valves and fittings

Type of material **(1)**	Service temperature	Testing required for
Steel, cast steel	> 300	DN > 32
Steel, cast steel Nodular cast iron	≤ 300	p_{zul} x DN > 2500 **(2)** or DN > 250
Copper alloys	≤ 225	p_{zul} x DN > 1500 **(2)**
p_{zul} : Working pressure, in bar DN : Nominal diameter, in mm **(1)** No tests are required for grey cast iron **(2)** Testing may be dispensed with if the nominal DN is ≤ 32		

2.3 Principles applicable to manufacture

2.3.1 Manufacturing processes applied to boiler materials

Materials are to be checked for defects during the manufacturing process. Care is to be taken to ensure that different materials cannot be confused. During the course of manufacture care is likewise required to ensure that marks and inspection stamps on the materials remain intact or are transferred in the prescribed manner.

Boiler parts whose structure has been adversely affected by hot or cold forming are to be subjected to heat treatment in accordance with NR 216 Materials and Welding, and tested.

2.3.2 Welding

The execution of welds, the approval of welding shops and the qualification testing of welders are to be in accordance with requirements of NR 216 materials and Welding.

2.3.3 Tube expansion

Tube holes must be carefully drilled and deburred. Sharp edges are to be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses. Tube ends to be expanded are to be cleaned and checked for size and possible defects. Where necessary, tube ends are to be annealed before being expanded.

2.3.4 Stays and stay bolts

Stays, stay tubes and stay bolts are to be so arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section, in screw threads and at welds are to be minimized by suitable component geometry.

Boiler walls into which longitudinal stays are welded are to be relieved by reinforcing plates.

The ends of relatively long stays are to be shaped in such a way that possible vibrational stresses are not transmitted to the weld zone.

Solid stays are to be drilled at both ends in such a way that the holes extend at least 25 mm into the water or steam space. Where the ends have been upset, the continuous shank must be drilled to a distance of at least 25 mm.

Wherever possible, the angle made by gusset stays and the longitudinal axis of the boiler shall not exceed 30°. Stress concentrations at the welds of gusset stays are to be minimized by suitable component geometry. In firetube boilers, corner stays are to be located at least 200 mm from the firetube.

Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of the said bolts shall not generally exceed 200 mm.

2.3.5 Stiffeners, straps and lifting eyes

Where flat end surfaces are stiffened by profile sections or ribs, the latter shall transmit their load directly (i.e. without welded-on straps) to the boiler shell.

Doubling plates may not be fitted in the first fire pass. intervening where necessary to protect the walls of the boiler, strengthening plates are to be fitted below supports and lifting brackets.

2.3.6 Boiler drums, shell sections, headers and firetubes

The manufacturing of boiler drums, shell sections, headers and firetubes has to be in accordance with the Society’s Rules.

2.3.7 Pipe connections and flanges

All pipe connections and flanges are to be of rugged design and properly welded to the shell. The wall thickness of branch pipes must be sufficiently large safely to withstand additional external loads. The wall thickness of welded-in pipe connections shall be appropriate to the wall thickness of the part into which they are welded.

Welding-neck flanges must be made of forged material with favourable grain orientation.

2.3.8 Cleaning and inspection, openings, cutouts and covers

Steam boilers are to be provided with openings through which the space inside can be cleaned and inspected. Boiler vessels with an inside diameter of more than 1200 mm and those measuring over 800 mm in diameter and 2000 mm in length are to be provided with means of access.

Inspection and access openings are required to have the following minimum dimensions (see Tab 5):

Table 5 : Opening dimensions

Manholes	300 x 400 mm or 400 mm diameter where the annular height is > 150 mm, the opening is to measure 320 x 420 mm.
Holes for the head	220 x 320 mm or 320 mm diameter
Handholes	87 x 103 mm
Sight holes	are required to have a diameter of at least 50 mm; they should, however, be provided only when the design of the equipment makes a handhole impracticable.

The edges of manholes and other openings, e.g. for domes, are to be effectively strengthened if the plate has been unacceptably weakened by the cutouts. The edges of openings closed with covers are to be reinforced by flanging or by welding on edge-stiffeners if it is likely that the tightening of the crossbars etc. would otherwise cause undue distortion of the edge of the opening.

Cover plates, manhole stiffeners and crossbars must be made of ductile material (not grey or malleable cast iron). Unless metal packings are used, cover plates must be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening is to be uniform round the periphery and may not exceed 2 mm for boilers with a working pressure of less than 32 bar, or 1 mm where the pressure is 32 bar or over. The height of the rim or spigot must be at least 5 mm greater than the thickness of the packing.

Only continuous rings may be used as packing. The materials used must be suitable for the given operating conditions.

2.4 Design

2.4.1 General

Design calculations are to be performed according to existing Society's Rules or to international codes such as AD-Merkblätter, ASME, CODAP, British Standards or harmonized 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.

2.5 Equipment and installation

2.5.1 Feed and circulating equipment

Each boiler must generally be provided with two feedwater pumps, each of which must be capable of supplying a quantity of water equivalent to 1,25 times the boiler output.

One feedwater pump is sufficient for boilers which are not needed to keep the machinery in operation provided that the following conditions are met:

a) The steam pressure and the water level must be automatically controlled.

b) After the firing has been shut down, the heat stored in the boiler may not cause any inadmissible lowering of the water level.

c) In the event of a failure of the power supply to the feedwater pump drive, the firing system must shut down automatically.

d) The boiler must be fitted with a water-level limiting device independent of the water-level control.

In the case of continuous-flow boilers a pump delivery rate equal to 1,0 times the boiler output is sufficient.

The feedwater system must be capable both of supplying the required quantity of feedwater against the maximum permitted working pressure and of delivering the quantity of feedwater corresponding to the steaming capacity against 1,1 times the maximum permitted working pressure.

For electrically driven feedwater pumps, each motor is to be supplied via a separate line from the bus-bar.

Each feedwater pump must be independently capable of being isolated from the suction and delivery lines.

Each boiler feed line must be equipped with a shutoff device and a non-return valve. If the shutoff device and the non-return valve are not mounted in immediate conjunction, the intervening length of pipe must be fitted with a pressure relief device.

Continuous-flow boilers require no shutoff device or non-return valve provided that the feed system serves only one boiler.

Feedwater must be introduced into the boiler in such a way that, should the non-return valve leak, the water cannot drain out through the feed line so as to lower the water level to less than 50 mm above the highest point of the heating gas paths (except for heating gas paths to [2.5.6]).

Feedwater inlets are to be arranged so as to avoid damage to the wall of the boiler.

Each forced-circulation boiler must generally be equipped with two independently driven circulating pumps. Failure of the circulating unit in service must trip an alarm.

One circulating pump is sufficient for continuous-flow boilers.

Should the power supply to the circulating pump drive fail, the firing must shut down automatically.

2.5.2 Isolating appliances

Each boiler must be equipped with means enabling it to be isolated from all connecting pipes. The shutoff devices are to be located as close as possible to the boiler shell.

2.5.3 Blow-down equipment

Each boiler, or at least the drums and the headers, must be equipped with one or more drainage devices. Blow-down fittings and their branch pipes must be protected against the action of heating gases and must be capable of safe operation. Self-closing blow-down valves must be provided with a locking mechanism, or an additional shutoff device must be mounted in the piping.

2.5.4 Safety valves

Each boiler is to be equipped with at least two reliable, spring-loaded safety valves. The size and setting of these are to be such that the maximum quantity of steam which can be produced continuously can be discharged without the maximum allowable working pressure (design pressure) being exceeded by more than 10 % in the process. At least one safety valve is to be set to respond when the maximum allowable working pressure is exceeded. Safety valves are required to close again inside a 10 % pressure drop below the response threshold.

The steam may not be led to the safety valves through pipes in which water may accumulate.

A drain which can not be shut-off is to be fitted at the lowest point at the discharge side of the safety valve.

2.5.5 Water level indicators

Each boiler with a free surface is to be equipped with at least two indicators giving a direct reading of the water level. Cylindrical glass water level gauges are not permitted.

The indicators are to be so fitted that the water level can be ascertained despite the movements and inclinations of the inland waterway vessel when at sea. The lower limit at which the water is visible must be at least 30 mm above the highest gas path but at least 30 mm below the lowest water level. The lowest water level may not be located above the middle of the range of visibility.

Water level indicators must be separately and individually connected to the boiler. The connecting lines must be free from sharp bends so as to avoid water and steam pockets, and must be safeguarded against the action of heating gases and cooling.

The connection lines must have an I.D. of at least 20 mm. Where water level indicators are connected by common pipes or where the pipes connected to the water space of the boiler exceed 750 mm in length, the inside diameter of these pipes must be at least 40 mm.

Water-level indicators must be capable of being isolated from the boiler and must have a blow-through connection. Where cocks are used, the direction of flow must be indicated.

Instead of the water-level indicators, continuous-flow boilers must be fitted with two mutually independent warning systems which draw attention to any deficiency in the water supply. The second warning system may take the form of an automatic device which shuts down the firing.

2.5.6 Lowest water level

The lowest specified water level is to be indicated on every boiler by means of a permanent water level pointer affixed to the boiler shell and by reference plates placed beside or behind the glass water gauges, attached to the boiler shells or the water level columns and clearly marked with the letters "LW" (lowest water level).

The highest point of heating gas paths must lie at least 150 mm below the lowest specified water level.

This minimum distance must still be maintained when the inland waterway vessel heels 4° to either side. In the case of water tube boilers, the highest point where downcomers are connected to the boiler drum (upper edge of connection) is to be considered as equivalent to the highest point of the heating gas path.

In addition, the lowest water level is to be fixed in such a way that the dropping time is not less than 7 minutes. For steam producers which comply with the conditions set out under [2.5.10], a dropping time of only 5 minutes is sufficient.

The requirements relating to the height of the heating gas paths do not apply to:

- Water tube boiler risers up to 102 mm outside diameter
- Flues in which the flue gas temperature at maximum continuous output does not exceed 400°C
- Continuous-flow boilers
- Forced-circulation boilers with heated tubes of outside diameter up to 102 mm
- Superheaters.

2.5.7 Pressure gauges

Each boiler is to be fitted with two pressure gauges connected to the steam space. The permitted working pressure is to be permanently and clearly marked by a red line on the scale. The indicating range of the pressure gauge must include the test pressure.

One pressure gauge must be located at the boiler, the second at the engine control platform.

The line leading to the pressure gauge must have a loop forming a water pocket and must be provided with a blow-through connection. Close to each boiler pressure gauge, the pressure gauge line must be fitted with a connection for a test pressure gauge. Where pressure gauges are located below the level of the pipe connection at the boiler, a second test connection must be provided close to the pressure gauge line connection to the boiler.

2.5.8 Name plate

Each boiler must be fitted with a plate giving the following details in permanent form:

- Maker's name and address
- Serial number and year of manufacture
- Maximum allowable working pressure in bar
- Steam generating capacity in kg/h or t/h.

The name plate must be permanently attached to the largest part of the boiler or boiler casing and must be visible even after the insulation has been applied.

2.5.9 Special requirements for low capacity boilers

In the case of boilers with a water volume of not more than 150 litres and a permitted working pressure of up to 10 bar and where the volume of water in litres multiplied by the max. allowable working pressure in bar does not exceed 500, the second feed pump and the second water level indicator, or for continuous-flow boilers the second warning device, may be dispensed with.

2.5.10 Special requirements for automatically controlled boilers not under permanent supervision

Steam generators are to be equipped with a rapidly controllable firing system. After the firing has been shut down, the heat stored in the firebox and the heating gas paths may not cause any inadmissible evaporation of the water contained in the steam generator. The control system must be capable of adapting the boiler to changes in the operating load without actuating the safety devices.

The firing system must be automatically controlled (see [4]). In addition, when the firing is shut down automatically, the oil supply must be cut off by two series-connected solenoid valves.

A pressure controller must control the steam pressure automatically by regulating the heat input.

In steam generators with a fixed minimum water level, the water level must be controlled automatically.

In continuous-flow boilers, the feedwater and the fuel supply must be controlled automatically and in association with each other.

A pressure limiter must shut down and secure the firing system if the permitted working pressure is exceeded.

Steam generators with a fixed minimum water level are to be equipped with two mutually independent low-water trips which shut down and secure the firing system if the water drops below the specified minimum level. Forced-circulation boilers must be equipped in addition to the stipulated low-water trips with two safety devices (limiters) which shut down and secure the firing system if the flow is reduced below the permitted level.

Instead of the low-water trips, continuous-flow boilers are to be fitted with two mutually independent safety devices which prevent an excessive temperature rise of the boiler shell (e.g. temperature limiters).

Where there is a possibility that foreign matter (oil, grease, caustic solutions etc.) may penetrate the water circuit and endanger the steam generator, the composition of the water requires to be monitored automatically. In such cases the firing system must be shut down and secured at the latest as soon as the permitted limit concentrations are exceeded.

The controls for steam pressure and water level and any additional safety devices (trips) must take the form of mutually independent units.

Unless an equivalent degree of safety is ensured by other means, the electrical equipment associated with the trips is to be designed on the closed-circuit principle so that, even in the event of a power failure, the trips will cut out and interlock the systems.

The interlocking system must be so designed that a tripped boiler can be put back into operation only at the boiler control platform.

Water level controls and trips located outside the boiler must be directly connected to the boiler. Shutoff devices must have an inside diameter of at least 20 mm and must indicate their closed or open position.

Shutoff devices in the connecting lines to water level trips must be designed to allow operation of the firing equipment only when they are in the open position, or else, after closure, they must reopen fully in an automatic and reliable manner.

The boiler room and the engine control platform must be fitted with audible and visual alarms actuated by trips. Emergency shutdown of the firing system must be possible from the engine control platform.

Means must be provided for carrying out operational tests on the trips and alarm systems at any time, even during service. Operational testing of the water level trip must be possible without lowering the water level below the lowest specified level (LW).

2.5.11 Design and testing of valves and fittings

With the exception of the special regulations for grey cast iron (see Tab 3), valves and fittings for boilers must be made of ductile materials, and all their components must be able to withstand the loads imposed in operation, in particular thermal loads and possible stressed due to vibration (e.g. blow-down valves and safety valves). Copper alloys are permitted up to the following limits:

- Working pressure up to 25 bar
- Operating temperature up to 225°C.

Care is to be taken to ensure that the bodies of shutoff gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets must be safeguarded to prevent unintentional loosening of the bonnet.

As a general rule, all valves and fittings are to be subjected to a hydrostatic pressure test at 1,5 times the nominal pressure before they are fitted. Valves and fittings for which no nominal pressure has been specified are to be tested at twice the working pressure. In this operation, the safety factor in respect of the 20°C yield point may not fall below 1,1. The manufacturer is to furnish evidence of the quality of the materials used.

2.5.12 Installation of boilers

Boilers must be installed in the inland waterway vessel with care and must be secured to ensure that they cannot be displaced by any of the circumstances arising when the inland waterway vessel is at sea. Means are to be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings must be easily accessible from all sides or must be easily rendered so. Boilers must always be placed a sufficient distance from watertight bulkheads to ensure that they remain accessible.

Safety valves and shutoff mechanisms must be capable of being operated without danger. Wherever necessary, permanent steps, ladders or platforms must be fitted. Water level indicator cocks and valves which cannot be directly reached by hand from the floor plates or a platform must be fitted with draw rods or chains enabling them to be operated from the boiler control platform. Cocks must be so arranged that they are open when the draw rod is in its lowest position.

2.6 Testing of boilers

2.6.1 Manufacturing test

After completion, boilers are to undergo a manufacturing test.

The manufacturing test includes verification that the boiler agrees with the approved drawing and is of satisfactory construction. For this purpose, all parts of the boiler must be accessible to allow adequate inspection. If necessary, the manufacturing test is to be performed at separate stages of manufacture. The following documents are to be presented: material test certificates covering the materials used, reports on the non-destructive testing of welds and, where applicable, the results of tests of workmanship and proof of the heat treatment applied.

2.6.2 Hydrostatic pressure tests

A hydrostatic pressure test is to be carried out on the boiler before the insulation is fitted. Where only some of the component parts are sufficiently accessible to allow proper visual inspection, the hydrostatic pressure test may be performed in stages. Boiler surfaces must withstand the test pressure without leaking or suffering permanent deformation.

The test pressure is generally required to be 1,3 times the maximum allowable working pressure, subject to a minimum of p_{zul} + 1 bar.

In the case of continuous-flow boilers, the test pressure must be at least 1,1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steaming capacity. In the event of danger that parts of the boiler might be subjected to stresses exceeding 0,9 of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

2.7 Hot water generators

2.7.1 Design

In respect of the materials used and the strength calculations, hot water generators heated by solid, liquid or gaseous fuels or by waste gases or electrically are to be treated in a manner analogous to that applied to boilers. The materials and strength calculations for hot water generators which are heated by steam or hot liquids are subject to the requirements in [1].

2.7.2 Equipment

The safety equipment of hot water generators is subject to the requirements contained in recognized standards with due regard for the special conditions attaching to shipboard operation.

2.7.3 Testing

Each hot water generator is to be subjected to a manufacturing test and to a hydrostatic pressure test at 1,3 times the maximum allowable working pressure subject to a minimum of 4 bar.

3 Thermal oil heaters

3.1 General

3.1.1 Scope

The following rule requirements apply to thermal oil systems in which organic liquids (thermal oils) are heated by oil fired burners to temperatures below their initial boiling point at atmospheric pressure.

Thermal oil heaters to which thermal energy is supplied by engine exhaust gases can be approved. The safety equipment is subject, as applicable, to the Society's Rules.

3.1.2 Definitions

The "maximum allowable working pressure" is the maximum pressure which may occur in the individual parts of the equipment under service conditions.

The "thermal oil temperature" is the temperature of the thermal oil at the centre of the flow cross-section.

The "discharge temperature" is the temperature of the thermal oil immediately at the heater outlet.

The "return temperature" is the temperature of the thermal oil immediately at the heater inlet.

The "film temperature" is the wall temperature on the thermal oil side. In the case of heated surfaces, this may differ considerably from the temperature of the thermal oil.

3.1.3 Documents for review/approval

The following documents are to be submitted to the Society, at least in triplicate, for review/approval:

- a description of the equipment stating the discharge and return temperatures
- the maximum allowable film temperature
- the total volume of the system
- the physical and chemical characteristics of the thermal oil
- drawings of the heater, the expansion vessel and the storage tank
- a flow-chart with details of the proposed safety devices.

If specially requested, mathematical proof of the maximum film temperature in accordance with recognized standards is to be submitted.

3.1.4 Construction and manufacture

Design calculation, materials, manufacture and testing are governed by:

- [2] for heaters
- [1] for expansion and pressure vessels
- [4] for oil firing systems (the cut-out conditions for trips are as stated in [3.2.2] and [3.3.2])
- Ch 1, Sec 10 for pipes, pumps, valves and fittings.

However, grey cast iron is not permitted for components of the hot thermal oil circuit.

Copper and copper alloys are to be avoided because of their catalytic action on the thermal oil.

Welded structures are subject to the Society's Rules for Materials and Welding.

3.1.5 Thermal oils

Thermal oil may be used only within the limits guaranteed by the manufacturer. A safety margin of about 50°C between the discharge temperature and the maximum service temperature specified by the manufacturer is recommended.

The thermal oil is to be protected from oxidation. Where necessary, special precautions are to be taken for this purpose.

3.2 Heaters

3.2.1 Design

The heater is to be equipped with an automatic, rapidly controllable heating system. Thermally, the heater is to be so designed that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil must be ensured by forced circulation. The surfaces which come into contact with the thermal oil are to be designed for the maximum allowable working pressure subject to a minimum gauge pressure of 10 bar. Inspection apertures are to be provided for the examination of the combustion chamber.

Heaters are to be fitted with devices enabling them to be completely drained.

3.2.2 Equipment and safety devices

Temperature measuring devices are to be fitted at the heater discharge and return inlet as well as in the flow of smoke gas leaving the heater. The outlet of the circulating pump is to be equipped with a pressure gauge.

The discharge temperature must be controlled automatically. A thermal trip must switch off the heat supply if the permitted discharge temperature is exceeded.

The flow must be indicated and monitored by a flow monitor. If the flow rate falls below a minimum value, the flow monitor must cut off the heating. Parallel-connected heating surfaces in the heater must be monitored separately. Start-up of the burner must be prevented by interlocks when the circulating pump is not running. For cold start-up the flow monitor can be by-passed.

If the specified smoke gas temperature is exceeded, the heating must be switched off by a temperature trip.

Electrical equipment items are subject to Part C, Chapter 2 and in particular to Ch 2, Sec 13.

3.3 Pressure vessels and tanks

3.3.1 All pressure vessels and tanks, including those open to the atmosphere, are to be designed for a pressure of at least 2 bar, unless provision has to be made for a higher working pressure.

Air ducts are to be installed above the free deck and are to be fitted with automatic shutoff devices.

Drains must be self-closing.

3.3.2 Expansion vessel

An expansion vessel is to be placed at the highest point in the system. The space provided for expansion must be such that the increase in the volume of the thermal oil at the maximum thermal oil temperature can be safely accommodated. The following are to be regarded as minimum requirements: 1,5 times the increase in volume for charges up to 1000 litres, and 1,3 times the increase for charges over 1000 litres. The charge is the total quantity of thermal oil contained in the equipment up to the lowest liquid level in the expansion vessel.

The expansion vessel must be equipped with a liquid level gauge with a mark indicating the lowest allowable liquid level.

Level gauges made of glass, plexiglass or plastic are not allowed.

A level monitoring device with an alarm signalling the lowest and highest liquid level is to be provided. If the liquid drops below the lowest level, the oil firing equipment must, in addition, be automatically switched off and locked.

The expansion vessel is to be provided with an overflow line leading to the discharge tank.

For rapid drainage in case of danger, a quick-opening valve is to be fitted directly to the expansion vessel with remote control from outside the space in which the equipment is installed. The quick drainage line can be led to the discharge tank jointly with the overflow line.

The opening of the quick drainage valve must cause the firing equipment and the circulating pumps to be switched off automatically.

The quick drainage system may be replaced by a emergency shut-off device which, in the event of danger, prevents the egress of large quantities of thermal oil.

A safety expansion line must connect the system to the expansion vessel. This must be installed with a continuous positive gradient and must be so dimensioned as to avoid a pressure rise of more than 10% above the maximum permissible working pressure.

All parts of the equipment which can be isolated from the expansion vessel and in which thermal oil may expand due to external heat input must be safeguarded against excessive pressure.

3.3.3 Pre-pressurized systems

Pre-pressurized systems are to be equipped with an expansion vessel, which contents is blanketed with an inert gas. The inert gas supply has to be guaranteed and monitored for minimum pressure.

The pressure in the expansion vessel must be indicated and safeguarded against overpressure.

3.3.4 Discharge tanks

Discharge tanks are to be so dimensioned that they can hold the isolable charge of the largest part of the system.Where discharge tanks simultaneously function as storage tanks, the above volume is additional to that required for the supply of thermal oil.

The discharge tank shall be sited low enough to enable the system to be drained into it.

For air ducts and drains, see [3.3.1].

For sounding pipes, see Ch 1, Sec 10, [13].

3.4 Fire precautions

3.4.1 See Ch 1, Sec 14, [2].

3.5 Testing

3.5.1 On completion of installation on board, the equipment is to be subjected to a pressure, tightness and operational tests.

4 Oil firing equipment

4.1 General

4.1.1 Scope

The oil firing equipment of automatically and semi-automatically controlled main and auxiliary boilers and thermal oil heaters is subject to the rule requirements in [4.2].

The oil burners of hot water generators, oil-fired heaters and small heating appliances which are located in the engine room or in spaces containing equipment important to the operation of the machinery are subject to the rule requirements specified under [4.3].

In addition, the following general requirements of this Section are mandatory for all installations and appliances.

4.1.2 Documents for review / approval

A sectional drawing of each type of burner together with a description of its mode of operation and circuit diagrams of the electrical control system are to be submitted to the Society, at least in triplicate, for review / approval. Equipment covered by [4.3]. is generally not subject to verification of drawings.

4.1.3 Approved fuels

See Ch 1, Sec 1, [2.6]

4.1.4 Boiler equipment and burner arrangement

Oil burners are to be designed, fitted and adjusted in such a manner as to prevent flames from causing damage to the boiler surfaces or tubes which border on the combustion space. Boiler parts which might otherwise suffer damage are to be protected by refractory lining.

The firing system shall be so arranged as to prevent flames from blowing back into the boiler or engine room and shall allow unburnt fuel to be safely drained.

Observation holes and openings in the burner registers for the insertion of ignition torches are to be arranged and closed off by sliding or rotating flaps in such a way that any danger to the operators from flame blowbacks is avoided.

The functioning of explosion doors or rupture disks may not endanger personnel or important items of equipment in the boiler room.

Fuel leaking from potential leak points is to be safely collected in oiltight trays and drained away.

4.1.5 Simultaneous operation of oil burning equipment and internal combustion machinery

The operation of oil burning equipment in spaces containing other items of plant with a high air consumption, e.g. internal combustion engines or air compressors, must not be impaired by variations in the air pressure.

4.2 Oil firing equipment for boilers and thermal oil heaters

4.2.1 Preheating of fuel oil

For the preheating of fuel oil any source may be used provided that it can be cut off immediately if the need arises and provided that it can be adequately controlled when in operation. Preheating with open flame is not allowed.

Where fuel oil is heated exclusively by thermal energy from the boiler, it must be possible to heat the boiler from cold with fuel needing no preheating.

After the oil firing equipment has been shut down, the heat retained in the preheater shall not cause an excessive temperature rise in the fuel oil.

The preheating temperature is to be selected so as to avoid foaming or the formation of vapour from water contained in the fuel oil. Also, it may not give rise to harmful effects due to oil vaporization and the carbonization of the heating surfaces.

Temperature or viscosity control must be automatic. For monitoring purposes, a thermometer or viscosimeter is to be fitted to the fuel oil pressure line in front of the burners. Should the oil temperature or viscosity deviate above or below the permitted limits, this must be signalled by an alarm system.

When a change is made from heavy to light oil, the latter may not be passed through the heater or be excessively heated.

The dimensional and constructional design of pressurized fuel oil preheaters is subject to the rules set out in [1].

Electrically heated continuous-flow heaters are to be equipped with temperature safety trips in accordance with [1.5.3].

4.2.2 Pumps, pipelines, valves and fittings

Fuel oil service pumps may be connected only to the fuel system.

Pipelines must be permanently installed and joined by oiltight welds, oiltight threaded connections of approved design or with flanged joints. Flexible pipes may be used only immediately in front of the burner or to enable the burner to swivel. They must be installed with adequate bending radii and must be protected against undue heating. For non-metallic flexible pipes and expansion compensators, see Ch 1, Sec 10, [14].

Suitable devices, e.g. relief valves, must be fitted to prevent any excessive pressure increase in the fuel oil pump or pressurized fuel lines.

By means of a hand-operated, quick-closing device it must be possible to isolate the fuel supply to the burners from the pressurized fuel lines.

4.2.3 Safety equipment

Interlocks or control systems must be provided to ensure that safety functions are performed in the correct sequence when the burners are started up or shut down.

Each installation must be equipped with an automatic quick-closing device. This must not release the oil supply to the burners on start-up and must interrupt the oil supply during operation if one of the following faults occurs:

- Failure of the required pressure of the atomizing medium (steam and compressed-air atomizers)

  Failure of the oil pressure needed for atomization (pressure atomizers) or

  Insufficient rotary speed of spinning cup (rotary atomizers)
- Failure of combustion air supply
- Actuation of limit switches (e.g. for water level or temperature)
- Actuation of flame monitor
- Failure of control power supply
- Failure of induced-draught fan or insufficient opening of exhaust gas register
- Burner retracted or pivoted out of position.

Each installation must be shut down automatically and secured if:

- a flame does not develop within the safety period following start-up (see [4.2.4])
- the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or
- limit switches are actuated.

Oil firing equipment with electrically operated components must also be capable of being shut down by an emergency switch located outside the space in which the equipment is installed.

4.2.4 Design and construction of burners

For the purpose of these Rules, the following definitions apply:

a) Fully automatic oil burners

   Fully automatic oil burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls so that the ignition, flame monitoring and burner start-up and shutdown are effected as a function of the controlled variable without the intervention of operating personnel.

b) Semi-automatic oil burners

   Semi-automatic oil burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls. Burner start-up is initiated manually. Shutdown may be initiated manually. Burner shutdown is not followed by automatic re-ignition.

c) Manually operated oil burners

   Manually operated oil burners are burners where every ignition sequence is initiated and carried through by hand. The burner is automatically monitored and shut down by the flame monitor and, where required by the safety system, by limiters. Re-starting can only be carried out directly at the burner and by hand.

d) Safety period

   The safety period is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.

The type and design of the burner and its atomizing and air turbulence equipment must ensure virtually complete combustion.

Oil burners must be so designed and constructed that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter must also be protected to prevent the entry of drip water.

Oil burners are to be so constructed that they can be retracted or pivoted out of the operating position only when the fuel oil supply has been cut off. The high-voltage ignition system must be automatically disconnected when this occurs. A catch is to be provided to hold the burner in the swung out position.

Steam atomizers must be fitted with appliances to prevent fuel oil entering the steam system.

Where dampers or similar devices are fitted in the air supply duct, care must be taken to ensure that air for purging the combustion space is always available unless the oil supply is positively interrupted.

Where an installation comprises several burners supplied with combustion air by a common fan, each burner must be fitted with a shutoff device (e.g. a flap). Means must be provided for retaining the shutoff device in position and its position must be indicated.

Every burner must be equipped with an igniter. The ignition operation is to be initiated immediately following purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and blower impeller) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

Every burner is to be equipped with a safety device for flame monitoring. This appliance must comply with the following safety periods on burner start-up or when the flame is extinguished in operation:

- On start-up 5 seconds
- In operation 1 second.

Where this is justified, longer safety periods may be permitted for burners with an oil throughput of up to 30 kg/h. Steps must be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniter (e.g. pilot burners).

4.2.5 Purging of combustion chamber and flues, exhaust gas ducting

The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. On manually operated equipment, a warning sign is to be mounted to this effect.

A threefold renewal of the total air volume of the combustion spaces and the flue gas ducts up to the funnel inlet is considered sufficient. Normally purging shall be performed with the total flow of combustion air for at least 15 seconds. It shall, however, in any case be performed with at least 50 % of the volume of combustion air needed for the maximum rating of the burner system.

By-passes and dead corners in the exhaust gas ducting are to be avoided.

Dampers in uptakes and funnels should be avoided. Any dampers which may be fitted must be so installed that no oil supply is possible when the cross-section of the purge line is reduced below a certain minimum value. The position of the damper must be indicated at the boiler control platform.

Where an induced-draught fan is fitted, an interlocking system must prevent start-up of the burner equipment before the fan has started. A corresponding interlocking system is also to be provided for any covers which may be fitted to the funnel opening.

4.2.6 Electrical equipment

Electrical controls, safety appliances and their types of enclosure must comply with the Rules in Part C, Chapter 2, Rules for Electrical Installations.

Safety appliances and flame monitors must be self-monitoring and must be connected in such a way as to prevent the supply of oil in the event of a break in the circuitry of the automatic oil burning system.

4.2.7 Emergency operation

Should the automatic control and monitoring systems malfunction, the safety appliances may be by-passed only by means of a key-operated switch. An effort should be made to ensure that safety functions, e.g. limiter responses, can be individually by-passed.

The flame monitoring system must remain operative even during emergency operation.

4.2.8 Testing

The fitted installation is to be subjected to operational testing including, in particular, determination of the purging time required prior to burner start-up. Satisfactory combustion at all load settings and the reliable operation of the safety equipment are to be checked. Following installation, the pressurized fuel oil system is to be subjected to a pressure and tightness test; see Ch 1, Sec 10, [7.4].

4.3 Oil burners for hot water generators oil fired heaters and small heating appliances

4.3.1 Atomizer burners

Fully and semi-automatic atomizer burners must meet the requirements of recognized standards or must be recognized as equivalent. Adequate purging by means of a fan must be ensured prior to each ignition effected by the controls. In general, a purging period of at least 5 seconds may be deemed sufficient. Where the flue gas ducting is unfavorable, the purging time is to be extended accordingly.

Electrical components and their type of enclosure must comply with Part C, Chapter 2, Rules for Electrical Installations. High-voltage igniters must be adequately protected against unauthorized interference.

Where dampers or similar devices are mounted in the air supply line, care must be taken to ensure that air is available in all circumstances for purging the combustion space.

Pivoted oil burners must be so constructed that they can be swivelled out only after the fuel oil has been cut off. The high-voltage ignition equipment must likewise be disconnected when this happens.

The plant must also be capable of being shut down by means of an emergency switch located outside the space in which the plant is installed.

4.3.2 Evaporation burners

The burner design (e.g. dish or pot-type burner) must ensure that the combustion of the fuel oil is as complete as possible at all load settings. At the maximum oil level and with all possible angles of inclination of the inland waterway vessel (see Ch 1, Sec 1) no fuel oil may spill from the combustion vessel or its air holes. Parts of the equipment important for the operation, monitoring and cleaning of the plant must be readily accessible.

Burners must be fitted with regulators ensuring a virtually constant flow of fuel oil at the selected setting. A safety device is required to prevent the oil in the combustion vessel from rising above the maximum permitted level. The regulators must function reliably despite all movements and inclinations of the inland waterway vessel.

Burners are normally to be equipped with a blower to ensure a sufficient supply of combustion air. Should the blower fail, the oil feed must be cut off automatically. Heating equipment with burners not supplied by a blower may only be installed and operated in the spaces mentioned in [4.1.1] provided a supply of air adequate to maintain trouble-free combustion is guaranteed.

4.3.3 Oil-fired heaters

Oil-fired heaters having an evaporation burner without blower may be installed in the spaces mentioned in [4.1.1] only if their thermal capacity does not exceed 42 000 kJ/h. They may only be operated, however, if items of equipment with a high air consumption such as internal combustion engines or air compressors do not draw air from the same space. Compliance is to be ensured by an appropriate directive in the operating instructions and by a warning sign fixed to such heaters. Attention is also to be drawn to the danger of blowbacks when the burner is reignited in the hot heater.

Oil-fired heaters must comply with the requirements of recognized standards and be tested and approved accordingly, or must be recognized as equivalent. Control and safety equipment must ensure the safe and reliable operation of the burner despite all movements and inclinations of the inland waterway vessel.

Smoke tubes and uptakes must have a cross-section at least equal to that of the flue pipe on the heater and must follow as direct a path as possible. Horizontal flue spans are to be avoided. Funnel (stack) outlets are to be fitted with safety appliances (e.g. Meidinger discs) to prevent downdraughts.

4.3.4 Small oil-fired heaters for heating air

Depending on their mode of operation, the requirements set out in [4.3.1] to [4.3.3] apply in analogous manner to these units.

Equipment which does not entirely meet the requirements of the standards mentioned can be allowed provided that its functional safety is assured by other means, e.g. by the explosion-proofing of the combustion chamber and exhaust ducts.

Heating ducts are to be competently installed in accordance with the manufacturer's installation and operating instructions, and reductions in cross-section, throttling points and sharp bends are to be avoided so as not to incur the danger of the equipment overheating. A thermostatic control must shut the appliance down in the event of overheating.

SECTION 4 HYDRAULIC SYSTEM

1 General

1.1 Scope

1.1.1 The Rules contained in this Article apply to hydraulic systems used, for example, to operate closing appliances in the vessel's shell, landing ramps and hoists. The Rules are to be applied in analogous manner to vessel's other hydraulic systems.

1.2 Documents for review/approval

1.2.1 The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used, etc., are to be submitted to the Society, at least in triplicate, for review/approval.

1.3 Dimensional design

1.3.1 For the design of pressure vessels, see Ch 1, Sec 3, [1], for the dimensions of pipes, see, Ch 1, Sec 10.

2 Materials

2.1 Approved materials

2.1.1 Components fullfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with NR 216 Materials and Welding. The use of other materials is subject to special agreement with the Society.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

Pipes are to be made of seamless or longitudinally welded steel tubes.

The pressure-loaded walls of valves, fittings, pumps, motors, etc., are subject to the requirements of Ch 1, Sec 10.

2.2 Testing of materials

2.2.1 The materials of pressure casings and pressure oil lines must possess mechanical characteristics in conformity with NR 216 Materials and Welding. Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in NR 216 Materials and Welding.

3 Design and equipment

3.1 Control

3.1.1 Hydraulic systems may be supplied either from a common power station or from a number of power stations, each serving a particular system.

3.1.2 Where the supply is from a common power station and in the case of hydraulic drives whose piping system is connected to other hydraulic systems, a second pump set is to be provided.

3.1.3 Hydraulic systems shall not be capable of being initiated merely by starting the pump. The movement of the equipment is to be controlled from special operating stations. The controls are to be so arranged that, as soon as they are released, the movement of the hoist ceases immediately.

3.1.4 Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hydraulic equipment should normally be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating stations are then to be equipped with indicators for monitoring the movement of the hoist.

3.1.5 In or immediately at each power unit (ram or similar) used to operate equipment which moves vertically or rotates about a horizontal axis, suitable precautions must be taken to ensure a slow descent following a pipe rupture.

3.2 Pipes

3.2.1 The pipes of hydraulic systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

3.2.2 Pipes are to be installed at a sufficient distance from the vessel's shell. As far as possible, pipes should not pass through cargo spaces. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

3.2.3 Pipes are to be so installed that they are free from stress and vibration.

3.2.4 The piping system is to be fitted with filters for cleaning the hydraulic fluid.

3.2.5 Equipment is to be provided to enable the hydraulic system to be vented.

3.2.6 The hydraulic fluids must be suitable for the intended ambient and service temperatures.

3.2.7 Where the hydraulic system includes accumulators, the accumulator chamber must be permanently connected to the safety valve of the associated system. The gas chamber of the accumulators shall only be filled with inert gases. Gas and hydraulic fluid are to be separated by accumulator bags, diaphragms or similar devices.

3.3 Oil level indicators

3.3.1 Tanks within the hydraulic system are to be equipped with oil level indicators.

An alarm located in the wheelhouse is to fitted for the lowest permissible oil level.

3.4 Hose lines

3.4.1 Hose assemblies comprise hoses and their fittings in a fully assembled and tested condition.

High pressure hose assemblies are to be used if necessary for flexible connections. These hose assemblies must meet the requirements of Ch 1, Sec 10 or an equivalent standard. The hose assemblies must be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose assemblies are to be flame-resistant or to be protected correspondingly.

4 Testing in the manufacturer's works

4.1 Testing of power units

4.1.1 The power units of hydraulic systems are required to undergo test on a test stand. The relevant works test certificates are to be presented at time to the final inspection of the hydraulic system.

For electric motors, see Ch 2, Sec 3.

Hydraulic pumps are to be subjected to pressure and operational tests.

4.2 Pressure and tightness tests

4.2.1 Pressure components are to undergo a pressure test at pressure

$p_{ST} = 1,5p$

where:

p_{ST} : Test pressure, in bar

p : Maximum allowable working pressure or pressure at which the relief valves open, in bar

For working pressures above 200 bar, the test pressure need not exceed p + 100.

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see Ch 1, Sec 10.

Tightness tests are to be performed on components to which this is appropriate.

SECTION 5 WINDLASSES

1 General

1.1 Scope

1.1.1 The Rules contained in this Article apply to bow anchor windlasses, stern anchor windlasses and wire rope windlasses. For anchors, chains and ropes, see Rules for Equipment in Pt B, Ch 7, Sec 4.

The provisions of [3] are given as a guidance but the design review of windlasses is not required.

2 Materials

2.1 Approved materials

2.1.1 The provisions contained in NR 216 Materials and Welding are to be applied as appropriate to the choice of materials.

2.2 Testing of materials

2.2.1 The material of components which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, brake bands, brake spindles, brake bolts, tension strap) must possess mechanical characteristics in conformity with NR 216 Materials and Welding. Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in the Society's Rules for Materials and Welding.

In the case of hydraulic systems, the material used for pipes as well as for pressure vessels is also to be tested.

3 Design and equipment

3.1 Type of drive

3.1.1 Windlasses are normally to be driven by an engine which is independent of other deck machinery. The piping systems of hydraulic windlass engines may be connected to other hydraulic systems provided that this is permissible for the latter.

Manual operation as the main driving power can be allowed for anchors with a weight up to 250 kg.

3.2 Overload protection

3.2.1 For protection of the mechanical parts in the case of the windlass jamming, an overload protection (e.g. slip coupling, relief valve) is to be fitted to limit the maximum torque of the drive engine (see [3.13]). The setting of the overload protection is to be specified (e.g. in the operating instructions)

3.3 Clutches

3.3.1 Windlasses are to be fitted with disengageable clutches between the cable lifter and the drive shaft. In an emergency case, hydraulic or electrically operated clutches must be capable of being disengaged by hand.

3.4 Braking equipment

3.4.1 Windlasses must be fitted with cable lifter brakes which are capable of holding a load equal to 80% of the nominal breaking load of the chain. In addition, where the gear mechanism is not of selflocking type, a device (e.g. gearing brake, lowering brake, oil hydraulic brake) is to be fitted to prevent paying out of the chain should the power unit fail while the cable lifter is engaged.

3.5 Pipes

3.5.1 For the design and dimensions of pipes, valves, fittings and hydraulic piping systems, etc. see Ch 1, Sec 10.

3.6 Cable lifters

3.6.1 Cable lifters shall have at least five snugs.

For cable lifters used for studless chains, the requirements of EN 14874 can be applied.

3.7 Windlass as warping winch

3.7.1 Combined anchor and mooring winches may not be subjected to excessive loads even when the maximum pull is exerted on the warping rope.

3.8 Electrical equipment

3.8.1 The electrical equipment is to comply with Part C, Chapter 2.

3.9 Hydraulic equipment

3.9.1 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

The lowest permissible oil level is to be monitored.

Filters for cleaning the operating fluid are to be located in the piping system.

3.10 Wire rope windlass

3.10.1 The rope drum diameter must be at least 14 times the required rope diameter.

The drive of the windlass must be capable of being uncoupled to the rope drum.

The rope end fastening of the windlass must break if the wire rope has to be released.

Rope drums shall be provided with flanges whose outer diameter extend above the top layer of the rope by at least 2,5 times rope diameter unless the rope is prevented from overriding the flange by a spooling device or other means.

3.11 Chain stoppers

3.11.1 Where a chain stopper is fitted, it is to be able to withstand a pull of 80% of the chain breaking load.

Where no chain stopper is fitted, the windlass must be able to withstand a pull of 80% of the chain breaking load. The caused stress in the loaded parts of the windlass may not exceed 90% of the yield strength of the respective parts and the windlass brake is not allowed to slip.

3.12 Connection with deck

3.12.1 The windlass, the foundation and the stoppers have to be connected efficiently and safely to the deck.

3.13 Driving power

3.13.1 Depending on the grade of the chain cable, windlasses must be capable of exerting the following nominal pulls at a speed of at least 0,15 m/s:

$Z_1 = 28\ d^2$ for grade Q_1

$Z_2 = 32\ d^2$ for grade Q_2

where:

Z_i : Pull, in N

d : Diameter of anchor chain, in mm

3.13.2 The nominal output of the power units must be such that the conditions specified above can be met for 30 minutes without interruption. In addition, the power units must be capable of developing a maximum torque equal to 1,5 times the rated torque for at least two minutes at a correspondingly reduced lifting speed.

3.13.3 At the maximum torque specified in [3.13.2], a short-time overload of up to 20% is allowed in the case of internal combustion engines.

3.13.4 An additional reduction gear stage may be fitted in order to achieve the maximum torque.

3.13.5 With manually operated windlasses, steps are to be taken to ensure that the anchor can be hoisted at a mean speed of 0,033m/s with the pull specified in a). This is to be achieved without exceeding a manual force of 150 N applied to a crank radius of about 350 mm with the hand crank turned at about 30 rev./min.

3.14 Design of transmission elements

3.14.1 The basis for the design of the load-transmitting components of windlasses are the anchors and chain cables specified in the rules for Equipment (see Pt B, Ch 7, Sec 4).

3.14.2 The cable lifter brake is to be so designed that the anchor and chain can be safely stopped while paying out the chain cable.

3.14.3 The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft and braking equipment, bedframe and deck fastening) is to be based on a theoretical pull equal to 80% of the nominal breaking load specified in NR 216 Materials and Welding for the chain in question. The design of the main shaft is to take account of the braking forces, and the cable lifter brake shall not slip when subjected to this load.

3.14.4 The design of all other windlass components is to be based upon a force acting on the cable lifter pitch circle and equal to 1,5 times the nominal pull specified in [3.13.1].

3.14.5 At the theoretical pull, the force exerted on the brake handwheel shall not exceed 500 N.

3.14.6 The total stresses applied to components must be below the minimum yield point of the materials used.

3.14.7 The foundations and pedestals of windlasses and chain stoppers must be adequate designed to withstand the forces and loads as specified in [3.11.1] and in paragraphs hereabove.

4 Testing in the manufacturer's works

4.1 Testing of driving engines

4.1.1 The power units are required to undergo test on a test stand. The relevant works test certificates are to be presented at the time of the final inspection of the windlass.

For electric motors, see Rules for rotating machines in Ch 2, Sec 3.

Hydraulic pumps are to be subjected to pressure and operational tests.

4.2 Pressure and tightness tests

4.2.1 Pressure components are to undergo a pressure test at pressure:

$p_{ST} = 1,5p$

where:

p_{ST} : Test pressure, in bar

p : Maximum allowable working pressure or pressure at which the relief valves open, in bar

For working pressures above 200 bar, the test pressure need not exceed p + 100.

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see Ch 1, Sec 10.

Tightness tests are to be performed on components to which this is appropriate.

4.3 Final inspection and operational testing

4.3.1 After finishing manufacture, windlasses are required to undergo final inspection and operational testing at twice the nominal pull in the presence of the Society's Surveyor. The hauling-in speed is to be verified with continuous application of the nominal pull. During the tests, particular attention is to be given to the testing and, where necessary, setting of braking and safety equipment.

Where manufacturing works does not have adequate facilities, the aforementioned tests including the adjustment of the overload protection can be carried out on board the vessel. In these cases, functional testing in the manufacturer's works is to be performed under no-load conditions.

SECTION 6 GEARS AND COUPLINGS

1 General

1.1 Scope

1.1.1 The requirements of this Article apply to spur, planetary and bevel gears and to all types of couplings for incorporation in the main propulsion plant or important auxiliary machinery such as:

- electric generator sets
- windlasses
- bow thruster units
- lubricating oil, cooling water, bilge pumps, etc.

The design requirements laid down here may also be applied to the gears and couplings of auxiliary machinery other than that mentioned above, if equivalent evidence of mechanical strength is not available.

1.1.2 Application of these Rules to the auxiliary machinery couplings mentioned above may generally be limited to a basic design approval by the Society of the particular coupling type. Regarding the design of elastic couplings for use in generator sets, reference is made to [7.1].

1.1.3 For the dimensional design of gears and couplings for vessels with reinforced design, see Pt D, Ch 2, Sec 1.

1.2 Documents for review / design

1.2.1 Assembly and sectional drawings together with the necessary detail drawings and parts lists are to be submitted to the Society, at least in triplicate, for review / approval. They must contain all data necessary to enable the load calculations to be checked.

2 Materials

2.1 Approved materials

2.1.1 Shafts, pinions, wheels and wheel rims of gears in the main propulsion plant should preferably be made of forged steel. Rolled steel bar may also be used for plain, flangeless shafts. Gear wheel may be of grey cast iron (see [2.1.5], Note 1) or nodular cast iron or may be fabricated from welded steel or cast steel hubs.

2.1.2 Couplings in the main propulsion plant must be made of steel, cast steel or nodular cast iron with a mostly ferritic matrix. Grey cast iron or suitable cast aluminium alloys may also be permitted for lightly stressed external components of couplings and the rotors and casings of hydraulic slip couplings.

2.1.3 The gears of important auxiliary machinery are subject to the same requirements as those specified in a) as regards the materials used. For gears intended for auxiliary machinery different to those mentioned in a), other materials may also be permitted.

2.1.4 Flexible coupling bodies for important auxiliary machinery according to a) may generally be made of grey cast iron, and for the outer coupling bodies a suitable aluminium alloy may also be used.

However, for generator sets use should only be made of coupling bodies preferably made of nodular cast iron with a mostly ferritic matrix, of steel or of cast steel, to ensure that the couplings are well able to withstand the shock torques occasioned by short circuits. The Society reserves the right to impose similar requirements on the couplings of particular auxiliary drive units.

Note 1: The peripheral speed of cast iron gear wheels shall generally not exceed 60 m/s, that of cast iron coupling clamps or bowls, 40 m/s.

2.2 Testing of materials

2.2.1 All materials of torque transmitting components of gearing and couplings and the plates and steel parts of welded gear casings must possess the properties specified in NR 216 Materials and Welding. This may be proved by a workshop certificate issued by the manufacturer.

With the consent of the Society, the tests prescribed in the Rules for Materials and Welding may be reduced if the execution of such tests is rendered impracticable by the small size of certain components or by the particular manufacturing techniques used. For such parts, proof of quality is to be furnished to the Society by other means.

3 Calculation of the load bearing capacity of cylindrical and bevel gearing

3.1 General

3.1.1 The sufficient load capacity of the gear-tooth system of main and auxiliary gears in main propulsion systems of inland water vessels is to be demonstrated by load calculations according to the international standards ISO 6336 and ISO 9083 for spur gear tooth systems respectively, ISO 10300 for bevel gears.

For the design and calculation of the gears, the Society Rules and requirements for the design and construction of gears are applicable.

3.2 Application factor K_A

3.2.1 The application factor K_A takes into account the increase in rated torque caused by external increases in dynamic and transient load. Normally, the application factor K_A should be determined by measurements or by system analysis acceptable by the Society.

Where a value as described above cannot be supplied, the application factor K_A is to be determined for main and auxiliary systems in accordance with Tab 1.

Table 1 : Application factor

System type	K_A
Main propulsion	
Diesel engine with fluid coupling or electromagnetic coupling	1,05
Diesel engine drive systems with highly flexible coupling between engine and gears	1,30
Diesel engine drive systems with other couplings than flexible	1,50
Shaft generator drives	1,50
Auxiliary propulsion	
Electric motor or diesel engine with fluid coupling or electromagnetic coupling	1,0
Diesel engine drive systems with highly flexible coupling between engine and gears	1,2
Diesel engine drive systems with other couplings than flexible	1,4
Note 1: For other types of systems, the factor K_A is to be stipulated separately	

4 Gear shafts

4.1 Minimum diameter

4.1.1 The dimensions of shafts of reversing and reduction gears are to be calculated by applying the following formula:

$$d \geq Fk \sqrt[3]{\frac{P_w}{N\left[1-\left(\frac{d_i}{d_a}\right)^4\right]} C_w}$$

For $d_i/d_a \leq 0,3$:

$$1-\left(\frac{d_i}{d_a}\right)^4 = 1,0$$

where:

d_i : Diameter of shaft bore, if applicable, in mm

d_a : Actual shaft diameter, in mm

P_w : Driving power of shaft, in kW

N : Shaft rotational speed, in rev./min

F : Factor for the type of drive

F = 90 for turbine plants, electrical drives and engines with slip couplings

F = 94 for all other types of drive. The Society reserves the right to specify higher F values if this appears necessary in view of the loading of the plant.

C_w : Material factor

$$C_w = \frac{560}{R_m + 160}$$

However, for wheel shafts, the value substituted for R_m in the formula shall not be higher than 800 N/mm^2. For pinion shafts the actual tensile strength value may generally be substituted for R_m.

k : Coefficient defined as:

k = 1,10 for gear shafts.

k = 1,15 for gear shafts in the area of the pinion or wheel body if this is keyed to the shaft and for multiple-spline shafts.

Higher values of k may be specified by the Society where increased bending stresses in the shaft are liable to occur because of the bearing arrangement, the casing design, the tooth pressure, etc.

5 Equipment

5.1 General

5.1.1 Oil level indicator

For monitoring the lubricating oil level in main and auxiliary gears, equipment must be fitted to enable the oil level to be determined.

5.1.2 Pressure and temperature control

Temperature and pressure gauges are to be fitted to monitor the lubricating oil pressure and the lubricating oil temperature at the oil-cooler outlet before it enters the gears.

Plain journal bearings are also to be fitted with temperature indicators.

Where gears are fitted with anti-friction bearings, a temperature indicator is to be mounted at a suitable point. For gears rated up to 2000 kW, special arrangements may be agreed with the Society.

Where vessels are equipped with automated machinery, the requirements for automation are to be complied with.

5.1.3 Lubricating oil pumps

Lubricating oil pumps driven by the gearing must be mounted in such a way that they are accessible and can be replaced.

5.1.4 Gear casings

The casings of gears belonging to the main propulsion plant and important auxiliaries must be fitted with removable inspection covers to enable the gears to be inspected and the thrust bearing clearance to be measured and oil sump to be cleaned.

5.1.5 Seating of gears

The seating of gears on steel or cast resin chocks is to conform to the Society Rules for the mechanical seating of engine plants.

In the case of cast resin seatings, the thrust must be absorbed by means of stoppers. The same applies to cast resin seatings of separate thrust bearings.

6 Balancing and testing

6.1 Balancing

6.1.1 Gear wheels, pinions, shafts, gear couplings and, where applicable, high-speed flexible couplings must be assembled in a properly balanced condition.

The generally permissible residual imbalance U, in kg.mm, per balancing plane of gears for which static or dynamic balancing is rendered necessary by the method of manufacture and by the operating and loading conditions can be determined by applying the formula:

$$U = \frac{9,6QG}{zN}$$

where:

G : Mass of body to be balanced, in kg

N : Operating rotational speed, in rev./min, of body to be balanced

z : Number of balancing planes

Q : Degree of balance

Q = 6,3, for gear shafts, pinions and coupling members for engine gears

Q = 2,5, for torsion shafts and gear couplings, pinions and gear wheels belonging to turbine transmissions.

6.2 Testing in the manufacturer’s works

6.2.1 When the testing of material and component tests have been carried out, gearing systems for the main propulsion plant and for important auxiliaries are to be presented to the Society for final inspection and operational testing in the manufacturer’s works. The final inspection is to be combined with a trial run lasting several hours under part or full-load conditions, on which occasion the tooth clearance and contact pattern are to be checked. In the case of a trial at full-load conditions, any necessary running-in of the gears must have been completed beforehand. Where no test facilities are available for the operational and on-load testing of large gear trains, these tests may also be performed on board vessel on the occasion of the dock trials.

Tightness tests are to be performed on those components to which such testing is appropriate.

Reductions in scope of tests require the consent of the Society.

7 Design and construction of couplings

7.1 General

7.1.1 For the design and construction of couplings in main and auxiliary propulsion systems, such as tooth couplings, flexible couplings, etc., the Society’s Rules and requirements for the design and construction of couplings are applicable.

SECTION 7 MAIN PROPULSION SHAFTING

Symbols

d : Required outside diameter of shaft, in mm

d_i : Diameter of the shaft bore, where present, in mm.

If $d_i \leq 0,3 d_a$

$$\left[1 - \left(\frac{d_i}{d_a}\right)^4\right] = 1$$

d_a : Actual shaft diameter, in mm

P_W : Shaft power, in kW

N : Shaft speed, in rev/min

C_W : Material factor

$$C_W = \frac{560}{R_m + 160}$$

R_m : Tensile strength of the shaft material, in N/mm²

z : Number of fitted or plain bolts

d_f, d_k : Diameters of fitted bolts and plain bolts, in mm

D : Diameter of pitch circle of bolts, in mm

1 General

1.1 Scope

1.1.1 The requirements of this Article apply to a standard and established types of main shafting. Novel designs require the Society's special approval.

Main shafts of reinforced design are additionally subject to the requirements of Pt D, Ch 2, Sec 1. The Society reserves the right to call for propeller shaft dimensions in excess of those specified in this Section if the propeller arrangement results in increased bending stresses.

1.2 Documents for review/approval

1.2.1 General drawings of the entire shafting, from the main engine coupling flange to the propeller, and detail drawings of the shafts, couplings and other component parts transmitting the propelling engine torque, are each to be submitted to the Society, at least in triplicate, for review/approval. The drawings must contain all the data necessary to enable the stresses to be evaluated.

2 Materials

2.1 Approved materials

2.1.1 Propeller, intermediate and thrust shafts together with flange and clamp couplings are to be made of forged steel; where appropriate, couplings may also be made of cast steel or nodular cast iron with a ferritic matrix.

Rolled round steel may also be used for plain, flangeless shafts. In general, the tensile strength of steels used for shafting shall be between 400 N/mm² and 800 N/mm². However, the value of R_m used for calculating the material factor C_W defined in [3.2.1] for propeller shaft shall not be greater than 600 N/mm².

Where parts of the main shafting are made of material other than steel, the special consent of the Society shall be obtained.

2.2 Material testing

2.2.1 All materials of torque transmitting shafting components must possess the properties specified in NR 216 Materials and Welding. This may be proved by a workshop certificate issued by the manufacturer.

3 Shaft dimensions

3.1 General

3.1.1 All parts of the shafting are to be dimensioned in accordance with the following formulas in compliance with the requirements relating to critical speeds set out in Ch 1, Sec 9, [1].

The dimensions of the shafting shall be based on the total installed power. Where the geometry of a part is such that it cannot be dimensioned in accordance with these formulas, special evidence of the mechanical strength of the part or parts concerned is to be furnished to the Society.

3.2 Minimum diameter

3.2.1 The minimum diameter is to be determined by applying the following formula:

$$d \geq Fk \sqrt[3]{\frac{P_W C_W}{N\left[1 - \left(\frac{d_i}{d_a}\right)^4\right]}} \leq d_a$$

where:

F : Factor for the type of propulsion installation

- F = 90 for turbine installations, engine installations with slip couplings and electrical propulsion installations
- F = 94 for all other types of propulsion installations

k : Factor for the type of shaft:

- k = 1,0 for intermediate shafts with integral forged coupling flanges or with shrink-fitted keyless coupling flanges
- k = 1,10 for intermediate shafts where the coupling flanges are mounted on the ends of the shaft with the aid of keys. At a distance of at least 0,2d from the end of the keyway, such shafts can be reduced to a diameter corresponding to k = 1,0
- k = 1,10 for intermediate shafts with radial holes whose diameter is not greater than 0,3d
- k = 1,10 for thrust shafts near the plain bearings on either side of the thrust collar, or near the axial bearings where an antifriction bearing design is used
- k = 1,15 for intermediate shafts designed as multi-splined shafts where d is the outside diameter of the splined shaft. Outside the splined section, the shafts can be reduced to a diameter corresponding to k = 1,0
- k = 1,20 for intermediate shafts with longitudinal slots where the length and width of the slot do not exceed 1,17d and 0,25d respectively
- k = 1,22 for propeller shafts from the area of the aft stern tube or shaft bracket bearing to the forward load-bearing face of the propeller boss subject to a minimum of 2,5d, if the propeller is shrink-fitted, without key, on the tapered end of the propeller shaft using a method approved by the Society, or if the propeller is bolted to a flange forged on the propeller shaft
- k = 1,26 for propeller shafts in the aft area as specified for k = 1,22, with tapered key/keyway connection
- k = 1,40 for propeller shafts in the area specified for k = 1,22, if the shaft inside the stern tube is lubricated with grease
- k = 1,15 for propeller shafts forward portion of shafts to where they emerge from the stern tube. The portion of the propeller shaft located forward of the stern tube can be reduced to the size of the line shaft.

Parts of the propeller shaft immersed in the water and without effective corrosion protection must be strengthened by 5%.

4 Design

4.1 Changes in diameter

4.1.1 Changes from larger to smaller shaft diameters are to be effected by tapering or ample radiusing.

4.2 Sealing

4.2.1 Propeller shafts running in oil or grease are to be fitted with seals of proven efficiency and approved by the Society at the stern tube ends. The propeller boss seating is to be effectively protected against the ingress of water. The seals at the propeller can be dispensed with if the propeller shaft is made of corrosion resistant material.

4.3 Shaft locking device

4.3.1 To prevent dragging of a shut down propulsion unit, the shafting is to be fitted with a locking device.

4.4 Shaft tapers and propeller nut threads

4.4.1 Keyways on the shaft taper for the propeller should be so designed that the forward end of the groove makes a gradual transition to the full shaft section. Preferably, the forward end of the keyway should be spoonshaped, so as to minimize notch effects and stress concentrations. The edges of the keyway at the surface of the shaft taper for the propeller may not be sharp. The forward end of the keyway must lie well within the seating of the propeller boss. Threaded holes to accommodate the securing screws for propeller keys should be located only in the aft half of the keyway.

Note 1: For most simplified designs of the keyway, the consent of the Society will be required.

4.4.2 The distance between the greater base of the propeller shaft cone and the forward end of the keyway is to be not less 20% of the actual diameter of the propeller shaft.

The fillet radius at the bottom of the keyway is not to be less than 1,20% of the actual propeller shaft diameter at the greater base of the propeller shaft cone.

(see Fig 1).

Note 1: In Fig 1 d_2 is the actual propeller shaft diameter.

4.4.3 In general, tapers for securing flange couplings should have a cone of between 1:10 and 1:20. In the case of shaft tapers for propellers, the cone must be between 1:10 and 1:15. Where the oil injection method is used to mount the propeller on the shaft, a taper of the cone between 1:15 and 1:20 is to be preferred.

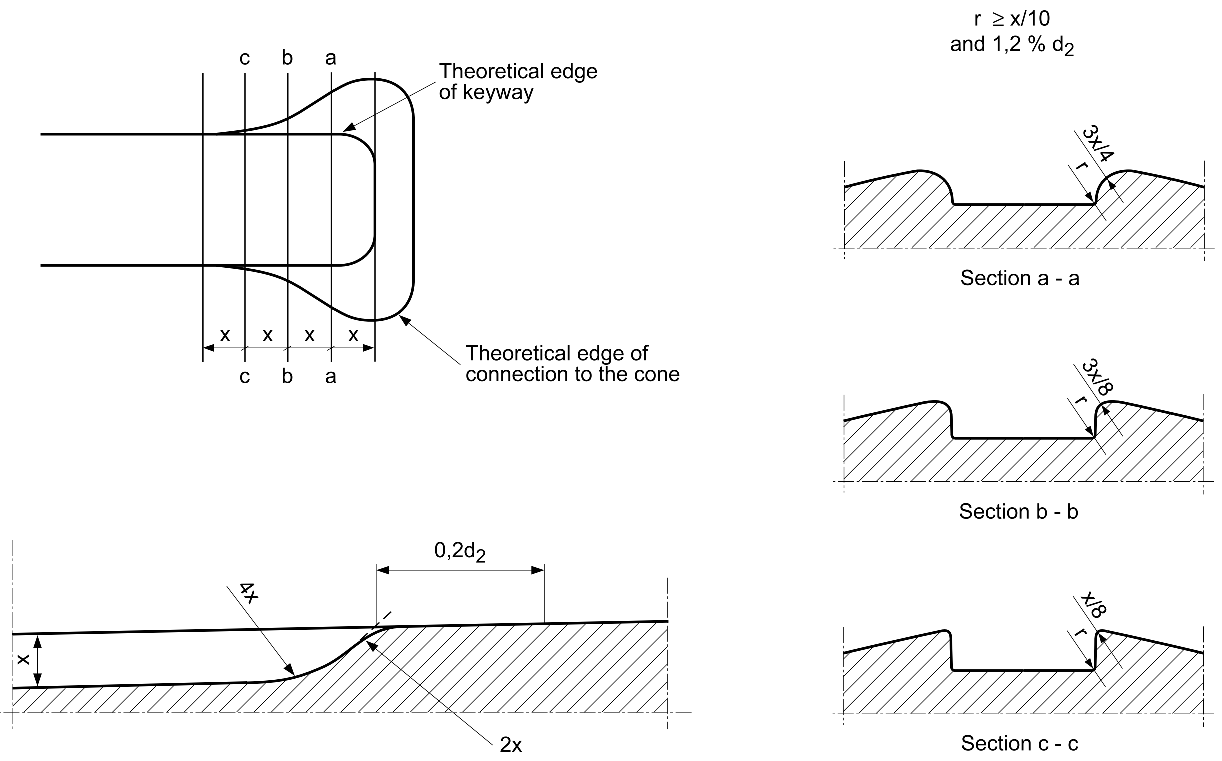
4.4.4 The outside diameter of the threaded end propeller retaining nut should not be less than 60% of the calculated major taper diameter.

4.5 Shaft liners

4.5.1 Propeller shafts which are not made of corrosion-resistant material are to be protected against contact with brackwater by metal liners or other liners approved by the Society and by seals of proven efficiency at the propeller.

4.5.2 Metal liners, in accordance with the requirement here above, must be made in a single piece. Only with the express consent of the Society may particularly long liners be made up of two parts, provided that, after fitting, the abutting edges are connected and made watertight by a method approved by the Society and the area of the joint is subjected to special testing.

Figure 1 : Design of keyway in propeller shaft



4.5.3 The minimum wall thickness, t, in mm, of metal shaft liners in way of bearings is to be determined using the following formula:

$$t = \frac{75d}{d + 1000}$$

where:

d : Shaft diameter under the liner, in mm

In the case of continuous liners, the wall thickness between the bearings may be reduced to 0,75t.

5 Couplings

5.1 Flange couplings

5.1.1 The thickness of forged coupling flanges on intermediate and thrust shafts and on the forward end of the propeller shaft must be equal at least 20% of the Rule diameter of the shaft in question.

Where propellers are attached to a forged flange on the propeller shaft, the flange must have a thickness equal to at least 25% of the Rule diameter.

These flanges may not be thinner than the Rule diameter of the fitted bolts if these are based on the same tensile strength as that of the shaft material.

The fillet radius at the base of solid forged flanges is to be not less than 0,08 times the actual shaft diameter.

5.1.2 The bolts used to connect flange couplings are normally to be designed as fitted bolts. The minimum diameter d_f of fitted bolts at the coupling flange faces is to be determined by applying the following formula:

$$d_f = 16\sqrt{\frac{10^6 P_W}{NzDR_m}}$$

5.1.3 Where, in special circumstances, the use of fitted bolts is not feasible, the Society may agree to the use of an equivalent frictional resistance transmission.

The minimum thread root diameter d_k , in mm, of such bolts is to be determined using the following formula:

$$d_k = 21\sqrt{\frac{10^6 P_W}{NzDR_m}}$$

5.1.4 The minimum thread root diameter d_k, in mm, of connecting bolts used for clamp-type couplings is to be determined using the following formula:

$$d_k = 12\sqrt{\frac{10^6 P_W}{NzdR_m}}$$

5.1.5 The shank of necked-down bolts can be designed to a minimum diameter of 0,9 times the thread root diameter. If, besides the torque, the bolted connection is also required to transmit considerable additional forces, the size of the bolts must be increased accordingly.

5.2 Shrunk couplings

5.2.1 Definitions

The following symbols are used in this sub-article.

A : Effective area of shrink fit seating, in mm²

c : Coefficient for shrink-fitted joints

$c = 1{,}0$ for gear drives

$c = 1{,}2$ for direct drives

C : Conicity of shaft ends

C = difference in taper diameter/length of taper

f : Coefficient for shrink-fitted joints

$$f = \left(\frac{\mu_0}{S}\right)^2 - \Theta^2$$

E : Modulus of elasticity, in N/mm²

P : Interface pressure of shrink fits, in N/mm²

Q : Peripheral force at the mean joint diameter of a shrink fit, in N

$$Q = \frac{2000 T_D}{d_m}$$

where:

T_D : Drive torque, in N.m

$$T_D = \frac{9550 P_W}{N}$$

d_m : Mean joint diameter of the shrink fit, in mm

S : Safety factor against slipping of shrink fits in the shafting

S = 3,0 between motor and gearing

S = 2,5 for all other applications

T : Propeller thrust, in N

Θ : Half-conicity of shaft ends

$\Theta = C/2$

μ_0 : Coefficient of static friction

$\mu_0 = 0{,}15$ for hydraulic shrink fits

$\mu_0 = 0{,}18$ for dry shrink fits

Δ_{min} : Minimum shrink interference, in mm

5.2.2 Where shafts are coupled together without keys by shrink-fitted coupling flanges or coupling sleeves, the dimensions of these shrink fits should be such that the maximum Von Mises equivalent stress in the boss of the coupling or the bore of the coupling sleeve, based on the "go" end of the prescribed tolerance gauge, does not exceed 80% of the yield strength of the coupling material.

The margin of safety against slipping of the joint is to be based on the "no go" ends of the prescribed tolerance gauges, and the necessary interface pressure p, in N/mm², in the shrunk joint is to be determined as follows:

a) Couplings aft of the thrust bearing (viewed from the motor):

$$p = \frac{\sqrt{\Theta^2 T^2 + f(c^2 Q^2 + T^2)} \pm \Theta T}{Af}$$

+ : Sign following the root applies to shrunk joints without an axial stop to absorb astern thrust

- : Sign following the root applies to shrunk joints with an axial stop to absorb astern thrust

b) Couplings forward of the thrust bearing:

$$p = \frac{cQ}{A\sqrt{f}}$$

With differing ratios of the outside diameters $d/D_{1/2}$ of flange couplings with a load-carrying length, in mm of:

$L = \ell_1 + \ell_2$

the required shrink interference of the shaft Δ_{min}, in mm, is calculated by applying the following formula:

$$\Delta_{min} = \frac{Lp2d}{E\ell'}$$

where:

ℓ' : Parameter to be determined from the formula:

$$\ell' = \left[1 - \left(\frac{d}{D_1}\right)^2\right]\ell_1 + \left[1 - \left(\frac{d}{D_2}\right)^2\right]\ell_2$$

ℓ_1 : Load-carrying length of D_1, in mm

ℓ_2 : Load-carrying length of D_2, in mm

D_1 : Outside diameter of length ℓ_1

D_2 : Outside diameter of length ℓ_2

6 Shaft bearings

6.1 Arrangement of shaft bearings

6.1.1 Shaft bearings both inside and outside the stern tube are to be so disposed that, when the plant is hot and irrespective of the condition of loading of the vessel, each bearing is subjected to positive reaction forces equivalent to not less than 20% of the weight of the shaft length carried by the bearing. By appropriate spacing of the bearings and by alignment of the shafting in relation to the coupling flange at the engine or gearing, care is to be taken to ensure that no undue transverse forces or bending moments are exerted on the crankshaft or gear shafts when the plant is hot. By spacing the bearings sufficiently far apart, steps are also to be taken to ensure that the reaction forces of line or gear shaft bearings are not appreciably affected should the alignment of one or more bearings be altered by hull deflections or by displacement or wear of the bearings themselves.

6.1.2 Guide values for the maximum permissible distance between bearings ℓ_{max}, in mm, can be determined using the following formula:

$$\ell_{max} = K_1\sqrt{d_a}$$

where:

K_1 : Coefficient defined as:

- for oil-lubricated white metal bearing
  $K_1 = 450$
- for grey cast iron, grease-lubricated stern tube bearings
  $K_1 = 280$
- for water-lubricated rubber bearings in stern tubes and shaft brackets (upper values for special designs only)
  $K_1 = 280 - 350$

Note 1: Where the shaft speed exceeds 350 rev./min, it is recommended that the maximum bearing spacing in accordance with formula here below be observed in order to avoid excessive loads due to bending vibrations. In borderline cases a bending stress analysis should be made for the shafting system.

$$\ell_{max} = K_2 \sqrt{\frac{d_a}{N}}$$

where:

K_2 : Coefficient defined as:

- $K_2 = 8400$ for oil-lubricated white metal bearings
- $K_2 = 5200$ for grease-lubricated, grey cast iron bearings and for rubber bearings inside stern tubes and tail shaft brackets

6.2 Stern tube bearings

6.2.1 Inside the stern tube, the propeller shaft should normally be supported by two bearings. In short stern tubes, the forward bearings may be dispensed with.

6.2.2 Where the propeller in the stern tube runs in bearings made of rubber or plastic, the length of the after bearing should equal approximately 3 - 4 times the shaft diameter, while the length of the forward bearing should be approximately 1 - 1,5 times the shaft diameter. Where the propeller shaft inside the stern tube runs in oil-lubricated white metal bearings, the lengths of the after and forward stern tube bearings should be approximately 2 and 0,8 times the shaft diameter respectively. Where the propeller shaft runs in grease-lubricated, grey cast iron bushes the lengths of the after and forward stern tube bearings should be approximately 2,5 and 1 times the shaft diameter respectively.

6.2.3 The peripheral speed of the propeller shafts in grease-lubricated, grey cast iron bearings should not exceed 2,5 - 3 m/s, while that of propeller shafts in water-lubricated rubber bearings should not exceed 6 m/s.

6.2.4 Where the propeller shafts are intended to run in anti-friction bearings within the stern tube, such bearings should preferably take the form of cylindrical roller bearings with cambered rollers or bearing races and with an increased bearing clearance. The camber must be sufficient to tolerate without adverse effects an angular deviation of 0,1% between the shaft and the bearing axis. Self-aligning roller bearings may be used to carry the propeller shaft only if provision is made for the axial adjustment of such bearings.

6.2.5 Propeller shafts running in anti-friction bearings must be fitted at the stern tube ends with seals approved by the Society for this type of bearing.

6.3 Bearing lubrication

6.3.1 The lubrication and the matching of the materials used for journal and anti-friction bearings inside and outside the stern tube must satisfy the requirements of marine service.

Lubricating oil or grease must be introduced into the stern tube in such a way as to ensure a reliable supply of oil or grease to the forward and after stern tube bearings. With grease lubrication, the forward and after bearings are each to be provided with a grease connection. Wherever possible, a grease pump driven by the shaft is to be used to secure a continuous supply of grease.

Where the shaft runs in oil within the stern tube, a header tank is to be fitted at a sufficient height above the vessel's load line. Facilities are to be provided for checking the level of oil in the tank at any time.

6.4 Stern tube connections

6.4.1 Oil-lubricated stern tubes are to be fitted with filling, testing and drainage connections as well as with a vent pipe. Connections and stern tube must be designed to ensure that oil, infiltrated water and air can be completely expelled.

Where the propeller shaft runs in water, a flushing line is to be fitted which is to be connected to a suitable pump or another pressure system.

6.5 Cast resin mounting

6.5.1 The mounting of stern tubes and stern tube bearings made of cast resin and also the seating of plummer bearings on cast resin parts is to be carried out by Society approved companies in the presence of a Society Surveyor.

Only cast resins approved by the Society may be used for seatings.

Note is to be taken of the installation instructions issued by the manufacturer of the cast resin.

7 Pressure tests

7.1 Shaft liners

7.1.1 Prior to fitting in the finish-machined condition, shaft liners are to be subjected to a hydraulic tightness test at 2 bar pressure.

7.2 Stern tubes

7.2.1 Prior to fitting in the finish-machined condition, cast stern tubes are to be subjected to a hydraulic tightness test at 2 bar pressure. A further tightness test is to be carried out after fitting.

For stern tubes fabricated from welded steel plates, it is sufficient to test for tightness during the pressure tests applied to the hull spaces traversed by the stern tube.

SECTION 8 PROPELLERS

1 General

1.1 Scope

1.1.1 The requirements of this Article apply to screw propellers and controllable pitch propellers. Where a design is proposed to which the following Rules cannot be applied, special strength calculations are to be submitted to the Society and the necessary tests are to be agreed with the Society.

The propellers of propulsion units of strengthened design are additionally subject to the provisions of Pt D, Ch 2, Sec 1.

1.2 Documents for review/approval

1.2.1 Design drawings of propellers are to be submitted to the Society, at least in triplicate, for review / approval. Drawings are to contain all the details necessary to verify compliance with the following rule requirements.

1.3 Symbols and terms

1.3.1 Following symbols and terms are used in this section.

A : Effective area of shrink fit, in mm²

l : Developed blade width of cylindrical sections at radii 0,25 R, 0,35 R and 0,60 R, in mm

c_A : Coefficient for shrunk joints

c_A = 1,0 for gear transmissions

c_A = 1,2 for direct drives

C_G : Size factor

$$1,1 \geq \sqrt{\frac{f_1 + 0,001D}{12,2}} \geq 0,85$$

C_r : Factor comprising position of the weakest section

$$C_r = \sqrt{\frac{0,9 - xx}{0,9 - 0,35}}$$

C_W : Characteristic value for propeller material as shown in Tab 1 (corresponds to the minimum tensile strength R_m of the propeller material where this has been shown to possess sufficient fatigue strength under alternating bending stresses in accordance with [2])

C : Conicity of shaft ends

C = difference in taper diameter/length of taper

d : Bolt-hole circle diameter of blade or propeller fastening bolts, in mm

d_k : Root diameter of blade or propeller fastening bolts, in mm

d_S : Nominal diameter of studs or bolts, in mm

D : Diameter of propeller, in mm

d_m : Mean taper diameter, in mm

e : Blade rake, in mm

- rake to aft: e = 0,5D.tanε
- rake to fore: e = - 0,5D.tanε

f, f_1 : Factors defined as:

$$f = \left(\frac{\mu_0}{S}\right)^2 - \Theta^2$$

f_1 = 7,2 for solid propellers

f_1 = 6,2 for separately cast blades of variable pitch or built-up propellers

H : Propeller blade face pitch at radii 0,25 R, 0,35 R and 0,60 R, in mm

H_m : Mean effective propeller pitch on blade face for pitch varying with the radius, in mm

$$H_m = \frac{\Sigma(R\,l\,H)}{\Sigma(R\,l)}$$

where R, l and H are to be substituted by values corresponding to generatrix to the pitch at the various radii

k : Coefficient for various profile shapes in accordance with Tab 2

k' : Coefficient calculated in compliance with [3.1.5], where use is made of profile shapes other than those given in Tab 2

ℓ_M : 2/3 of the leading edge component of the blade width at 0,9 R, but at least 1/4 of the total blade width at 0,9 R for propellers with heavily skewed blades, in mm

L : Pull-up length when mounting propeller on taper, in mm

L_{mech} : Pull-up length at t = 35°C, in mm

L_{temp} : Temperature-related portion of pull-up length at t < 35°C, in mm

N : Propeller speed, in rev/min

P_W : Shaft power, in kW

P : Specific pressure in shrunk joint between propeller and shaft, in N/mm²

Q : Peripheral force at mean taper diameter at maximum continuous rating (MCR) condition, in N

$$Q = 19,1\frac{P_W}{N d_m}10^6$$

Q_{FR} : Peripheral force at mean taper diameter at MCR condition including Q and $Q_{V\text{-}MCR}$, in N

$Q_{V\text{-}MCR}$: Peripheral force at mean taper diameter at MCR condition due to torsional vibration, in N

$R_{P0,2}$: 0,2% proof stress of propeller material, in N/mm²

R_{eH} : Yield strength, in N/mm²

R_m : Tensile strength of the material of fitted or conventional bolts, in N/mm²

S : Margin of safety against propeller slipping on taper

S = 2,8

t : Maximum blade thickness of developed cylindrical section at radii 0,25 R, 0,35 R and 0,60 R, in mm

T : Propeller thrust, in N

T_M : Impact moment in accordance with [4.3.1], in N.m

W_{xxR} : Section modulus of cylindrical section at radius xxR, in mm³

Z : Total number of bolts used to retain one blade or propeller

z : Number of blades

α : Pitch angle of profile at radii 0,25 R, 0,35 R and 0,60 R

$$\alpha_{0,25} = \operatorname{atan}\frac{1,27H}{D}$$

$$\alpha_{0,35} = \operatorname{atan}\frac{0,91H}{D}$$

$$\alpha_{0,60} = \operatorname{atan}\frac{0,53H}{D}$$

α_A : Tightening factor for retaining bolts and studs, depending on the method of tightening used

α_A = 1,3 for bolt elongation control

α_A = 1,6 for torque control

α_A = 3 for impulse control (impact drivers)

β_{xxR} : Factor for the section modulus of developed cylindrical section about blade pitch line for blade profiles in accordance with Tab 2

β'_{xxR} : Factor for the section modulus of developed cylindrical section about blade pitch line for blade profiles other than those in Tab 2

ε : Angle included by face generatrix and normal (see Fig 1)

$$\varepsilon = \operatorname{atan}\frac{2e}{D}$$

Θ : Half-conicity of shaft ends

$\Theta = C/2$

μ_0 : Coefficient of static friction

μ_0 = 0,13 for hydraulic oil shrunk joints brass/bronze to steel

μ_0 = 0,15 for hydraulic oil shrunk joints steel to steel

μ_0 = 0,18 for dry shrunk joints brass/bronze to steel

μ_0 = 0,20 for dry shrunk joints steel to steel

Friction improving agents are not taken into account.

Table 1 : Characteristic values C_W for propeller materials

Material	Description **(1)**	C_W
Cu 1	Cast manganese brass	440
Cu 2	Cast manganese nickel brass	440
Cu 3	Cast nickel aluminium bronze	590
Cu 4	Cast manganese aluminium bronze	630
Fe 3	Martensitic cast chrome steel 13/1-6	600
Fe 4	Martensitic-austenitic cast steel 17/4	600
Fe 5	Ferritic-austenitic cast steel 24/8	600
Fe 6	Austenitic cast steel 18/8-11	500

(1) For chemical composition of the alloys, see the Society's Rules for Materials and Welding

2 Materials

2.1 Approved materials

2.1.1 Wherever possible, propellers are to be made of established cast copper or cast steel alloys with a tensile strength of at least 440 N/mm² and of proven sufficient fatigue strength under alternating bending stresses.

This proof is considered to have been established if the fatigue strength under alternating bending stresses measured under 10^8 load cycles in a 3% NaCl solution amounts to at least 20% of the minimum tensile strength of the propeller material.

The use of grey cast iron, un- and low alloyed cast steel for propellers may be permitted in exceptional cases.

Composite materials may also be used, provided that a sufficient strength has been demonstrated and the propeller is manufactured according to an approved procedure.

Where use is to be made of propeller materials whose performance has not yet been sufficiently established, special proof of their suitability must be furnished to the Society.

2.2 Testing of materials

2.2.1 Propeller materials and materials of blade mounting screws/bolts as well as those of important components involved in the adjustment of variable pitch propellers must possess the properties specified in NR 216 Materials and Welding. This may be proved by a workshop certificate issued by the manufacturer.

3 Calculation of the blade thickness

3.1 General

3.1.1 At radii 0,25 R, and 0,60 R (see Fig 1), the blade thickness of solid propellers must, as a minimum requirement, comply with the following formula:

$t = K_0 \, k \, K_1 \, C_G$

where:

K_0 : Coefficient defined as:

$$K_0 = 1 + \frac{e \cos\alpha}{H} + \frac{N}{15000}$$

K_1 : Coefficient defined as:

$$K_1 = \sqrt{\frac{P_W 10^5\left(2\frac{D}{H_m}\cos\alpha + \sin\alpha\right)}{N l z C_W(\cos\varepsilon)^2}}$$

3.1.2 The blade thicknesses of controllable pitch propellers are to be determined at radii 0,35 R and 0,60 R by applying the formula given in [3.1.1].

For the controllable pitch propellers of tugs and pushing vessels with similar operating conditions, the diameter / pitch ratio D/H_m for the maximum static bollard pull is to be used in formula given in [3.1.1].

For other vessels, the diameter / pitch ratio D/H_m applicable to open-water navigation can be used in formula given in [3.1.1].

3.1.3 The blade thicknesses calculated by applying formula given in [3.1.1] are minima for the finish-machined propellers without fillets.

If the propeller is subjected to an essential wear, e.g. abrasion in muddy waters, the thickness determined under [3.1.1] has to be increased. If the actual thickness in service is below 90% of the values obtained from formula given in [3.1.1] countermeasures have to be taken.

3.1.4 The fillet radii at the transition from the face and back of the blades to propeller boss should correspond, in the case of three and four-bladed propellers, to about 3,5% of the propeller diameter. For propellers with a larger number of blades, the maximum fillet radii allowed by the propeller design should be aimed at, and the radii shall not in any case be made smaller than $0,4.t_{0,25R.}$

3.1.5 For special designs such as propellers with skew angle $\vartheta \geq 25°$, end plate propellers, tip fin propellers, special profiles etc, special mechanical strength calculations are to be submitted to the Society.

A blade geometry data file and details on the measured wake are to be submitted to the Society together with the design documents to enable the evaluation of the blade stress of these special designs to be carried out. Supplementary information on the classification of special designs can be obtained from the Society.

For profile shapes other than those given in Tab 2, the following condition applies:

$$k' = k\sqrt{\frac{\beta_{xxR}}{\beta'_{xxR}}}$$

where:

β'_{xxR} : Coefficient to be determined from the following fomula:

$$\beta'_{xxR} = \frac{W_{xxR}}{t^2 l}$$

Figure 1 : Blade sections

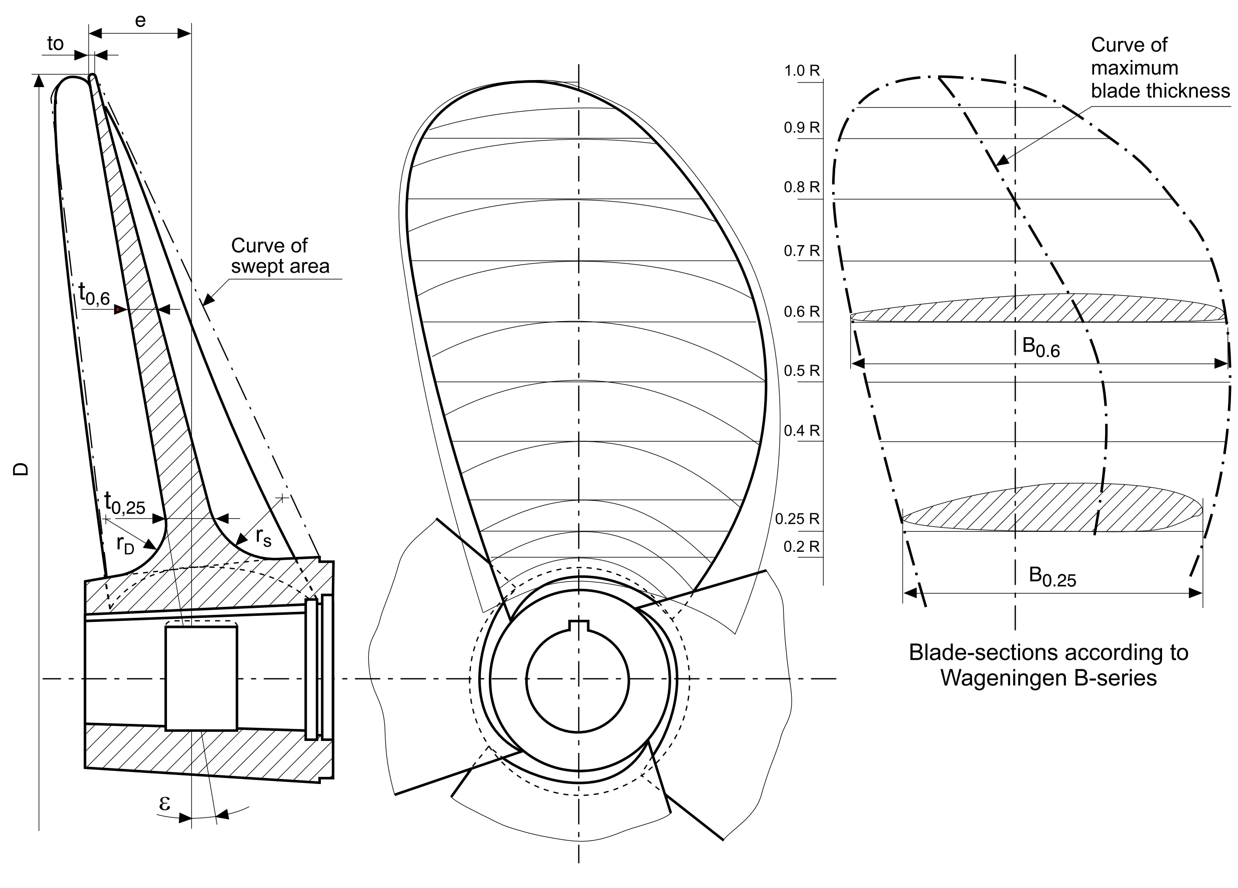


Table 2 : Values of k for various profile shapes

Profile shape	Values of k		
	0,25 R	0,35 R	0,60 R
Segmental profiles with circular arced back, $\beta_{xxR} = 0{,}12$	73	62	44
Segmental profiles with parabolic back $\beta_{xxR} = 0{,}11$	77	66	47
Segmental profiles as for Wageningen B series propellers where $\beta_{0,25R} = 0{,}10$ $\beta_{0,35R} = 0{,}11$ $\beta_{0,60R} = 0{,}12$	80	66	44
Note 1: The Society reserves the right to specify an increase in the values of k in the case of special propellers where the blade width B at 0,25R is less than 4t.			

4 Controllable pitch propeller

4.1 Documents for review/approval

4.1.1 In the case of controllable pitch propellers, besides the design drawings of the blades and propeller boss, general and sectional drawings of the entire controllable pitch propeller installation are to be submitted to the Society, at least in triplicate, for review/approval. Diagrams of control systems and piping are to be accompanied by a functional description. For new designs and controllable pitch propellers which are to be installed for the first time on a vessel, a description of the controllable pitch propeller system is to be submitted at the same time.

4.2 Hydraulic control equipment

4.2.1 Where the pitch control mechanism is operated hydraulically, one set of pumps might be sufficient for the pitch setting. However, one hand pump must be provided, by which blade adjustment is possible.

4.3 Pitch control mechanism

4.3.1 For the pitch control mechanism, proof is required that, when subjected to impact moment T_M as defined by formula here below, the individual components still have a safety factor of 1,5 with respect to the yield strength of the material used.

$$T_M = \frac{1,5 R_{P0,2} W_{0,6R}}{\sqrt{\left(\frac{0,15D}{\ell_M}\right)^2 + 0,75}} 10^{-3}$$

where:

$W_{0,6R}$: Parameter defined in [1.3.1]

$$W_{0,6R} = 0,12(Bt^2)_{xxR}$$

4.4 Blade retaining bolts and studs

4.4.1 The blade retaining bolts shall be designed in such a way as to withstand the forces induced in the event of plastic deformation at the weakest section at xxR below 0,9 R caused by a force acting on the blade at 0,9 R. The bolt material shall have a safety margin of 1,5 against its yield strength which has to be demonstrated.

The demonstration can be dispensed from, if the thread core diameter is not less than:

$$d_k = 2,6 C_r \sqrt{\frac{M_{xxR}\alpha_A}{dZR_{eH}}}$$

where:

$$M_{xxR} = W_{xxR} R_{p0,2}$$

W_{xxR} may be calculated according to [4.3.1] for the respective blade section.

If no minimum of W_{xxR} below 0,9 radius is obtained, 0,35 R has to be used.

The blade retaining bolts or studs are to be tightened in a controlled manner in such a way that the loading on the bolts or studs is about 60 - 70% of their yield strength.

The shank of the blade retaining bolts or nuts may be designed with a minimum diameter equal to 0,9 times the root diameter of the thread. Blade retaining bolts may be secured against unintentional loosening.

4.5 Flanges for connection of blades to hubs

4.5.1 The diameter D_F, in mm, of the flange for connecting the blade to the propeller hub is not to be less than that obtained from the following formula:

$D_F = d + 1{,}8 d_S$

The thickness of the flange is not to be less than 1/10 of the diameter D_F.

This formula is also applicable for built-up propellers.

4.6 Indicators

4.6.1 Controllable pitch propeller systems are to be provided with an engine room indicator showing the actual setting of the blades. If the controllable pitch propeller is operated from the steering stand of the vessel, the steering stand is also to be equipped with an indicator showing the actual blade setting.

For vessels with automated machinery installations, see also Ch 1, Sec 1, [3.8].

4.7 Failure of control system

4.7.1 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.

Steps must be taken to ensure that, in the event of failure of the control system, the setting of the blades:

- does not change or
- reaches a final position slowly enough to allow the emergency control system to be put into operation.

4.8 Emergency control

4.8.1 Controllable pitch propeller systems must be equipped with means of emergency control enabling the controllable pitch propeller to remain in operation, should the remote control system fail. It is recommended that a device has to be fitted which locks the propeller blades in the "ahead" setting.

5 Balancing and testing

5.1 Balancing

5.1.1 Balancing

The finished propeller and the blades of controllable pitch propellers are required to undergo static balancing.

5.2 Testing

5.2.1 The finished propeller is to be presented at the manufacturer's premises to the Society's Surveyor for final inspection and verification of the dimensions.

The Society reserves the right to require non-destructive tests to be conducted to detect surface cracks and casting defects.

In addition, controllable pitch propeller systems are required to undergo pressure, tightness and operational tests.

6 Propeller mounting

6.1 General

6.1.1 Screw propeller hubs are to be properly adjusted and fitted on the propeller shaft cone.

6.1.2 The forward end of the hole in the hub is to have the edge rounded to a radius of approximately 6 mm.

6.1.3 For propeller keys and key area, see Ch 1, Sec 7, [4.4.1].

6.2 Tapered mounting

6.2.1 Where the tapered joint between the shaft and the propeller is fitted with a key, the propeller is to be mounted on the tapered shaft in such a way that approximately the mean torque can be transmitted from the shaft to the propeller by the frictional bond. The propeller nut is to be secured in a suitable manner.

Where the tapered fit is performed by the hydraulic oil technique without the use of a key, the necessary pull-up distance on the tapered shaft is given by the expression:

$$L = L_{mech} + L_{temp}$$

Where appropriate, allowance is also to be made for surface smoothing when calculating L.

L_{mech} is determined according to the formulas of elasticity theory applied to shrunk joints for a specific pressure p, in N/mm², at the mean taper diameter determined by applying the following formula and for a water temperature of 35°C:

$$p = \frac{\sqrt{\Theta^2 T^2 + f(c_A{}^2 Q^2 + T^2)} \pm \Theta T}{A f}$$

where:

"+" : Sign applying to shrunk joints of tractor propeller

"-" : Sign applying to shrunk joints of pusher propeller

L_{temp} applies only to propellers made of bronze and austenitic steel.

$$L_{temp} = \frac{d_m}{C} 6 \cdot 10^{-6} (35 - t_1)$$

where:

t_1 : Temperature, in °C, at which the propeller is mounted

The safety factor has to be taken as S = 2,8 for geared plants.

For direct drives the safety factor has to be taken as S = 1,0 and the circumferential force Q has to be replaced by Q_{FR} according to the following formula:

$$Q_{FR} = 2{,}0\ Q + 1{,}8\ Q_{V\text{-}MCR}$$

Q_{FR} replaces Q in the formula of specific pressure p given here above.

$Q_{V\text{-}MCR}$: maximum value from torsional vibration evaluations, but is not to be taken less than 0,44 times the Q

The torsional vibration evaluation is to consider the worst relevant operating conditions, e.g. such as misfiring (one cylinder with no injection) and cylinder unbalance (the latter is subject to the Society's Rules).

The tapers of propellers which are mounted on the propeller shaft with the aid of hydraulic oil technique should not be more than 1:15 or less than 1:20.

The Von Mises equivalent stress based on the maximum specific pressure p and the tangential stress in the bore of the propeller hub may not exceed 75% of the 0,2% proof stress or yield strength of the propeller material.

The propeller nut must be secured to the propeller shaft by mechanical means.

6.3 Flange connections

6.3.1 Flanged propellers and the bosses of controllable pitch propellers are to be attached using fitted pins and bolts (necked down bolts for preference).

The diameter of the fitted pins is to be calculated by applying formula given in Ch 1, Sec 7, [5.1.2].

The propeller retaining bolts are to be of similar design to those described in [4.4.1].

The thread core diameter shall not be less than:

$$d_k = 4,4 C_r \sqrt{\frac{M_{xxR} \alpha_A}{d Z R_{eH}}}$$

where:

$$M_{xxR} = W_{xxR} R_{p0,2}$$

W_{xxR} may be calculated according to [4.3.1] for the respective blade section.

If no minimum of W_{xxR} below 0,9 radius is obtained, 0,35 R has to be used.

In exceptional cases flange connections may transmit a fraction of the torque by friction. The fraction should not exceed 50% and fraction multiplied by safety factor must not be below 100% of the maximum engine torque. The suitability of the connection has to be demonstrated. Friction coefficients have to be used according to [1.3.1].

SECTION 9 TORSIONAL VIBRATIONS

Symbols

N : Speed of the shaft for which the check is carried out, in rev/min

N_N : Nominal speed of the engine, in rev/min

λ : Speed ratio

$\lambda = N/N_N$

1 General

1.1 Application

1.1.1 The requirements of this Article 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.

1.2 Definition

1.2.1 For the purposes of these Rules, torsional vibration stresses are additional loads due to torsional vibrations. They result from the alternating torque which is normally superimposed on the mean torque.

2 Calculation of torsional vibrations

2.1 General

2.1.1 A torsional vibration analysis covering the torsional vibration stresses to be expected in the main engine shafting system including its branches is to be submitted to the Society for review/approval.

The following data shall be included in the analysis:

- Equivalent dynamic system comprising individual masses and inertialess torsional elasticities.
- Prime mover: engine type, rated power, rated speed, engine cycle, engine type (in-line / V-type), number of cylinders, firing order, cylinder diameter, crank pin radius, stroke to connecting rod ratio, oscillating weight of one crank gear.
- Vibration dampers, damping data.
- Coupling, dynamic characteristics and damping data.
- Gearing data.
- Shaft diameter of crankshafts, intermediate shafts, gear shafts, thrust shafts and propeller shafts.
- Propellers: propeller diameter, number of blades, pitch and area ratio.
- Natural frequencies with their relevant vibration forms and the vector sums for the harmonics of the engine excitation.
- Estimated torsional vibration stresses in all important elements of the system with particular reference to clearly defined resonance speeds of rotation and continuous operating ranges.

2.1.2 The calculations are to be performed both for normal operation and for departures from normal operation due to irregularities in ignition. In this respect, the calculations are to assume operation with one cylinder without ignition (misfiring).

2.1.3 Where the arrangement of the installation allows various different operation modes, the torsional vibration characteristics are to be investigated for all possible modes, e.g. in installations fitted with controllable pitch propellers for zero and full pitch, with power take off from the gearing or on the output side of the engine for loaded and idling conditions of the generator unit, and for installations with disconnectable branches for clutches in the engaged and disengaged states.

2.1.4 The calculation of torsional vibrations shall also take account of the stresses resulting from the superimposition of several orders of vibration (synthesized torques / stresses).

2.1.5 If modifications are introduced into the system which have a substantial effect on the torsional vibration characteristics, the calculation of the torsional vibrations is to be repeated and submitted for checking.

3 Permissible torsional vibration stresses

3.1 General

3.1.1 The calculation of the permissible torsional vibration stresses as well as the determination of the permissible vibratory torques for gearing, couplings and crankshaft is to be performed in accordance with the Society's Rules.

4 Torsional vibration measurements

4.1 General

4.1.1 After consideration of the results of the calculations according to [2.1], the Society may request the performance of torsional vibration measurements during river trials.

4.1.2 Torsional vibration measurements may also be required by the Society in the case of conversions affecting significantly and resulting to major alterations of the main propulsion plant.

5 Barred speed range

5.1 Normal operation

5.1.1 Operating ranges which, because of the magnitude of the torsional vibration stresses, may only be passed through are to be indicated as barred ranges for continuous operation by red marks on the tachometer or in some other suitable manner at the operating stations from which the plant can be controlled. Barred speed ranges are to be passed through as quickly as possible. In specifying barred speed ranges it is important to ensure that the navigating and manoeuvring functions are not unreasonably restricted.

The speed range $\lambda \geq 0{,}8$ is to be kept free of barred speed ranges.

Even within prohibited ranges of operation, exceeding the maximum permissible loads for shafting, twice the rated torque for gear toothing systems and maximum impulse torque for flexible couplings is not permitted.

5.2 Deviations from normal operation

5.2.1 This is understood to include firing irregularities or, in an extreme case, the complete interruption of the fuel supply to a cylinder.

The actions necessary to prevent overloading of the propulsion plant in case of deviation from normal operation are to be clearly displayed on tables at all the operating stations from which the plant can be controlled.

The major components of the propulsion plant should be capable of withstanding for a reasonable time the consequences of an abnormal operation. Running under abnormal conditions should not lead to overloading as defined in [5.1.1].

Even in the event of an abnormal operation due to ignition failure of one cylinder, a continuous operation over extended time periods within certain speed ranges must still remain possible, thus maintaining the manoeuvrability for safe operation of the vessel.

6 Auxiliary machinery

6.1 General

6.1.1 Important auxiliary machinery such as diesel generators and lateral thrust units are to be so designed that the operating speed range is free from undue stresses caused by torsional vibrations. For installations of more than 110 kW, the torsional vibration calculation is to be submitted to the Society.

6.1.2 Essential auxiliary machinery must be designed such that, operation under misfiring condition is possible, so far no adequate redundancy is provided.

6.1.3 In the case of diesel generators with rigidly coupled generators, the torsional vibration torque in continuous operation shall not exceed 2,5 times the generator's normal torque.

SECTION 10 PIPING SYSTEMS

1 General

1.1 Scope

1.1.1 These Rules apply to piping systems, including valves, fittings and pumps, which are necessary for the operation of the main propulsion plant together with its auxiliaries and equipment. They also apply to piping systems used in the operation of the vessel whose failure could directly or indirectly impair the safety of vessel or cargo, and to piping systems which are dealt with in other Sections of the Rules.

Cargo pipelines on vessels for the carriage of chemicals in bulk are additionally subject to the provisions of Pt D, Ch 3, Sec 1, Pt D, Ch 3, Sec 3 and Pt D, Ch 3, Sec 4.

Cargo pipelines on vessels for the carriage of liquefied gases in bulk are additionally subject to the provisions of Pt D, Ch 3, Sec 1 and Pt D, Ch 3, Sec 2.

1.2 Documents for review / approval

1.2.1 Diagrammatic plans of the following piping systems must be submitted to the Society, at least in triplicate, and must contain all the details necessary for assessment:

a) Steam systems

b) Boiler feed and condensate systems

c) Fuel systems (bunkering, transfer and supply systems)

d) Lubricating oil systems

e) Cooling water systems, including the cooler and the cooler arrangement

f) Compressed air systems

g) Bilge systems

h) Thermal oil systems

i) Air, sounding and overflow systems

j) Hose assemblies and compensators

Hoses and expansion joints made of non-metallic materials are to be clearly indicated.

Further documents may be asked for by the Society, if considered necessary.

1.3 Classes of pipes

1.3.1 Pipes are subdivided into two classes as indicated in Tab 1.

Table 1 : Classification of pipes into "pipe classes"

Medium conveyed by the piping system	Design pressure PR, in bar Design temperature t, in °C	
Toxic media Inflammable media with service temperature above the flash point Inflammable media with a flash point below 60°C Liquefied gases (LPG, LNG, LG) Corrosive media	all	not applicable
steam, thermal oil	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t ≤ 170
Air, gas Lubricating oil, hydraulic oil Boiler feedwater, condensate Seawater and fresh water for cooling	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
Liquid fuels	PR ≤ 16 and t ≤ 150	PR ≤ 7 and t ≤ 60
Cargo pipelines for tankers	not applicable	all
Open-ended pipelines (without shutoff), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	not applicable	all
Pipe class	II	III

2 Materials, quality assurance, pressure tests

2.1 General

2.1.1 Materials must be suitable for the proposed application and must comply with NR 216 Materials and Welding. In the case of especially corrosive media, the Society may impose special requirements on the materials used. For welds, see NR 216 Materials and Welding. For the materials used for pipes and valves for steam boilers, see Ch 1, Sec 3, [1.2].

2.2 Materials

2.2.1 Pipes, valves and fittings of steel

Pipes belonging to class II must be either seamless drawn or produced by a welding procedure approved by the Society.

2.2.2 Pipes, valves and fittings of copper and copper alloys

Pipes of copper and copper alloys must be of seamless drawn material or produced by a method approved by the Society. class II copper pipes must be seamless.

In general, copper and copper alloys pipe lines shall not be used for media having temperatures above the limits given in Tab 2.

Table 2 : Medium limit temperature

Material	Medium limit temperature
Copper and aluminium brass	200°C
Copper nickel alloys	300°C
High-temperature bronze	230°C

2.2.3 Pipes, valves and fittings of cast iron with spheroidal or nodular graphite (GGG)

Pipes, valves and fittings of nodular ferritic cast iron according to the applicable NR 216 Materials and Welding may be accepted for bilge, ballast and cargo pipes within double-bottom tanks and cargo tanks and for other purposes approved by the Society, at temperatures up to 350°C.

2.2.4 Pipes, valves and fittings of cast iron with lamellar graphite (grey cast iron) (GG)

Pipes, valves and fittings of grey cast iron may be accepted by the Society for class III. Pipes of grey cast iron may be used for cargo and ballast pipelines within cargo tanks of tankers. Grey cast iron is not allowed for clean ballast lines to forward ballast tanks through cargo oil tanks.

Pipes, valves and fittings of grey cast iron may also be accepted for cargo lines on tankers intended to carry flammable liquids with a flash point ≤ 60°C. Tough materials must be used for cargo hose connections and distributor headers.

This applies also to the hose connections of fuel and lubricating oil filling lines. Grey cast iron may not be used for cargo lines in cargo systems of vessels carrying chemicals (see Pt D, Ch 3, Sec 1, Pt D, Ch 3, Sec 3 and Pt D, Ch 3, Sec 4).

Grey cast iron is not allowed for pipes, valves and fittings for media having temperatures above 220°C and for pipelines subject to water hammer, excessive strains and vibrations.

Grey cast iron is not allowed for river valves and pipes fitted on the vessel sides and for valves fitted on the collision bulkhead.

Valves on fuel tanks subject to static head may be made of grey cast iron only if they are adequately protected against damage.

The use of grey cast iron for other services will be subject to special consideration by the Society.

2.2.5 Plastic pipes

Plastic pipes may be used after special approval by the Society.

Pipes, connecting pieces, valves and fittings made of plastic materials are to be subjected by the manufacturer to a continuous Society-approved quality control.

Pipe penetrations through watertight bulkheads and decks as well as through fire divisions are to be approved by the Society. Plastic pipes are to be continuously and permanently marked with the following particulars:

- Manufacturer’s marking
- Standard specification number
- Outside diameter and wall thickness of pipe
- Year of manufacture.

Valves and connecting pieces made of plastic must, as a minimum requirement, be marked with the manufacturer's marking and the outside diameter of the pipe.

2.2.6 Aluminium and aluminium alloys

Aluminium and aluminium alloys must comply with the Society's Rules for Materials and Welding and may in individual cases, with the agreement of the Society, be used for temperatures up to 200°C. They are not acceptable for use in fire extinguishing lines.

2.2.7 Application of materials

For the pipe classes named in [1.3] materials must be applied according to Tab 3.

2.3 Quality assurance

2.3.1 The proof of the quality of materials for pipe class II is to be in the form of an inspection certificate according to EN 10.204 3.1 or equivalent. For this purpose, the manufacturer of the material must have been accepted by the Society.

2.3.2 For components in pipe class III a works certificate issued by the manufacturer of the material is sufficient.

2.3.3 Welded joints in pipelines of class II are to be tested in accordance with the Society’s Rules for Materials and Welding.

2.4 Hydraulic tests on pipes

2.4.1 Definitions

a) Maximum allowable working pressure, PB, in bar, formula symbol: $p_{e,zul}$

   This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design requirements, the working temperature and undisturbed operation.

b) Nominal pressure, PN, in bar

   This is the term applied to a selected pressure temperature relation used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20°C.

c) Test pressure, PP, in bar, formula symbol: p_p

   This is the pressure to which components or piping systems are subjected for testing purposes.

d) Design pressure, PR, in bar, formula symbol: p_c

This is the maximum allowable working pressure PB for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

2.4.2 Pressure tests of piping before assembly on board

All class II pipes as well as steam lines, feedwater pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3,5 bar together with their associated fittings, connecting pieces, branches and bends, after completion of manufacture but before insulation and coating, if this is provided, shall be subjected to a hydraulic pressure test in the presence of the Surveyor at the following value of pressure:

$p_p = 1{,}5 p_c$

where:

p_c : Design pressure defined in [2.4.1]

Where for technical reasons it is not possible to carry out complete hydraulic pressure tests on all sections of piping before assembly on board, proposals are to be submitted for approval to the Society for testing the closing lengths of piping, particularly in respect of closing seams.

When the hydraulic pressure test of piping is carried out on board, these tests may be conducted in conjunction with the tests required under [2.4.3].

Pressure testing of pipes with a nominal diameter less than 15 mm may be omitted at the Society's discretion depending on the application.

Table 3 : Approved materials

Material or application		Pipe classes: II	Pipe classes: III
Steel	Pipes	Pipes for general applications Below −10°C, pipes made of steels with high low-temperature toughness Stainless steel pipes for chemicals	Steel not subject to any special quality specification, weldability in accordance with Society's Rules for Materials and Welding
	Forgings, plates, flanges	Steels suitable for the corresponding loading and processing conditions Below −10°C, steels with high low-temperature toughness	
	Bolts, nuts	Bolts for general machine construction Below −10°C, steels with high low-temperature toughness	Bolts for general machine construction
Castings (valves, fittings, pipes)	Cast steel	Cast steel for general applications Below −10°C, cast steel with high low-temperature toughness For aggressive media stainless castings	Cast steel for general applications
	Spheroidal/Nodular cast iron (GGG)	Only ferritic grades, elongation A5 at least 12%	
	Cast iron with lamellar graphite (grey cast iron) (GG)	Not applicable	At least GG-20 for Pipe Class III up to 220°C Not permitted in: • ballast lines of ballast tanks outside cargo area through cargo tanks • valves on vessel's side, collision bulkhead and fuel tanks **(1)**
Non-ferrous metals (valves, fittings, pipes)	Copper, copper alloys	In cargo lines on tank vessels carrying chemicals only with special approval Low-temperature copper nickel alloys by special agreement	For river water and alkaline water only corrosion-resistant copper and copper alloys
	Aluminium, aluminium alloy	In cargo and processing lines on gas tank vessels	Only with the agreement of the Society up to 200°C Not permitted in fire extinguishing systems
Non-metallic	Plastics	Not applicable	On special approval see [2.2.5]

(1) For valves on fuel tanks, see 6th paragraph of [2.2.4].

2.4.3 Pressure tests of piping after assembly on board

In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests are to be applied. In particular the following applies:

- Heating coils in tanks and fuel lines must be tested to not less than 1,5 PB but in no case less than 4 bar.
- Liquefied gas process piping systems are to be leak tested (by air, halides, etc.) to a pressure depending on the leak detection method applied.

2.5 Hydrostatic tests of valves

2.5.1 The following valves are to be subjected in the manufacturer's works to a hydraulic pressure test in the presence of a Society Surveyor:

a) Valves of Pipe class II to 1,5 PR

b) Valves mounted on the vessel's side not less than 5 bar.

The valves specified under a) and b) shall also undergo a tightness test at 1,0 times the nominal pressure.

For the valves of steam boilers, see Ch 1, Sec 3, [2].

3 Pipe wall thicknesses

3.1 Minimum wall thickness

3.1.1 The pipe thicknesses given in Tab 4 to Tab 8 are the assigned minimum thicknesses, where:

d_a : Outside diameter of pipe, in mm

t : Wall thickness, in mm

3.2 Thickness of pressure piping

3.2.1 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 4 to Tab 7.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

t_0 : Coefficient, in mm, equal to

$$t_0 = \frac{p_C \cdot d_a}{0,2Ke + p_C}$$

with:

p_C : Design pressure, in bar, defined in [2.4.1]

d_a : Pipe external diameter, in mm.

K : Permissible stress defined in [3.2.2]

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 [3.2.3], in mm

c : Corrosion allowance defined in [3.2.4], 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 4 : Steel pipes

d_a		t	d_a		t
up to	10,2	1,6	from	114,3	3,2
from	13,5	1,8	from	133,0	3,6
from	20,0	2,0	from	152,4	4,0
from	48,3	2,3	from	177,8	4,5
from	70,0	2,6	from	244,5	5,0
from	88,9	2,9	from	298,5	5,6

Note 1: For systems where carbon dioxide is stored at ambient temperature, see Tab 5.
Note 2: For steel pipes located inside tanks, see also [4.3.5]

Table 5 : Steel pipes for CO_2 systems

d_a		t	
		Between bottles and master valves	Between master valves and nozzles
up to	26,9	3,2	2,6
from	48,3	4,0	3,2
from	60,3	4,5	3,6
from	76,1	5,0	3,6
from	88,9	5,6	4,0
from	101,6	6,3	4,0
from	114,3	7,1	4,5
from	127,8	8,0	4,5
from	139,7	8,0	5,0
from	168,3	8,8	5,6

Table 6 : Copper and copper alloy pipes

Copper pipes			Copper alloy pipes		
d_a		t	d_a		t
up to	12,2	1,0	up to	22,0	1,0
from	14,0	1,5	from	25,0	1,5
from	44,5	2,0	from	76,0	2,0
from	60,0	2,5	from	108,0	2,5
from	108,0	3,0	from	219,0	3,0
from	159,0	3,5			

Table 7 : Stainless steel pipes

d_a	t
0 - 50	1,7
54 - 70	2,0
73 -140	2,1
141 -220	2,8
270 -280	3,4
320 -360	4,0
400 - 460	4,2
500 - 560	4,8
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.	

3.2.2 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:

$$\frac{R_{m,20}}{2,7} \qquad \frac{R_e}{A} \qquad \frac{\sigma_R}{A} \qquad \sigma$$

where:

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

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm²

σ_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm²

σ : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm²

A : Safety factor to be taken equal to:
- 1,6 when R_e and s_R values result from tests attended by the Society,
- 1,8 otherwise.

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by the Society.

Table 8 : Aluminium and aluminium alloy pipes

d_a	t
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards. **Note 2:** For river water pipes, the minimum thickness is not to be less than 5 mm.	

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/mm^2)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	44
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm^2)	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/mm^2)	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

3.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{d_a t_0}{2{,}5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

d_a : as defined in [3.2.1].

t_0 : as defined in [3.2.1].

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.

3.2.4 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.

3.2.5 Tees

As well as complying with the provisions of [3.2.1] to [3.2.4] 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:

$$t_T = \left(1 + \frac{d_1}{d_a}\right) \cdot t_0$$

where:

d_1 : External diameter of the branch pipe

d_a : as defined in [3.2.1].

t_0 : as defined in [3.2.1].

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

Table 12 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance, in mm
Superheated steam	0,3
Saturated steam	0,8
Steam coils in cargo tanks and liquid fuel tanks	2,0
Feed water for boilers in open circuit systems	1,5
Feed water for boilers in closed circuit systems	0,5
Blow-down systems for boilers	1,5
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Thermal oil	1,0
Fresh water	0,8
River water	3,0
Cargo systems for oil tankers	2,0
Cargo systems for vessels carrying liquefied gases	0,3

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.
Note 2: The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%.
Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

Table 13 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance, in 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.

4 Principles for the construction of pipes, valves, fittings and pumps

4.1 General principles

4.1.1 Piping systems are to be constructed and manufactured on the basis of standards generally used in vessel building.

4.1.2 Welded connections instead of detachable connections should be used for pipelines carrying toxic media and inflammable liquefied gases.

4.1.3 Expansion in piping systems due to heating and shifting of their suspensions caused by deformation of the vessel are to be compensated by bends, compensators and flexible pipe connections. The arrangement of suitable fixed points is to be taken into consideration

4.2 Pipe connections

4.2.1 Dimensions and calculation

The dimensions of flanges and bolting are to comply with recognized standards.

4.2.2 Pipe connections

The following pipe connections may be used:

- Fully penetrating butt welds with/without provision to improve the quality of the root
- Socket welds with suitable fillet weld thickness and possibly in accordance with recognized standards
- Screw connections of approved type.

For the use of these pipe connections, see Tab 14.

Screwed socket connections and similar connections are not permitted for pipes of classes II and III. Screwed socket connections are allowed only for subordinate systems (e.g. sanitary and hot-water heating systems) operating at low pressures. Screwed pipe connections and pipe coupling may be used subject to special approval.

Steel flanges may be used under considering the allowed pressures and temperatures as stated in the corresponding standards.

Table 14 : Pipe connections

<table>
<tr><th>Types of connections</th><th>Pipe class</th><th>Nominal diameter</th></tr>
<tr><td>Welded butt-joints with special provisions for root side</td><td>II, III</td><td rowspan="3">all</td></tr>
<tr><td>Welded butt-joints without special provisions for root side</td><td>II, III</td></tr>
<tr><td>Welded sockets</td><td>III</td></tr>
<tr><td>Screwed sockets</td><td>for subordinate systems see [4.2.2]</td><td>< 50</td></tr>
</table>

Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals. Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

a) Welding neck flanges according to standard up to 200°C or 300°C for all Pipe classes.

b) Loose flanges with welding collar; as for a).

c) Plain brazed flanges: only for Pipe class III up to a nominal pressure of 16 bar and a temperature of 120°C.

Approved pipe couplings are permitted in the following piping systems outside engine rooms:

- Bilge and ballast systems
- Fuel and oil systems
- Fire extinguishing and deck washing systems
- Cargo oil pipes
- Air, filling and sounding pipes
- Sanitary drain pipes
- Drinking water pipes.

These couplings may only be used inside machinery spaces if they have been approved by the Society as flame-resistant.

The use of pipe couplings is not permitted in:

- Fuel and seawater lines inside cargo spaces
- Bilge lines inside fuel tanks and ballast tanks.

4.3 Layout, marking and installation

4.3.1 Piping systems must be adequately identified according to their purpose. Valves are to be permanently and clearly marked.

4.3.2 Pipes leading through bulkheads and tank walls must be water and oil tight. Bolts through bulkheads are not permitted. Holes for set screws may not be drilled in the tank walls.

4.3.3 Piping systems close to electrical switchboards must be so installed or protected that possible leakage cannot damage the electrical installation.

4.3.4 Piping systems are to be so arranged that they can be completely emptied, drained and vented. Piping systems in which the accumulation of liquids during operation could cause damage must be equipped with special drain arrangements.

4.3.5 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness or tunnels, in particular for:
   - bilge pipes
   - ballast pipes
   - scuppers and sanitary discharges
   - air, sounding and overflow pipes
   - fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or flange connections. See also [4.2.2].

4.4 Shutoff devices

4.4.1 Shutoff devices must comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover.

4.4.2 Hand-operated shutoff devices are to be closed by turning in the clockwise direction.

4.4.3 Indicators are to be provided showing the open/closed position of valves unless their position is shown by other means.

4.4.4 Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service must not be used.

4.5 Outboard connections

4.5.1 Outboards are to be made of steel or appropriate non-brittle material.

4.5.2 Valves may only be mounted on the vessel's side by means of reinforcing flanges or thick-walled connecting pipes.

4.5.3 Vessel's side valves shall be easily accessible. Water inlet and outlet valves must be capable of being operated from above the floor plates. Cocks on the vessel's side must be so arranged that the handle can only be removed when the cock is closed.

4.5.4 Where discharge pipes without shutoff devices may be connected to the vessel's hull below the freeboard deck, the wall thickness of the pipes to the nearest shutoff device must be equal to that of the shell plating at the ends of the vessel, but need not to exceed 8 mm.

4.5.5 Outboard connections are to be fitted with shutoff valves.

Cooling water discharge lines may be provided with loops led at a minimum height of 0,3 m above the maximum draft.

4.6 Remote controlled valves

4.6.1 Scope

These Rules apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

4.6.2 Construction

Remote controlled bilge valves and valves important to the safety of the vessel are to be equipped with an emergency operating arrangement.

For the emergency operation of remote controlled valves in cargo piping systems, see Pt D, Ch 3, Sec 1, [3.2].

4.6.3 Arrangement of valves

The accessibility of the valves for maintenance and repairing is to be taken into consideration.

Valves in bilge lines and sanitary pipes must always be accessible.

Bilge lines valves and control lines are to be located as far as possible from the bottom and sides of the vessel.

The requirements stated hereabove also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

Remote-controlled valves mounted on high and wing fuel tanks must be capable of being closed from outside the compartment in which they are installed.

Where remote controlled valves are arranged inside cargo tanks, valves should always be fitted in the tank adjoining that to which they relate. A direct arrangement of the remote controlled valves in the tanks concerned is allowed only if each tank is fitted with two suction lines each of which is provided with a remote controlled valve.

4.6.4 Control stands

The control devices of remote controlled valves are to be arranged together in one control stand.

The control devices are to be clearly and permanently identified and marked.

It must be recognized at the control stand whether the valves are open or closed.

In the case of bilge valves and valves for changeable tanks, the closed position is to be indicated by limit-position indicators approved by the Society as well as by visual indicators at the control stand.

On passenger vessels, the control stand for remote controlled bilge valves is to be located outside the machinery spaces and above the bulkhead deck.

4.6.5 Power units

Power units are to be equipped with at least two independent sets for supplying power for remote controlled valves.

The energy required for the closing of valves which are not closed by spring power is to be supplied by a pressure accumulator.

Pneumatically operated valves can be supplied with air from the general compressed air system.

Where the quick-closing valves of fuel tanks are closed pneumatically, a separate pressure accumulator is to be provided. This is to be of adequate capacity and is to be located outside the engine room. Filling of this accumulator by a direct connection to the general compressed air system is allowed. A non-return valve is to be arranged in the filling connection of the pressure accumulator.

The accumulator is to be provided either with a pressure control device with a visual and acoustic alarm or with a hand-compressor as a second filling appliance.

The hand-compressor is to be located outside the engine room.

4.6.6 After installation on board, the entire system is to be subjected to an operational test.

4.7 Pumps

4.7.1 Displacement pumps must be equipped with sufficiently dimensioned relief valves without shutoff to prevent any excessive overpressure in the pump housing.

4.7.2 Rotary pumps must be capable of being operated without damage even when the delivery line is closed.

4.7.3 Pumps mounted in parallel are to be protected against overloading by means of non-return valves fitted at the outlet side.

4.7.4 Pumps for essential services are subject to adequate pressure and running tests.

4.8 Protection of piping systems against overpressure

4.8.1 The following piping systems are to be fitted with safety valves to avoid unallowable overpressures:

- Piping systems and valves in which liquids can be enclosed and heated
- Piping systems which may be exposed in service to pressures in excess of the design pressure.

Safety valves must be capable of discharging the medium at a maximum pressure increase of 10 %. Safety valves are to be fitted on the low pressure side of reducing valves.

4.8.2 Air escaping from the pressure-relief valves of the pressurised air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.

4.9 Bending process

4.9.1 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.

4.9.2 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.

4.9.3 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.

4.9.4 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.

4.10 Supporting of the pipes

4.10.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the vessel's structure by means of collars or similar devices.

4.10.2 Arrangements of supports

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.

Heavy components in the piping system, such as valves, are to be independently supported.

5 Steam systems

5.1 Laying out of steam systems

5.1.1 Steam systems are to be so installed and supported that expected stresses due to thermal expansion, external loads and shifting of the supporting structure under both normal and interrupted service conditions will be safely compensated.

5.1.2 Steam lines are to be so installed that water pockets will be avoided.

5.1.3 Means are to be provided for the reliable drainage of the piping system.

5.1.4 Pipe penetrations through bulkheads and decks are to be insulated to prevent heat conduction.

5.1.5 Steam lines are to be effectively insulated to prevent heat losses.

At points where there is a possibility of contact, the surface temperature of the insulated steam systems may not exceed 80°C.

Wherever necessary, additional protection arrangements against unintended contact are to be provided.

The surface temperature of steam systems in the pump rooms of tankers may nowhere exceed 220°C.

It is to be ensured that the steam lines are fitted with sufficient expansion arrangements.

Where a system can be entered from a system with higher pressure, the former is to be provided with reducing valves and relief valves on the low pressure side.

Welded connections in steam systems are subject to the requirements specified in the Society's Rules for Materials and Welding.

5.2 Steam strainers

5.2.1 Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.

5.3 Steam connections

5.3.1 Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam out arrangements, are to be so secured that fuel and oil cannot penetrate into the steam systems.

6 Boiler feedwater and circulating arrangement, condensate recirculation

6.1 Feed water pumps

6.1.1 At least two feedwater pumps are to be provided for each boiler installation.

6.1.2 Feedwater pumps are to be so arranged or equipped that no backflow of water can occur when the pumps are at a standstill.

6.1.3 Feedwater pumps are to be used only for feeding boilers.

6.2 Capacity of feed water pumps

6.2.1 Where two feedwater pumps are provided, the capacity of each is to be equivalent to at least 1,25 times the maximum permitted output of all the connected steam producers.

6.2.2 Where more than two feedwater pumps are installed, the capacity of all other feedwater pumps in the event of the failure of the pump with the largest capacity is to comply with the requirements of [6.2.1].

6.2.3 For continuous flow boilers the capacity of the feedwater pumps is to be at least 1,0 times the maximum steam output.

6.3 Delivery pressure of feedwater pumps

6.3.1 Feedwater pumps are to be so laid out that the delivery pressure can satisfy the following requirements:

- The required capacity according to [6.2] is to be achieved against the maximum allowable working pressure of the steam producer
- The safety valves must have a capacity equal 1,0 times the approved steam output at 1,1 times the allowable working pressure.

The resistances to flow in the piping between the feedwater pump and the boiler are to be taken into consideration. In the case of continuous flow boilers the total resistance of the boiler must be taken into account.

6.4 Power supply to feedwater pumps

6.4.1 For electric drives, a separate lead from the common bus-bar to each pump motor is sufficient.

6.5 Feedwater systems

6.5.1 General

Feedwater systems may not pass through tanks which do not contain feedwater.

6.5.2 Feedwater systems for boilers

a) Each boiler is to be provided with a main and an auxiliary feedwater systems.

b) Each feedwater system is to be fitted with a shutoff valve and a check valve at the boiler inlet. Where the shutoff valve and the check valve are not directly connected in series, the intermediate pipe is to be fitted with a drain.

c) Each feedwater pump is to be fitted with a shutoff valve on the suction side and a screw-down non-return valve on the delivery side. The pipes are to be so arranged that each pump can supply each feedwater system.

d) Continuous flow boilers need not to be fitted with the valves required in b) provided that the heating of the boiler is automatically switched off should the feedwater supply fail and that the feedwater pump supplies only one boiler.

6.6 Boiler water circulating systems

6.6.1 Each forced-circulation boiler is to be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation is to be signalled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.

6.6.2 The provision of only one circulating pump for each boiler is sufficient if:

- a common stand-by circulating pump is provided which can be connected to any boiler or
- the burners of oil-fired auxiliary boilers are so arranged that they are automatically shut off should the circulating pump fail and the heat stored in the boiler does not cause any unacceptable evaporation of the water present in the boiler.

6.7 Condensate recirculation

6.7.1 The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil etc.) is to be led to condensate observation tanks. These tanks are to be fitted with air vents.

7 Fuel oil systems

7.1 Fuel oil tank

7.1.1 The thickness of the top plating is to be greater by 1 mm than the rule thickness of bulkheads under the same load, without being less than the scantlings obtained by considering it as a deck plating.

7.1.2 Liquid fuel must be carried in oiltight tanks which may either form part of the hull or must be solidly connected with the vessel's hull.

7.1.3 Fuel oil bunkers and tanks provided in the machinery space are not to be located above the boilers nor in places where they are likely to reach a high temperature, unless special arrangements are provided with the agreement of the Society.

7.1.4 Where a cargo space is adjacent to a fuel bunker which is provided with heating system, the fuel bunker boundaries are to be adequately heat insulated.

7.1.5 Arrangements are to be made to restrict leaks through the bulkheads of liquid fuel tanks adjacent to the cargo space.

7.1.6 Gutterways are to be fitted at the foot of bunker bulkheads, in the cargo space and in the machinery space in order to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The gutterways may however be dispensed with if the bulkheads are entirely welded.

7.1.7 Where ceilings are fitted on the tank top or on the top of deep tanks intended for the carriage of fuel oil, they are to rest on grounds 30 mm in depth so arranged as to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The ceilings may be positioned directly on the plating in the case of welded top platings.

7.1.8 General safety precautions for liquid fuel

Tanks and fuel pipes are to be so located and equipped that fuel cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see [13]).

7.1.9 Fuel supply

The fuel supply is to be stored in several tanks so that, even in event of damage to one tank, the fuel supply will not be entirely lost. (At least 1 storage tank and 1 service/settling tank).

7.1.10 Location

The location of fuel oil tanks is to be in compliance with Pt B, Ch 5, Sec 5, [7.1], particularly as regards the installation of cofferdams, the separation between fuel oil tanks or bunkers and other spaces of the vessel.

No fuel tanks may be located forward of the collision bulkhead.

7.1.11 Scantlings

Scantlings of fuel tanks are to be in compliance with Pt B, Ch 5, Sec 4 and Pt B, Ch 5, Sec 5.

7.2 Fuel tank fittings and mountings

7.2.1 For fuel filling and suction systems see [7.6]; for air, overflow and sounding pipes, see [13].

The open ends of air pipes and overflow pipes leading to the deck shall be provided with a protecting screen.

7.2.2 Service tanks are to be so arranged that water and residues can settle out despite the movement of the vessel.

7.2.3 Free discharge and drainage lines must be fitted with self-closing shutoff valves.

7.2.4 Tank gauges

The following tank gauges are permitted:

- Sounding pipes
- Oil level indicating devices
- Oil gauges with flat glasses and self-closing shutoff valves at the connections to the tank and protected against external damage.

For fuel storage tanks, the provision of sounding pipes is sufficient. Such sounding pipes need not be fitted to tanks equipped with oil level indicating devices which have been type-tested by the Society.

Fuel service tank supplying the main propulsion unit, important auxiliaries and the driving engines for bow thruster are to be fitted with visual and audible low level alarm which has been approved by the Society.

See also Ch 2, Sec 13.

The low level alarm shall be fitted at a height which enables the vessel to reach a safe location in accordance with the class notation without refilling the service tank.

Sight glasses and oil gauges fitted directly on the side of the tank and round glass oil gauges are not permitted.

Sounding pipes of fuel tanks may not terminate in accommodation nor shall they terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise

7.3 Attachment of mountings and fittings to fuel tanks

7.3.1 Only appliances, mountings and fittings forming part of the fuel tank equipment may generally be fitted to tank surfaces.

7.3.2 Valves and pipe connections are to be attached to strengthening flanges welded to the tank surfaces. Holes for attachment bolts must not be drilled in the tank surfaces. Instead of strengthening flanges, short, thick pipe flange connections may be welded into the tank surfaces.

7.4 Hydraulic pressure test

7.4.1 See [2.4].

7.5 Filling and delivery system

7.5.1 The filling of fuels is to be effected from the open deck through permanently installed lines.

7.6 Tank filling and suction systems

7.6.1 Fuel pumps are to be equipped with emergency stops.

7.6.2 Filling and suction lines must be fitted with remote controlled shutoff valves.

7.6.3 The emergency stops and the remote-controlled shutoff valves must be capable of being operated from a permanently accessible open deck and protected from unauthorized use.

7.6.4 Air and sounding pipes shall not be used to fill fuel tanks.

7.6.5 The inlet openings of suction pipes must be located above the drain pipes.

7.6.6 Service tanks of up to 50 litres capacity mounted directly on diesel engines need not be fitted with remote controlled shutoff valves.

7.7 Pipe layout

7.7.1 Fuel lines may not pass through tanks containing feedwater, drinking water or lubricating oil.

7.7.2 Fuel lines may not be laid in the vicinity of hot engine components, boilers or electrical equipment. The number of detachable pipe connections is to be limited. Shutoff valves in fuel lines shall be operable from above the floor plates in machinery spaces.

Glass and plastic components are not permitted in fuel systems.

7.7.3 Shutoff valves in fuel return (spill) lines to tanks may be permitted, ensuring that return line to the tanks under normal operating conditions will not be blocked.

7.8 Filters

7.8.1 Fuel supply lines to continuously operating engines are to be fitted with duplex filters with a changeover cock or with self-cleaning filters. By-pass arrangements are not permitted.

See also Ch 1, Sec 2, [6].

7.9 Alarms

7.9.1 See Ch 2, Sec 13.

8 Lubricating oil systems

8.1 Storage of lubricating oil

8.1.1 The scantlings of the tanks are to be in compliance with Pt B, Ch 5, Sec 4 and Pt B, Ch 5, Sec 5.

8.1.2 Alarms

See Ch 2, Sec 13.

8.2 Tank fittings and mountings

8.2.1 Oil level glasses are to be connected to the tanks by means of self-closing shutoff valves.

8.2.2 The requirements set out under [2.4] apply likewise to the mounting of appliances and fittings on these tanks.

8.3 Capacity and construction of tanks

8.3.1 Lubricating oil circulating tanks should be sufficiently large to ensure that the dwelling time of the oil is long enough for the expulsion of air bubbles, the settling out of residues etc. The tanks must be large enough to hold at least the lubricating oil contained in the entire circulation system.

8.3.2 Measures, such as the provision of baffles or limber holes are to be taken to ensure that the entire contents of the tank remain in circulation. Limber holes should be located as near the bottom of the tank as possible. Lubricating oil drain pipes from engines are to be submerged closed to the tank bottom at their outlet ends. Suction pipe connections should be placed as far as is practicable from oil drain pipes so that neither air nor sludge can be sucked up irrespective of the inclination of the vessel.

8.3.3 Lubricating oil drain tanks are to be equipped with vent pipes in compliance with [13.1].

8.4 Hydraulic pressure test

8.4.1 See [2.4].

8.5 Lubricating oil piping

8.5.1 Lubricating oil systems are to be constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines and to ensure adequate heat transfer.

8.5.2 Priming pumps

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

8.6 Lubricating oil pumps

8.6.1 The suction connections of lubricating oil pumps are to be located as far as possible from drain pipes.

8.7 Filters

8.7.1 Change-over duplex filters or automatic back-flushing filters are to be mounted in lubricating oil lines on the delivery side of the pumps.

See also Ch 1, Sec 2, [6].

9 Cooling water systems

9.1 Cooling water intakes, river chest

9.1.1 Each river chest is to be provided with an air pipe which can be shutoff and which must extend above the bulkhead deck (see Pt B, Ch 1, Sec 1, [1.2.10], for definition). The inside diameter of the air pipe must be compatible with the size of the river chests and shall not be less than 30 mm.

9.1.2 Where compressed air is used to blow through river chests, the pressure shall not exceed 2 bar.

9.2 Cooling water intake valves

9.2.1 Two valves are to be provided for main propulsion plants:

- one valve at the water inlet secured:
  - directly on the shell plating, or
  - on river chest built on the shell plating, with scantlings in compliance with Pt B, Ch 5, Sec 1, [2.2]
- one valve at the cooler inlet

The cooling water pumps of important auxiliaries should be connected to the river chests over separate valves.

9.3 Filters

9.3.1 The suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

9.4 Expansion tanks of fresh water cooling systems

9.4.1 The fresh water cooling system is to be provided with expansion tanks located at a sufficient height. The tanks are to be fitted with a filling connection, a water level indicator and an air pipe. A venting shall connect the highest point of the cooling water common pipe to the expansion tank.

In closed circuits, the expansion tanks are to be fitted with overpressure/underpressure valves.

9.5 Fresh water coolers

9.5.1 For fresh water coolers forming part of the vessel's shell plating and for special outboard coolers, provision must be made for satisfactory deaeration of the cooling water.

10 Compressed air systems

10.1 General

10.1.1 Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.

10.1.2 Efficient oil and water traps are to be provided in the filling lines of compressed air receivers.

10.1.3 Starting air lines may not be used as filling lines for air receivers.

10.1.4 The starting air line to each engine is to be fitted with a non-return valve and a drain.

10.1.5 Tyfons are to be connected to at least two compressed air receivers.

10.1.6 A safety relief valve is to be fitted downstream of each pressure-reducing valve.

10.1.7 Pressure water tanks and other tanks connected to the compressed air system are to be considered as pressure vessels and must comply with the requirements in Ch 1, Sec 3, [1].

10.2 Compressed air connections for blowing through river chests

10.2.1 For compressed air connections for blowing through river chests refer to [9.1.2].

10.3 Compressed air supply to pneumatically operated valves

10.3.1 For the compressed air supply to pneumatically operated valves refer to [4.6].

11 Bilge systems

11.1 General

11.1.1 The equipment of vessels with oil-separating facilities is to conform to applicable Society's Rules.

11.2 Bilge lines

11.2.1 Layout of bilge lines

Bilge lines and bilge suctions are to be so arranged that the bilges can be completely pumped even under disadvantageous trim conditions.

Bilge suctions are normally to be located on both sides of the vessel. For compartments located fore and aft in the vessel, one bilge suction may be considered sufficient provided that it is capable of completely draining the relevant compartment.

Spaces located forward of the collision bulkhead and aft of the stern tube bulkhead and not connected to the general bilge system are to be drained by other suitable means of adequate capacity.

The collision bulkhead may be pierced by a pipe for filling and draining of the fore peak, provided that a screwdown 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.

11.2.2 Pipes led through tanks

Bilge pipes may not be led through tanks for lubricating oil, thermal oil, drinking water or feedwater.

11.2.3 Bilge suctions and strums

Bilge suctions are to be so arranged as not to impede the cleaning of bilges and bilge wells. They are to be fitted with easily detachable, corrosion-resistant strums.

11.2.4 Bilge valves

Valves in connecting pipes between the bilge and the river water and ballast water system, as well as between the bilge connections of different compartments, are to be so arranged that even in the event of faulty operation or intermediate positions of the valves, penetration of river water through the bilge system will be safely prevented.

Bilge discharge pipes are to be fitted with shutoff valves at the vessel's side.

Bilge valves are to be arranged so as to be always accessible irrespective of the ballast and loading condition of the vessel.

11.2.5 Pipe connections

To prevent water penetration, each of the branch bilge pipes from the individual compartments is to be connected to the main bilge pipe by a screw-down non-return valve. In the case of small vessels with only one cargo hold, the branch bilge pipes serving the various spaces can also be connected to the bilge pumps over changeover or three-way angle cocks.

Where a bilge pump is also to be used for pumping water over the vessel's side and from ballast water tanks, the main bilge pipe must be connected to the suction line of the pump by a non-return device to prevent raw or ballast water from penetrating the bilge system.

Such non-return devices include three-way cocks with L plugs, three-way angle cocks and changeover gate valves. Instead of these changeover devices, a screw-down non-return valve may also be fitted between the pump and the main bilge pipe, so that two non-return valves will then be connected in series.

A direct suction from the engine room must be connected to the largest of the specified bilge pumps. Its diameter shall not be less than that of the main bilge pipe.

However, the direct suction in the engine room need be fitted with only one screw-down non-return valve.

Where the direct suction is connected to a centrifugal pump which can also be used for cooling water, ballast water or fire extinguishing, a screw-down non-return valve is to be fitted in the discharge pipe of the pump.

11.3 Calculation of pipe diameters

11.3.1 The following apply to vessels other than tankers.

The inside diameter of bilge pipes is not to be less than 35 mm nor than the values derived from following formulae:

a) Main bilge pipes

$$d_H = 1,5\sqrt{(B + D)L} + 25$$

b) Branch bilge pipes

$$d_Z = 2,0\sqrt{(B + D)\ell} + 25$$

where:

d_H : Inside diameter of main bilge pipe, in mm

d_Z : Inside diameter of branch bilge pipe, in mm

L : Rule length, in m, defined in Pt B, Ch 1, Sec 1

B : Breadth, in m, defined in Pt B, Ch 1, Sec 1

D : Depth, in m, defined in Pt B, Ch 1, Sec 1

ℓ : Length of the watertight compartment, in m

The branch bilge pipe diameter may be taken not greater than the diameter of the main bilge pipe.

11.4 Bilge pumps

11.4.1 Capacity of independent pumps

Each bilge pump must be capable of delivering:

$Q = 5,75 \cdot 10^{-3}\, d_H^2$

where:

Q : Minimum capacity, in m^3/h

d_H : Calculated inside diameter of main bilge pipe, in mm.

11.4.2 Where centrifugal pumps are used for bilge pumping, they must be self-priming or connected to an air extracting device.

11.4.3 Number of bilge pumps

Vessels with a propulsion power of up to 225 kW must have one bilge pump, which may be driven from the main engine. Where the propulsion power is greater than 225 kW, a second bilge pump driven independently of the main propulsion plant must be provided.

11.4.4 Use of other pumps for bilge pumping

Ballast pumps, general service pumps and similar units may also be used as independent bilge pumps provided they are of the required capacity according to [11.4.1].

Oil pumps may not be connected to the bilge system.

11.4.5 Capacity of attached bilge pumps

Bilge pumps having a smaller capacity than that specified in [11.4.1] are acceptable provided that the independent pumps are designed for a correspondingly larger capacity.

11.5 Bilge pumping for various spaces

11.5.1 Machinery spaces

The bilges of every main and essential auxiliary machinery spaces must be capable of being pumped as follows:

a) through the bilge suctions connected to the main bilge system and

b) through one direct suction connected to the largest independent bilge pump.

11.5.2 Fore and after peaks

Where the peak tanks are not connected to the ballast system, separate means of pumping are to be provided. Where the after peak terminates at the engine room, it may be drained to the engine room bilge through a pipe fitted with a shutoff valve. Similar emptying of the fore peak into an adjoining space is not permitted.

11.5.3 Spaces above peak tanks

These spaces may either be connected to the bilge system or be pumped by means of hand-operated bilge pumps. Spaces above the after peak may be drained to the machinery space, provided that the drain line is fitted with a self-closing shutoff valve at a clearly visible and easily accessible position. The drain pipes shall have an inside diameter of at least 40 mm.

11.5.4 Cofferdams and void spaces

Bilge pumping arrangements are to be provided for cofferdams and void spaces.

11.5.5 Chain lockers

Chain lockers may be connected to the main bilge system or drained by a hand pump. Draining to the fore peak tank is not permitted.

12 Thermal oil systems

12.1 General

12.1.1 Thermal oil systems shall be installed in accordance with Ch 1, Sec 3, [3].

12.2 Pumps

12.2.1 Circulating pumps

Two circulating pumps which are to be independent of each other are to be provided.

12.2.2 Transfer pumps

A transfer pump is to be installed for filling the expansion tank.

12.2.3 The pumps are to be so mounted that any oil leakage can be safely disposed of.

12.2.4 For emergency stopping, see Ch 1, Sec 14, [2.3].

12.3 Valves

12.3.1 Only valves made of ductile materials may be used.

12.3.2 Valves shall be designed for a nominal pressure of PN 16.

12.3.3 Valves are to be mounted in accessible positions.

12.3.4 Non-return valves are to be fitted in the pressure lines of the pumps.

12.3.5 Valves in return pipes are to be secured in the open position.

12.4 Piping

12.4.1 The material of the sealing joints is to be suitable for permanent operation at the design temperature and resistant to the thermal oil.

12.4.2 Provision is to be made for thermal expansion by an appropriate pipe layout and the use of suitable compensators.

12.4.3 The pipe lines are to be preferably connected by means of welding. The number of detachable pipe connections is to be minimized.

12.4.4 The laying of pipes through accommodation, public or service spaces is not permitted.

12.4.5 Pipelines passing through cargo holds are to be installed in such a way that no damage can be caused.

12.4.6 Pipe penetrations through bulkheads and decks are to be insulated against conduction of heat.

12.4.7 The venting is to be so arranged that air/oil mixtures can be carried away without danger.

12.5 Tightness and operational testing

12.5.1 General

After installation, the entire arrangement is to be subjected to tightness and operational testing under the supervision of the Society.

12.6 Location and equipment of thermal oil tanks

12.6.1 For the location and equipment of thermal oil tanks, see Ch 1, Sec 3, [3].

12.7 Design pressure and test pressure

12.7.1 For design pressure and test pressure, see [2.4].

13 Air, sounding and overflow pipes

13.1 Air pipes

13.1.1 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 water in the compartment.

The height d_{AP}, in m, of air pipes above the deck is to be such that:

$z_{AP} \geq T + n/1,7 + \delta_{AP}$

where:

z_{AP}	:	Z co-ordinate, in m, of the top of air pipe
n	:	Navigation coefficient defined in Pt B, Ch 3, Sec 1, [5.2]
D	:	Depth, in m, defined in Pt B, Ch 1, Sec 1
T	:	Draught, in m, defined in Pt B, Ch 1, Sec 1
δ_{AP}	:	Increase of air pipe height, in m for pipes with closing devices: $\delta_{AP} = 0,15$ for pipes without closing devices: $\delta_{AP} = \max(0,15;0,39n)$

Air pipes are to be laid vertically. Air 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 must equal at least 125 % that of the corresponding filling pipe.

Air pipes of lubricating oil storage tanks may terminate in the engine room. Air pipes of the lubricating oil storage tanks which form part of the vessel's shell are to terminate in the engine room casing above the freeboard deck.

It is necessary to ensure that no leaking oil can spread on to heated surfaces where it may ignite.

The air pipes of lubricating oil tanks, gear and engine crankshaft casings shall not be led to a common line.

Cofferdams and void spaces with bilge connections must be provided with air pipes terminating above the open deck.

13.2 Sounding pipes

13.2.1 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 (void spaces, cofferdams and bilges (bilge wells)).

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:
   - a level gauge of an approved type efficiently protected against shocks, or
   - a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

13.2.2 General arrangement

As far as possible, sounding pipes are to be laid straight and are to extend as near as possible to the bottom of the tank.

Sounding pipes which terminate below the deepest load waterline are to be fitted with self-closing shutoff devices. Such sounding pipes are only permissible in spaces which are accessible at all times. All other sounding pipes are to be extended to the open deck. The sounding pipe openings must always be accessible and fitted with watertight closures.

Sounding pipes of tanks are to be provided close to the top of the tank with holes for equalizing the pressure.

A striking pad is to be fitted under every sounding pipe. Where sounding pipes are connected to the tanks over a lateral branch pipe, the branch-off under the sounding pipe is to be adequately reinforced.

13.2.3 Sounding pipes for fuel and lubricating oil tanks

Where sounding pipes cannot be extended above the open deck, they must be provided with self-closing shutoff devices as well as with self-closing test valves.

The openings of sounding pipes must be located at a sufficient distance from boilers, electrical equipment and hot components.

Sounding pipes shall not terminate in accommodation or service spaces. They are not to be used as filling pipes.

13.3 Overflow pipes

13.3.1 Liquid fuel tanks

Where an overflow pipe is provided for liquid fuel tanks, the discharge is generally to be led to an overflow tank of appropriate capacity.

Overflows from service tanks are generally to be led back either to the fuel bunkers, or to an overflow tank of appropriate capacity.

Where filling of a tank is performed by a power pump, it is recommended to fit on the overflow pipe an alarm or a sight glass to indicate when the tank is full.

13.3.2 Design of overflow systems.

Where overflows from service tanks intended to contain the same liquid or different ones are connected to a common main, provision is to be made to prevent any risk of intercommunication between the various tanks in the course of movements of liquid when emptying or filling.

13.3.3 Construction

Overflow pipes are normally to be made of the same material as the pipes serving the corresponding compartments

In each compartment which can be pumped up, the total cross section of overflow pipes is not to be less than 125 % that of the corresponding filling pipe.

Overflow pipes are to be laid vertically. Overflow pipes passing through cargo holds are to be protected against damage.

The open ends of overflow pipes leading to the deck shall be provided with a protecting screen.

14 Hose assemblies and compensators

14.1 Scope

14.1.1 The following Rules are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

14.1.2 Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel-, lubricating oil-, hydraulic oil-, bilge-, ballast-, fresh water cooling-, river water cooling-, compressed air-, auxiliary steam, exhaust gas and thermal oil systems as well as in secondary piping systems.

14.2 Definitions

14.2.1 Hose assemblies consist of metallic or non-metallic hoses completed with end fittings ready for installation.

Compensators consist of bellows with end fittings as well as anchors for absorption of axial loads where angular or lateral flexibility is to be ensured. End fittings may be flanges, welding ends or approved pipe unions.

Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

14.2.2 High pressure hose assemblies and compensators

Hose assemblies or compensators which are suitable for use in systems with predominant dynamic load characteristics.

14.2.3 Low-pressure hose assemblies and compensators

Hose assemblies or compensators which are suitable for use in systems with predominant static load characteristics.

14.2.4 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators

The maximum allowable working pressure of high pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

The maximum allowable working pressure respectively nominal pressure for low pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the components.

14.2.5 Test pressure

For non-metallic high pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

For non-metallic low pressure hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

For metallic hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure or 1,5 times the nominal pressure.

14.2.6 Burst pressure

For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or 4 times the nominal pressure. Excepted hereof are non-metallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure.

14.3 Requirements

14.3.1 Hoses and compensators used in the systems mentioned in [14.1.2] are to be of approved type.

14.3.2 Manufacturers of hose assemblies and compensators must be recognized by the Society.

14.3.3 Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

14.3.4 The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar is to be considered as the minimum working pressure.

14.3.5 Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and river water systems are to be flame-resistant.

14.4 Installations

14.4.1 Non-metallic hose assemblies shall only be used at locations where they are required for compensation of relative movements. They shall be kept as short as possible under consideration of the installation instructions of the hose manufacturer.

14.4.2 The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

14.4.3 Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

14.4.4 In fresh water systems with a working pressure of <= 5 bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

14.4.5 Where hose assemblies and compensators are installed in the vicinity of hot components they must be provided with approved heat-resistant sleeves.

14.5 Test

14.5.1 Hose assemblies and compensators are to be subjected in the manufacturer's works to a pressure test in accordance with [2.4] under the supervision of the Society.

14.6 Vessel cargo hoses

14.6.1 Vessel cargo hoses for cargo-handling on chemical tankers and gas tankers shall be type approved.

Mounting of end fittings is to be carried out only by approved manufacturers.

14.6.2 Vessel cargo hoses are to be subjected to final inspection at the manufacturer under supervision of a Society's Surveyor as follows:

- Visual inspection
- Hydrostatic pressure test with 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure. The nominal pressure shall be at least 10 bar
- Measuring of the electrical resistance between the end fittings. The resistance shall not exceed 1 kΩ.

14.7 Marking

14.7.1 Hose assemblies and compensators must be permanently marked with the following particulars:

- Manufacturer's mark or symbol
- Date of manufacturing
- Type
- Nominal diameter
- Maximum allowable working pressure respectively nominal pressure
- Test certificate number and sign of the responsible Society inspection.

SECTION 11 STEERING GEARS

Symbols

d_T : Theoretical rudder stock diameter, in mm, based on ahead run in accordance with Pt B, Ch 7, Sec 1, [3.1]

d : Minimum actual rudder stock diameter, in mm

k_1 : $k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$

R_{eH} : Yield stress, in N/mm^2, of the steel used, and not exceeding the lower of 0,7 R_m and 450 N/mm^2,

R_m : Minimum ultimate tensile strength, in N/mm^2, of the steel used,

n_1 : Coefficient to be taken equal to:

- n_1 = 0,75 for R_{eH} > 235 N/mm^2
- n_1 = 1,00 for R_{eH} ≤ 235 N/mm^2

1 General

1.1 Scope

1.1.1 The Rules of this section apply to the steering gear, the steering station and all transmission elements from the steering station to the steering gear.

For the rudder and manoeuvring arrangement, see Pt B, Ch 7, Sec 1.

For the purposes of these Rules, steering gears comprise all the equipment used to operate the rudder from the rudder actuator to the steering station including the transmission elements.

This section is to be applied in analogous manner to rudder propellers in their function as steering gears.

1.2 Documents for review/approval

1.2.1 Assembly and general drawings of all steering gears (arrangement in normal and arrangement in emergency condition), diagrams of the hydraulic and electrical equipment together with detail drawings of all important load transmitting components are to be submitted to the Society, at least in triplicate, for review/approval.

The drawings and other documents must contain all the information relating to materials, working pressures, pump delivery rates, drive motor ratings, etc. necessary to enable the documentation to be checked.

2 Materials

2.1 Approved materials

2.1.1 As a rule, important load transmitting components of the steering gear (e.g. tiller, hydraulic cylinder, plunger, rotary vane, bolts, keys and so on) should be made of steel or cast steel complying with NR216 Materials and Welding.

With the consent of the Society, cast iron may be used for certain components.

Pressure vessels should, in general, be made of steel, cast steel or nodular cast iron (with predominantly ferritic matrix).

For welded structures, the Society's Rules for Materials and Welding are to be observed.

2.1.2 The pipes of hydraulic steering gears are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to external influences, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

2.1.3 High pressure hose lines may be used for short connections subject in compliance with Ch 1, Sec 4.

The materials used for pressurized components including the seals must be suitable for the hydraulic oil in use.

2.2 Testing of materials

2.2.1 The materials of important load-transmitting components of the steering gear including the pressurized oil pipes and the pressurized casings of hydraulic steering gears must possess mechanical characteristics conforming to NR 216 Materials and Welding. Evidence of this may take the form of manufacturer's workshop certificate.

For welded pressurized casings, relevant requirements of NR 216 Materials and Welding are to be applied.

3 Design and equipment

3.1 Number of steering gears

3.1.1 Every vessel must be equipped with at least one main and one auxiliary steering gear. Each steering gear must be able to operate the rudder for its own and independent of the other system. The Society may agree to components being used jointly by the main and auxiliary steering gear. For the electrical part of steering gear systems, see Ch 2, Sec 8.

3.2 Main steering gear

3.2.1 Main steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 35° port to 35° starboard and vice versa and the vessel travelling at full speed, see Pt B, Ch 7, Sec 1. The time required to put the rudder over shall not exceed 20 seconds.

The main steering gear must normally be power-operated.

3.2.2 Manual operation is acceptable for rudder stock diameters up to 150 mm calculated for torsional loads in accordance with Pt B, Ch 7, Sec 1, [3.1.1]. In the case of multi-surface rudders controlled by a common steering gear, the specified diameter is to be determined by applying the formula:

$$d_T = \sqrt[3]{\sum d_{Ti}^3}$$

Not more than 30 turns of the handwheel shall be necessary to put the rudder from one hard over position to the other. Taking account of the efficiency of the system, the force required to operate the handwheel should generally not exceed 200 N.

3.3 Auxiliary steering gear

3.3.1 Auxiliary steering gears shall be designed to ensure continued adequate manoeuvrability with the rudder fully immersed and the vessel travelling at reduced speed.

Manual operation of auxiliary steering gear systems is permitted where the size of the system allows this.

3.4 Omission of the auxiliary steering gear

3.4.1 Where power operated hydraulic main steering gears are equipped with two or more identical power units, no auxiliary steering gear need be installed provided that the conditions stipulated under [3.4.2] and [3.4.3] are fulfilled.

3.4.2 In the event of failure of a single component of the main steering gear, excluding the rudder tiller or similar components as well as the cylinders, rotary vanes and casing, means must be provided for quickly regaining control of one steering system.

3.4.3 In the event of a loss of hydraulic oil, it must be possible to isolate the damaged system in such a way that the second control system remains fully serviceable and may take over in not more than 5 sec.

3.4.4 Hydraulic pumps should be protected by means of non-return valves mounted at the discharge part.

3.5 Rudder angle limitation

3.5.1 The rudder angle of power-operated steering gears is to be limited to the specified maximum amount by devices fitted to the steering gear (e.g. limit switches).

3.6 End position limitation

3.6.1 For limitation of end positions, stoppers are to be provided. Where necessary, a mechanical safety device at the end position is to be supplied.

3.6.2 In the case of hydraulic steering gears without an end position limitation of the tiller and similar components, an end position limiting device must be fitted within the rudder actuator.

3.7 Locking equipment

3.7.1 Steering gear systems are to be equipped with a locking system effective in all rudder positions.

For hydraulic plants shutoff valves directly at the cylinder are accepted instead.

3.8 Overload protection

3.8.1 Power-operated steering gear systems are to be fitted with overload protection (slip coupling, relief valve) to ensure that the driving torque is limited to the maximum permissible value. Means must be provided for checking the setting while in service.

3.8.2 The pressurized casings of hydraulic steering gears which also fulfill the function of the locking equipment mentioned in [3.7] are to be fitted with relief valves unless they are so designed that the pressure generated when the elastic limit torque is applied to the rudder stock cannot cause rupture or permanent deformation of the pressurized casings.

3.8.3 In the case of hydraulic steering gears, the torque transmitted by the rudder as a result of grounding, e.g., must in addition, be limited by safety valves.

3.9 Controls

3.9.1 Control of the main and auxiliary steering gears must be exercised from a steering gear station. Controls must be mutually independent and so designed that the rudder cannot move unintentionally.

Alarm for oil high temperature has to be provided for.

3.10 Rudder angle indication

3.10.1 The rudder position must be clearly indicated in the wheelhouse and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle must be signalled by a device (rudder position indicator) which is actuated either by the rudder stock itself or by parts which are rigidly connected to it.

3.10.2 The rudder position at any moment must also be indicated at the steering gear itself.

3.11 Piping

3.11.1 The pipes of hydraulic steering gear systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

Pipes are to be installed at a sufficient distance from the vessel's shell. As far as possible, pipes should not pass through cargo spaces.

Pipes are to be so installed that they are free from stress and vibration.

3.11.2 The pipes of main and auxiliary steering gear systems are normally to be laid independently of each other. With the Society's consent, the joint use of pipes for the main and auxiliary steering gear systems may be permitted.

In such cases the design pressure for pipes and joints shall be 1,3 times the maximum permissible working pressure.

3.11.3 No other power consumers may be connected to the hydraulic steering gear drive unit. Where there are two independent drive units such a connection to one of the two systems is however acceptable if the consumers are connected to the return line and may be disconnected from the drive unit by means of an isolating device.

3.11.4 For the design and dimensions of pressure vessels, pipes, valves, fittings, etc., see Ch 1, Sec 3 and Ch 1, Sec 10.

3.12 Oil level indicators, filters

3.12.1 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

3.12.2 The lowest permissible oil level is to be alarmed.

3.12.3 Filters for cleaning the operating fluid are to be located in the piping system.

3.13 Arrangement

3.13.1 Steering gears are to be so installed that they are accessible at all times and can be maintained without difficulty.

4 Power and design

4.1 Power of steering gears

4.1.1 The power of the steering gear is governed by the requirements set out in [3.2] and [3.3]. The minimum requirement with regard to the maximum effective torque (M_{TR}), in N.m, for which the steering gear including piping is to be designed is to be calculated according to the following formula:

$$M_{TR} = \frac{d_T^{\,3}}{74 k_1}$$

For the determination of the pertinent working pressure (maximum pressure), the frictional losses in the steering gear including piping are to be considered.

The relief valves are to be set at this pressure value.

4.1.2 Electrical drive motors are also subject to the Rules for electrical installations, Ch 2, Sec 8, [1].

4.2 Design of transmission components

4.2.1 The design calculations for those parts of the steering gear which are not protected against overload are to be based on the elastic limit torque of the rudder stock. The elastic limit torque, in N.m, is:

$$M_F = \frac{26,6 d^3}{1000 k_1}$$

where, the value used for the minimum actual rudder stock diameter, d, need not be larger than $1,145 d_T$.

In the case of multi-surface rudders, the diameter of only one rudder stock, i.e. the largest, is to be taken into account.

The loads on the components of the steering gear determined in this way must be below the yield strength of the materials used. The design of parts of the steering gear with overload protection is to be based on the loads corresponding to the response threshold of the overload protection.

4.2.2 Tiller and rotary vane hubs

Tiller and rotary vane hubs made of material with tensile strength of up to 500 N/mm² must satisfy the following conditions in the area where the force is applied (see Fig 1).

Height of hub, in mm: $H_0 \geq d$

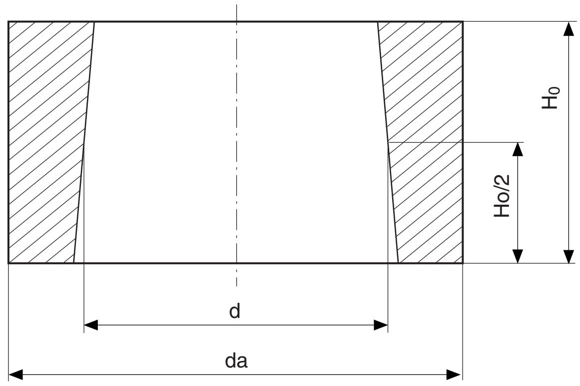
Outside diameter, in mm: $d_a \geq 1,8d$

In special cases the outer diameter may be reduced to:

$d_a \geq 1,7d$

but the height of the hub must then be at least: $H_0 \geq 1,145d$

Figure 1 : Hub dimensions



4.2.3 Tillers, tiller arms, quadrants and key ways

a) The scantling of the tiller is to be determined as follows:

the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value Z_b, in cm³, calculated from the following formula:

$$Z_b = \frac{0,147 d^3}{1000} \frac{L'}{L} \frac{R_e}{R'_e}$$

where:

L : Distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig 2)

L' : Distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig 2)

R_e : Value of the minimum specified yield strength of the material at ambient temperature, in N/mm²

R'_e : Design yield strength, in N/mm², determined by the following formulae:

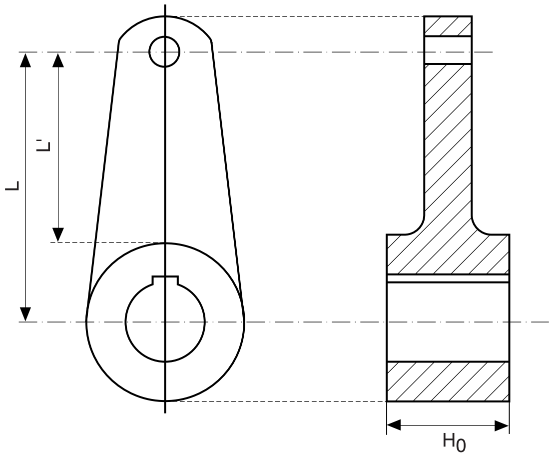
- $R'_e = R_e$, where $R \geq 1,4\ R_e$
- $R'_e = 0,417\ (R_e+R)$ where $R < 1,4\ R_e$

R : Value of the minimum specified tensile strength of the material at ambient temperature, in N/mm²

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 under [4.2.2].

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 2 : 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 should be designed according to the following provisions:

   - the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm²
   - the width of the key is not to be less than 0,25.d
   - the thickness of the key is not to be less than 0,10.d
   - the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5 per cent of the key thickness
   - The permissible surface pressure of the key and keyway should not exceed 90% of the materials yield strength.

4.2.4 Where materials with a tensile strength greater than 500 N/mm² are used, the section of the hub may be reduced by 10 %.

4.2.5 Where the force is transmitted by clamped or tapered connections, the elastic limit torque may be transmitted by a combination of frictional resistance and a positive locking mechanism using adequately tightened bolts and a key.

For the elastic limit torque according to formula given in [4.2.1], the thread root diameter, in mm, of the bolts can be determined by applying the following formula:

$$d_B = 9,76d\sqrt{\frac{1}{zR_{eH}k_1}}$$

where:

z : Total number of bolts

4.2.6 Split hubs of clamped joints must be joined together with at least four bolts.

The key is not to be located at the joint in the clamp.

5 Tests in the manufacturer’s work

5.1 Testing of power units

5.1.1 The power units are required to undergo test on a test stand. The relevant works test certificates are to be presented at the time of the final inspection of the steering gear.

For electric motors, see Ch 2, Sec 3.

Hydraulic pumps are to be subjected to pressure and operational tests. Where the drive power of the hydraulic pump is 50 kW or more, these tests are to be carried out in presence of a Society Surveyor.

5.2 Pressure and tightness tests

5.2.1 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 10.

Tightness tests are to be performed on components to which this is appropriate.

5.3 Final inspection and operational test

5.3.1 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 the Society Surveyor. The overload protection is to be adjusted at this time.

SECTION 12 LATERAL THRUST UNITS

1 General

1.1 Scope

1.1.1 The requirements of this Section apply to the lateral thrust unit, the control station and all the transmission elements from the control station to the lateral thrust unit.

1.2 Documents for review/approval

1.2.1 Assembly and sectional drawings together with detail drawings of the gear mechanism and propellers containing all the necessary data and calculations are to be submitted to the Society for review/approval.

2 Materials

2.1 General

2.1.1 Materials are subject, as appropriate, to the provisions of Ch 1, Sec 7, [2.1] and Ch 1, Sec 6, [2.1].

3 Thruster tunnel

3.1 Scantlings and arrangements

3.1.1 The scantlings and arrangements of the thruster tunnel are to be in compliance with Pt B, Ch 6, Sec 1, [7].

4 Machinery and systems

4.1 Dimensions and design

4.1.1 The dimensional design of the driving mechanisms of lateral thrust units is to be in compliance with Ch 1, Sec 6, [1].

The dimensional design of the propellers is to comply with Ch 1, Sec 8, [1].

The free end of the driving shaft from the non drive end bearing to the propeller is to be dimensionally designed as a propeller shaft in accordance with Ch 1, Sec 7, [1].

4.1.2 The pipes for drive systems of lateral thrust units are to be of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to danger, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

Hose lines comprise hoses and their fittings in a fully assembled and tested condition.

High pressure hose lines are to be used if necessary for flexible connections. These hose lines must meet the requirements of the Society Rules for Piping systems, Ch 1, Sec 10, or an equivalent standard. The hose lines must be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose lines are to be flame-resistant or to be protected correspondingly.

4.1.3 Lateral thrust units must be capable of being operated independently of other connected systems.

4.2 Steering thruster control

4.2.1 Controls for steering thrusters are to be provided from the wheelhouse, machinery control station and locally.

Means are to be provided to stop any running thruster at each of the control stations.

A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

5 Electrical installations

5.1 General

5.1.1 Electrical installations of lateral thrust units are to comply with Ch 2, Sec 8, [2].

5.2 Cables

5.2.1 The cables are to be intended to supply a short-time load for up to one hour service.

5.3 Auxiliary machinery

5.3.1 Thruster auxiliary plants

The thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

6 Test in the manufacturer's work

6.1 Testing of power units

6.1.1 The power units are required to undergo a test on a test stand. The relevant manufacturers test certificates are to be presented at the time of the final inspection of unit.

For electrical motors, see Rules for Rotating machines, in Ch 2, Sec 3, [2].

Hydraulic pumps are to be subjected to pressure and operational tests.

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 10.

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 lateral thrust unit is required to undergo final inspection and an operational test in the presence of the Society Surveyor. The overload protection is to be adjusted at this time.

SECTION 13 DOMESTIC GAS INSTALLATIONS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to permanently installed domestic liquefied gas installations on vessels.

1.1.2 Exceptions to these Rules are possible where they are permitted by the statutory Regulations in force in the area of service.

1.2 General provisions

1.2.1 On vessels intended to carry dangerous goods, liquefied gas installations are to comply also with applicable requirements of Pt D, Ch 3, Sec 1, [2.12], Pt D, Ch 3, Sec 8, [2.10] and Pt D, Ch 3, Sec 9, [2.8].

1.2.2 Liquefied gas installations consist essentially of a supply unit comprising one or more gas receptacles, and of one or more reducing valves, a distribution system and a number of gas-consuming appliances.

1.2.3 Such installations may be operated only with commercial propane.

1.3 Documents for review/approval

1.3.1 Diagrammatic drawings including following information, are to be submitted for review/approval by the Society:

- service pressure
- size and nature of materials for piping
- capacity and other technical characteristics for accessories
- generally, all information allowing the verification of the requirements of the present Section.

2 Gas installations

2.1 General

2.1.1 Liquefied gas installations shall be suitable throughout for use with propane and shall be built and installed in accordance with the state of the art.

2.1.2 A liquefied gas installation may be used only for domestic purposes in the accommodation and the wheelhouse, and for corresponding purposes on passenger vessels.

2.1.3 There may be a number of separate installations on board. A single installation may not be used to serve accommodation areas separated by a hold or a fixed tank.

2.1.4 No part of a liquefied gas installation shall be located in the engine room.

2.2 Gas receptacles

2.2.1 Only receptacles with an approved content of between 5 and 35 kg are permitted.

In principle, in the case of passenger vessels, the use of receptacles with a larger content may be approved

2.2.2 The gas receptacles must be permanently marked with the test pressure.

2.3 Supply unit

2.3.1 Supply units shall be installed on deck in a freestanding or wall cupboard located outside the accommodation area in a position such that it does not interfere with movement on board. They shall not, however, be installed against the fore or aft bulwark plating. The cupboard may be a wall cupboard set into the superstructure provided that it is gastight and can only be opened from outside the superstructure. It shall be so located that the distribution pipes leading to the gas consumption points are as short as possible.

2.3.2 No more receptacles may be in operation simultaneously than are necessary for the functioning of the installation. Several receptacles may be in operation only if an automatic reversing coupler is used. Up to four receptacles may be in operation per installation. The number of receptacles on board, including spare receptacles, shall not exceed six per installation.

2.3.3 Up to six receptacles may be in operation on passenger vessels with galleys or canteens for passengers. The number of receptacles on board, including spare receptacles, shall not exceed nine per installation.

2.3.4 The pressure reducer, or in the case of two-stage reduction the first pressure reducer, shall be fitted to a wall in the same cupboard as the receptacles.

2.3.5 Supply units shall be so installed that any leaking gas can escape from the cupboard into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition.

2.3.6 Cupboards shall be constructed of fire-resistant materials and shall be adequately ventilated by apertures in the top and bottom. Receptacles shall be placed upright in the cupboards in such a way that they cannot be overturned.

2.3.7 Cupboards shall be so built and placed that the temperature of the receptacles cannot exceed 50°C.

2.4 Pressure reducers

2.4.1 Gas-consuming appliances may be connected to receptacles only through a distribution system fitted with one or more reducing valves to bring the gas pressure down to the utilization pressure. The pressure may be reduced in one or two stages. All reducing valves shall be set permanently at a pressure determined in accordance with [2.5].

2.4.2 The final pressure reducers shall be either fitted with or immediately followed by a device to protect the pipe automatically against excess pressure in the event of a malfunctioning of the reducing valve. It shall be ensured that in the event of a breach in the airtight protection device any leaking gas can escape into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition; if necessary, a special pipe shall be fitted for this purpose.

2.4.3 The protection devices and vents shall be protected against the entry of water.

2.5 Pressure

2.5.1 Where two-stage reducing systems are used, the mean pressure shall be not more than 2,5 bar above atmospheric pressure.

2.5.2 The pressure at the outlet from the last pressure reducer shall be not more than 0,05 bar above atmospheric pressure, with a tolerance of 10 %.

2.6 Piping and flexible tubes

2.6.1 Pipes shall consist of fixed steel or copper tubing, in compliance with requirements of Ch 1, Sec 10.

However, pipes connecting with the receptacles shall be high-pressure flexible tubes or spiral tubes suitable for propane. Gas-consuming appliances may be connected by means of suitable flexible tubes not more than 1 m long.

2.6.2 Pipes shall be able to withstand any stresses or corrosive action which may occur under normal operating conditions on board and their characteristics and layout shall be such that they ensure a satisfactory flow of gas at the appropriate pressure to the gas-consuming appliances.

2.6.3 Pipes shall have as few joints as possible. Both pipes and joints shall be gastight and shall remain gastight despite any vibration or expansion to which they may be subjected.

2.6.4 Pipes shall be readily accessible, properly fixed and protected at every point where they might be subject to impact or friction, particularly where they pass through steel bulkheads or metal walls. The entire outer surface of steel pipes shall be treated against corrosion.

2.6.5 Flexible pipes and their joints shall be able to withstand any stresses which may occur under normal operating conditions on board. They shall be unencumbered and fitted in such a way that they cannot be heated excessively and can be inspected over their entire length.

2.7 Distribution system

2.7.1 It shall be possible to shut off the entire distribution system by means of a valve which is at all times easily and rapidly accessible.

2.7.2 Each gas-consuming appliance shall be supplied by a separate branch of the distribution system, and each branch shall be controlled by a separate closing device.

2.7.3 Valves shall be fitted at points where they are protected from the weather and from impact.

2.7.4 An inspection joint shall be fitted after each pressure reducer. It shall be ensured using a closing device that in pressure tests the pressure reducer is not exposed to the test pressure.

2.8 Gas-consuming appliances

2.8.1 The only appliances that may be installed are propane-consuming appliances equipped with devices that effectively prevent the escape of gas in the event of either the flame or the pilot light being extinguished.

2.8.2 Appliances shall be so placed and connected that they cannot overturn or be accidentally moved and as to avoid any risk of accidental wrenching of the connecting pipes.

2.8.3 Heating and water-heating appliances and refrigerators shall be connected to a duct for evacuating combustion gases into the open air.

2.8.4 The installation of gas-consuming appliances in the wheelhouse is permitted only if the wheelhouse is so constructed that no leaking gas can escape into the lower parts of the vessel, in particular through the control runs leading to the engine room.

2.8.5 Gas-consuming appliances may be installed in sleeping quarters only if combustion takes place independently of the air in the quarters.

2.8.6 Gas-consuming appliances in which combustion depends on the air in the rooms in which they are located shall be installed in rooms which are sufficiently large.

3 Ventilation system

3.1 General

3.1.1 In rooms containing gas-consuming appliances in which combustion depends on the ambient air, fresh air shall be supplied and combustion gases evacuated by means of ventilation apertures of adequate dimensions, with a clear section of at least 150 cm² per aperture.

3.1.2 Ventilation apertures shall not have any closing device and shall not lead to sleeping quarters.

3.1.3 Evacuation devices shall be so designed as to ensure the safe evacuation of combustion gases. They shall be reliable in operation and made of non-flammable materials. Their operation shall not be affected by the ventilators.

4 Tests and trials

4.1 Definition

4.1.1 A piping shall be considered gastight if, after sufficient time has elapsed for thermal balancing, no drop in the test pressure is noted during the following 10 minutes.

4.2 Testing conditions

4.2.1 The completed installation shall be subjected to tests defined in [4.2.2] to [4.2.8].

4.2.2 Medium-pressure pipes between the closing device, referred to in [2.8.4], of the first reducing device and the valves fitted before the final pressure reducer:

a) pressure test, carried out with air, an inert gas or a liquid at a pressure 20 bar above atmospheric pressure

b) gastightness test, carried out with air or an inert gas at a pressure 3,5 bar above atmospheric pressure.

4.2.3 Pipes at the utilization pressure between the closing device, referred to in [2.7.4], of the single pressure reducer or the final pressure reducer and the valves fitted before the gas-consuming appliances:

- tightness test, carried out with air or an inert gas at a pressure of 1 bar above atmospheric pressure.

4.2.4 Pipes situated between the closing device, referred to in [2.7.4], of the single pressure reducer or the final pressure reducer and the controls of the gas-consuming appliance:

- leak test at a pressure of 0,15 bar above atmospheric pressure.

4.2.5 In the tests referred to in sections [4.2.2](b), [4.2.3] and [4.2.4], the pipes are deemed gastight if, after sufficient time to allow for normal balancing, no fall in the test pressure is observed during the following 10 minutes.

4.2.6 Receptacle connectors, piping and other fittings subjected to the pressure in the receptacles, and joints between the reducing valve and the distribution pipe:

- tightness test, carried out with a foaming substance, at the operating pressure.

4.2.7 All gas-consuming appliances shall be brought into service and tested at the nominal pressure to ensure that combustion is satisfactory with the regulating knobs in the different positions.

Flame failure devices shall be checked to ensure that they operate satisfactorily.

4.2.8 After the test referred to in [4.2.7], it shall be verified, in respect of each gas-consuming appliance connected to a flue, whether, after five minutes operation at the nominal pressure, with windows and doors closed and the ventilation devices in operation, any combustion gases are escaping through the damper.

If there is a more than momentary escape of such gases, the cause shall immediately be detected and remedied. The appliance shall not be approved for use until all defects have been eliminated.

SECTION 14 FIRE PROTECTION, DETECTION AND EXTINCTION

1 General

1.1 Scope

1.1.1 These Rules apply to fire protection, fire detection and fire extinction equipment on all inland vessels.

1.1.2 For additional requirements on fire protection, fire detection and fire extinction on passenger vessels, see Pt D, Ch 1, Sec 6, [3].

1.1.3 For additional requirements on fire extinction on tankers, see Pt D, Ch 3, Sec 1, [4].

1.1.4 For additional requirements on fire extinction on dry cargo vessels carrying dangerous goods, see Pt D, Ch 3, Sec 1, [4].

1.1.5 Fire extinguishing systems not dealt with in these Rules are to be in compliance with other Society's Rules.

1.2 Approval

1.2.1 Hoses, nozzles, fire extinguishers, fire detection and alarm systems, fire protection equipment and extinguishing media must have been approved. Exceptions to the Rules compatible with the statutory Regulations of the vessel's country of registration may be agreed with the Society.

1.3 Documents for review / approval

1.3.1 Plans of the following equipment are to be submitted for review/approval by the Society, at least in triplicate, where applicable:

- general water fire extinguishing systems
- CO_2 extinguishing systems
- other gas fire extinguishing systems
- fire detection and alarm systems
- fire control plan.

  The plan shall clearly show for each deck the control stations, the various fire sections enclosed by class A and B divisions together with particulars of the fire detection and alarm systems, the sprinkler installation, if any, the fire extinguishing appliances, means of access to the different compartments and the ventilation system including the location of fire dampers and fan control positions.

1.4 Definitions

1.4.1 The term "Type Approval" is defined in Pt A, Ch 1, Sec 1, [1.2.13].

1.4.2 Non-combustible material

Non-combustible material is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C (see [1.4.3], Note 1).

Note 1: Reference is made to the Fire Test Procedure Code, Annex 1, Part 1, adopted by IMO by Resolution MSC.61 (67).

1.4.3 Low flame spread surface material

Low flame spread means that the surface thus described will adequately restrict the spread of flame (see [1.4.4], Note 1).

Note 1: Reference is made to the Fire Test Procedure Code, Annex 1, Part 5, adopted by IMO by Resolution MSC.61 (67).

1.4.4 Not readily ignitable material

Not readily ignitable materials means a material which will not give rise to smoke or toxic and explosive hazards at elevated temperatures (see [1.4.5], 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).

1.4.5 A-class divisions

A-class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

b) they are suitably stiffened

c) they are insulated with type approved 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-0 0 min

d) they are constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test (see [1.4.6], Note 1).

Note 1: Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61 (67).

1.4.6 B-class divisions

B-class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials used in the construction and erection of B-class divisions are non-combustible, with the exception that surface materials may have low flame spread characteristics

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature, within the time listed below:
   - class B-15 15 min
   - class B-0 0 min

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test (see [1.4.5], Note 1).

Note 1: Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61 (67).

2 Fire prevention

2.1 Installation of boilers

2.1.1 Auxiliary and domestic boilers are to be arranged in such a way that other equipment is not endangered, even in the event of overheating. They must, in particular, be placed as far away as possible from fuel tanks, lubricating oil tanks and hold bulkheads. Oiltight trays are to be located below oil-fired boilers.

2.2 Insulation of exhaust gas lines

2.2.1 See Ch 1, Sec 2, [6.4.1].

2.3 Emergency stops, remotely operated shutoff devices

2.3.1 Fuel pumps, thermal oil pumps, fan motors and boiler fans are to be equipped with emergency stops. The outlet valves of fuel service tanks must be fitted with remotely operated shutoff devices. Emergency stops and remotely operated shutoff devices must be capable of being operated from permanently accessible open deck and protected from unauthorized use.

2.4 Airtight seals

2.4.1 Means must be provided for the airtight sealing of boiler, engine and pump rooms. The air ducts to these spaces are to be fitted with closing appliances or equivalent devices made of non-combustible material which can be closed from the deck. Engine room skylights must also be able to be closed from outside.

3 Escapes

3.1 General

3.1.1 Every engine room shall be provided with two means of escape as widely separated as possible. One of the means of escape shall be an emergency exit. If a skylight is permitted as an escape, it must be possible to open it from the inside.

3.1.2 The escape trunk shall have clear dimensions of at least 0,6 x 0,6 m.

3.1.3 In case of engine rooms of less than 35 m^2 one means of escape may be accepted.

3.1.4 At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

4 Detection and alarm

4.1 General

4.1.1 Minimum numbers of detectors

Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in [4.3.2], at least one detector complying with [4.1.2] shall be installed in each such space.

4.1.2 Detector requirements

Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12,5 per cent obscuration per metre, but not until the smoke density exceeds 2 per cent obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

Heat detectors shall be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

At the discretion of the Society, the permissible temperature of operation of heat detectors may be increased to 30°C above the maximum deckhead temperature in drying rooms and similar spaces of a normal high ambient temperature.

All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

4.1.3 The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in the wheelhouse, the accommodation and the space to be protected.

4.2 Protection of machinery spaces

4.2.1 Installation

A fixed fire detection and fire alarm system shall be installed in any machinery space:

a) which is periodically unattended,

b) where the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space, or

c) where the main propulsion and associated machinery including sources of main electrical supply is provided with various degrees of automatic or remote control and is under continuous manned supervision from a control room.

For fire detecting system for unattended machinery spaces, see also Pt D, Ch 2, Sec 8.

4.2.2 Design

The fire detection system required in [4.2.1] shall be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors are not permitted.

4.3 Protection of accommodation and service spaces

4.3.1 Application

[4.3.2] applies to vessels of all types and [4.4] applies to cargo carriers.

4.3.2 Smoke detectors in stairways, corridors and escape route

Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

4.3.3 Accommodation and service spaces of cargo carriers shall be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler, fire detection and fire alarm system, depending on a protection method adopted.

5 Fire extinguishing

5.1 General water fire extinguishing system

5.1.1 Fire pumps

Self-propelled vessels are to be equipped with a power-driven pump suitable for use as a fire pump.

The capacity of the fire pump, acting through fire mains and hoses, must be sufficient to project at least one jet of water to any part of the vessel. This is to be based on a length of throw of 12 m from a 12 mm diameter nozzle.

The minimum pump capacity must be 10 m^3/h.

The pump must have a drive independent of the main propulsion unit. On vessels with a gross volume ($L \cdot B \cdot D$) of up to 800 m^3 or with a propulsive power of up to 350 kW, a bilge pump or cooling water pump coupled to the main engine may also be used provided that the propeller shafting can be disengaged.

Combined ballast pumps, bilge pumps or other pumps exclusively pumping water may be accepted as fire pumps and shall be connected to the fire main by means of a non return valve.

Fire pumps are to be located aft of the forward collision bulkhead.

Outboard connections for fire pumps are to be located as deep as possible. Pump suction must be safeguarded even in lightship condition.

5.1.2 Fire mains and hoses

Fire mains are to be so arranged that a water jet can at all times be projected to any part of the vessel through a single length of hose not exceeding 20 m. At least three hydrants are to be provided.

For vessels less than 40 m in length, at least two hydrants are to be provided.

Deck-washing lines may be incorporated in the fire extinguishing system.

Hoses must be able to be connected to the fire mains via fire hydrants and quick couplings.

At least two hoses with dual purpose nozzles are to be provided. These are to be stowed in hose boxes placed close to the hydrants.

Hose boxes are to be properly marked. Hose wrenches are to be provided in every hose box.

5.1.3 Water fire extinguishing systems for vessels without self-propulsion

Where a water fire extinguishing system is provided on a vessel without self-propulsion, the rules set out in [5.1.1] and [5.1.2] are to be applied as appropriate.

5.2 Portable fire extinguishers

5.2.1 Extinguishing media and weights of charge

Fire extinguishers must have been type approved, or approved by Authorities.

In the case of water and foam extinguishers, the charge shall not be less than 9,0 l and not more than 13,5 l.

The weight of the charge in dry powder extinguishers should be at least 6 kg. The maximum weight of a portable fire extinguisher ready for use shall not exceed 20 kg.

The extinguishing agent must be suitable at least for the class of fire most likely to occur in the space (or spaces) for which the fire extinguisher is intended. See Tab 1.

On vessels with electrical installations having an operating voltage greater than 50 V, the extinguishing agent must also be suitable for fighting fire in electrical equipment.

On motor vessels and vessels with oil-fired equipment, engine rooms and accommodation spaces are to be provided with dry powder extinguishers covering class A, B and C fires.

As extinguishing agent, fire extinguishers may contain neither CO_2 nor agents capable of emitting toxic gases in use.

Nevertheless, CO_2 extinguishers may be used for galleys and electrical installations.

Fire extinguishers with charges which are sensitive to frost or heat are to be mounted or protected in such a way that their effectiveness is guaranteed at all times.

Where fire extinguishers are mounted under cover, the covering must be properly marked.

Table 1 : Classification of extinguishing media

Fire class	Fire hazard	Extinguishing media
A	Solid combustible materials of organic nature (e.g. wood, coal, fibre materials)	Water, dry powder, foam
B	Flammable liquids (e.g. oils, tars, petrol)	Dry powder, foam, carbon dioxide
C	Gases (e.g. acetylene, propane)	Dry powder, carbon dioxide
D	Metals (e.g. aluminium, magnesium, sodium)	Special dry powder

5.2.2 Number of portable fire extinguishers

Portable fire extinguishers of appropriate types are to be provided as follows.

One portable fire extinguisher each is to be provided:

- in the wheelhouse
- at each entrance from the deck to accommodation areas
- at each entrance to spaces which are not accessible from the accommodation area and which contain heating, cooking or cooling equipment operated with solid or liquid fuels or with liquefied gas
- at each entrance to engine rooms
- at each entrance to spaces in which oil-fired auxiliary boilers or heating boilers are installed
- at each entrance to spaces in which materials presenting a fire hazard are stored.

  In the part of machinery spaces situated below deck and containing internal combustion engines, additional fire extinguishers are to be mounted in such a way that an extinguisher is accessible in the immediate vicinity of any part of the room.

The number of additional fire extinguishers shall be as indicated in Tab 2.

Table 2 : Portable fire extinguishers in machinery space

Total power, in kW	Number of fire extinguishers
Over 100 up to 375	1
up to 750	2
over 750	1 further extinguisher for each additional 750 kW or part thereof

5.3 Automatic pressure water spraying system (Sprinkler system)

5.3.1 General

Where fitted, automatic pressure water spraying system shall comply with the requirements of this Subarticle.

Alternative systems complying with recognized standards may, subject to approval, be accepted.

5.3.2 Pressure water tanks

Pressure water tanks are to be fitted with a safety valve, connected directly without valves to the water compartment, with a water level indicator that can be shut off and is protected against damage, and with a pressure gauge. Furthermore Ch 1, Sec 3 is to be applied.

The volume of the pressure water tank shall be equivalent to at least twice the specified pump delivery per minute.

The tank shall contain a standing charge of fresh water equivalent to at least the specified volume delivered by the pump in one minute.

The tank is to be fitted with a connection to enable the entire system to be refilled with fresh water.

The pressure water tank is to be installed in a frostproof space.

Means are to be provided for replenishing the air cushion in the pressure water tank.

5.3.3 Pressure water-spraying pumps

The pressure pumps may only be used for supplying water to the pressure water-spraying systems.

In the event of a pressure drop in the system, the pump shall start up automatically before the fresh water charge in the pressure water tank has been exhausted. Suitable means of testing are to be provided.

The capacity of the pump shall be sufficient to cover an area of at least 75 m^2 at the pressure required for the spray nozzles. At a rate of application of at least 5 $l/m^2 \cdot min$, this is equivalent to a minimum delivery rate of 375 l/min.

The pump is to be provided with a direct suction connection at the vessel's side. The shutoff device is to be secured in the open position. A suitable raw water filter is to be fitted, the mesh size of which is able to prevent coarse impurities from clogging the nozzles. The pump delivery is to be fitted with a test valve with connecting pipes, the cross-section of which is compatible with the pump capacity at the prescribed head.

5.3.4 Location

Pressure water tanks and pressure water pumps are to be located outside, and at a sufficient distance from, the rooms to be protected.

5.3.5 Water supply

The system shall be completely charged with fresh water when not in operation.

In addition to the water supply to the spraying equipment located outside the spaces to be protected, the system is also to be connected to the fire main via a screw-down non-return valve.

The equipment must be kept permanently under pressure and must be ready at all times for immediate, automatic operation. With the test valve at the alarm valve in the fully open position, the pressure at the level of the highest spray nozzles shall still be at least 1,75 bar.

5.3.6 Power supply

At least two mutually independent power sources shall be provided for supplying the pump and the automatic indicating and alarm systems. Each source shall be sufficient to power the equipment.

5.3.7 Piping, valves and fittings

Lines between suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in Ch 1, Sec 10, Tab 4. Lines shall be effectively protected against corrosion.

Check valves are to be fitted to ensure that raw water cannot penetrate into the pressure water tank nor water for fire extinguishing be discharged overboard through pump suction lines.

Hose connections are to be provided at suitable points on the port and starboard sides for supplying the equipment with water from the shore. The connecting valves are to be secured against being opened unintentionally.

Each line leading to a section of the system is to be equipped with an alarm valve (see also [5.3.9]).

Shutoff devices located between the pump delivery and the alarm valves are to be secured in the open position.

5.3.8 Spray nozzles

The spray nozzles are to be grouped into sections.

A sprinkler section may extend only over one main fire section or one watertight compartment and may not include more than two vertically adjacent decks.

The spray nozzles are to be so arranged in the upper deck area that a water volume of not less than 5 l/m² · min is sprayed over the area to be protected.

Inside accommodation and service spaces the spray nozzles shall be activated within a temperature range from 68°C to 79°C. This does not apply to spaces such as drying rooms with higher temperatures. Here the triggering temperature may be up to 30 °C above the maximum temperature in the deck head area.

The nozzles are to be made of corrosion-resistant material. Nozzles of galvanized steel are not allowed.

5.3.9 Indicating and alarm systems

Every spray nozzle section is to be equipped with an alarm valve which, when a nozzle is opened, actuates a visual and audible alarm at one or more suitable positions, at least one of which must 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 must be self-monitoring and must be capable of being tested separately for each section.

5.4 Fixed gas fire extinguishing systems

5.4.1 Application

Where fitted, fixed fire extinguishing systems for the engine room, boiler room, pump room and all spaces containing essential equipment (switchboards, compressors, etc.) for the refrigeration equipment, if any, are to comply with the requirements of this Subarticle.

5.4.2 Fire extinguishing systems, inert gas systems, CO_2 systems etc. are to be installed after agreement with the Society in accordance with the Society's Rules.

5.4.3 Extinguishing agents

The following extinguishing agents are permitted:

a) CO_2 (carbon dioxide)

b) HFC 227 ea (heptafluoropropane) (FM 200)

c) IG-541 (52% nitrogen, 40% argon, 8% carbon dioxide). (INERGEN)

d) FK-5-1-12 (dodecafluoro-2-methylpentan-3-one)

(NOVEC 1230)

Other extinguishing agents are permitted only on the basis of recommendations by the Society.

The fixed fire-extinguishing systems according to a) and d) here above shall be type approved by the Society (based on the requirements laid down in IMO MSC/Circ. 848).

If other extinguishing agents will be permitted, these fixed fire-extinguishing systems are to be type approved by the Society as well.

5.4.4 Ventilation, air extraction

a) The combustion air required by the combustion engines which ensure propulsion should not come from spaces protected by permanently fixed fire-extinguishing systems. This requirement is not mandatory if the vessel has two independent main engine rooms with a gastight separation or if, in addition to the main engine room, there is a separate engine room installed with a bow thruster that can independently ensure propulsion in the event of a fire in the main engine room.

b) All forced ventilation systems in the space to be protected shall be shut down automatically as soon as the fire-extinguishing system is activated.

c) All openings in the space to be protected which permit air to enter or gas to escape shall be fitted with devices enabling them to be closed quickly. It shall be clear whether they are open or closed.

d) Air escaping from the pressure-relief valves of the pressurised air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.

e) Overpressure or negative pressure caused by the diffusion of the extinguishing agent shall not destroy the constituent elements of the space to be protected. It shall be possible to ensure the safe equalization of pressure.

f) Protected spaces shall be provided with a means of extracting the extinguishing agent. If extraction devices are installed, it shall not be possible to start them up during extinguishing.

5.4.5 Piping system

a) The extinguishing agent shall be routed to and distributed in the space to be protected by means of a permanent piping system. Piping installed in the space to be protected and the reinforcements it incorporates shall be made of steel. This shall not apply to the connecting nozzles of tanks and compensators provided that the materials used are fire resistant. Piping shall be protected against corrosion both internally and externally.

b) The discharge nozzles shall be so arranged as to ensure the regular diffusion of the extinguishing agent. In particular, the extinguishing agent must also be effective beneath the floor.

c) The necessary pipes for conveying fire-extinguishing medium into protected spaces shall be provided with control valves so marked as to indicate clearly the space to which the pipes are led. Suitable provision shall be made to prevent inadvertent release of the medium into the space. Where a cargo space fitted with a gas fire-extinguishing system is used as a passenger space the gas connection shall be blanked during such use.

   The pipelines may pass through accommodation spaces providing they are of substantial thickness and their tightness is verified with a pressure test, after installation, at a pressure head not less than 5 MPa. In addition, pipelines passing through accommodation spaces are to be joined only by welding and are not to be fitted with drains or other openings within such spaces. The pipelines are not to pass through refrigerated spaces.

5.4.6 Triggering device

a) Automatically activated fire-extinguishing systems are not permitted.

b) It shall be possible to activate the fire-extinguishing system from outside the space to be protected.

c) Triggering devices shall be so installed that they can be activated in the event of a fire and so that the risk of their breakdown in the event of a fire or an explosion in the space to be protected is reduced as far as possible.

   Systems which are not mechanically activated shall be supplied from two energy sources independent of each other. These energy sources shall be located outside the space to be protected. The control lines located in the space to be protected shall be so designed as to remain capable of operating in the event of a fire for a minimum of 30 minutes. The electrical installations are deemed to meet this requirement if they conform to the IEC 60331-21:1999 standard.

   When the triggering devices are so placed as not to be visible, the component concealing them shall carry the "Fire-fighting system" symbol, each side being not less than 10 cm in length, with the following text in red letters on a white ground:

   Fire extinguishing system

d) If the fire-extinguishing system is intended to protect several spaces, it shall comprise a separate and clearly marked triggering device for each space.

e) The instructions shall be posted alongside all triggering devices and shall be clearly visible and indelible. The instructions are to be at least in a language the master can read and understand and if this language is not English, French or German, they are to be at least in English, French or German in addition.

   They shall include information concerning:

   1) the activation of the fire-extinguishing system
   2) the need to ensure that all persons have left the space to be protected
   3) the correct behaviour of the crew in the event of activation or diffusion, in particular in respect of the possible presence of toxic substances
   4) the correct behaviour of the crew in the event of the failure of the fire-extinguishing system to function properly.

f) The instructions shall mention that prior to the activation of the fire-extinguishing system, combustion engines installed in the space and aspirating air from the space to be protected shall be shut down.

5.4.7 Alarm device

a) Permanently fixed fire-extinguishing systems shall be fitted with an audible and visual alarm device.

b) The alarm device shall be set off automatically as soon as the fire-extinguishing system is first activated. The alarm device shall function for an appropriate period of time before the extinguishing agent is released; it shall not be possible to turn it off.

c) Alarm signals shall be clearly visible in the spaces to be protected and their access points and be clearly audible under operating conditions corresponding to the highest possible sound level. It shall be possible to distinguish them clearly from all other sound and visual signals in the space to be protected.

d) Sound alarms shall also be clearly audible in adjoining spaces, with the communicating doors shut, and under operating conditions corresponding to the highest possible sound level.

e) If the alarm device is not intrinsically protected against short circuits, broken wires and drops in voltage, it shall be possible to monitor its operation.

f) A sign with the following text in red letters on a white ground shall be clearly posted at the entrance to any space the extinguishing agent may reach:

WARNING, FIRE-EXTINGUISHING SYSTEM!

LEAVE THIS SPACE IMMEDIATELY WHEN THE ... (DESCRIPTION)

ALARM IS ACTIVATED!

5.4.8 Pressurized tanks, fittings and piping

a) Pressurized tanks, fittings and piping shall conform to the requirements of the competent authority.

b) Pressurized tanks shall be installed in accordance with the manufacturer's instructions.

c) Pressurized tanks, fittings and piping shall not be installed in the accommodation.

d) The temperature of cabinets and storage spaces for pressurized tanks shall not exceed 50°C.

e) Cabinets or storage spaces on deck shall be securely stowed and shall have vents so placed that in the event of a pressurized tank not being gastight, the escaping gas cannot penetrate into the vessel. Direct connections with other spaces are not permitted.

5.4.9 Quantity of extinguishing agent

If the quantity of extinguishing agent is intended for more than one space, the quantity of extinguishing agent available does not need to be greater than the quantity required for the largest of the spaces thus protected.

5.4.10 Fire extinguishing system operating with CO_2

In addition to the requirements contained in [5.4.2] to [5.4.9], fire-extinguishing systems using CO_2 as an extinguishing agent shall conform to the following provisions:

a) Tanks of CO_2 shall be placed in a gastight space or cabinet separated from other spaces. The doors of such storage spaces and cabinets shall open outwards; they shall be capable of being locked and shall carry on the outside the symbol "Warning: general danger", not less than 5 cm high and "CO_2" in the same colour and the same size

b) Storage cabinets or spaces for CO_2 tanks located below deck shall only be accessible from the outside. These spaces shall have a mechanical ventilation system with extractor hoods and shall be completely independent of the other ventilation systems on board.

The mechanical ventilation system shall be designed to take exhaust air from the bottom of the space and sized to provide at least 6 air changes per hour.

c) The level of filling of CO_2 tanks shall not exceed 0,75 kg/l. The volume of depressurised CO_2 shall be taken to be 0,56 m^3/kg

d) The concentration of CO_2 in the space to be protected shall be not less than 40% of the gross volume of the space. This quantity shall be released within 120 seconds. It shall be possible to monitor whether diffusion is proceeding correctly

Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire-extinguishing system, the Society shall require the provision of an additional quantity of fire-extinguishing medium.

The volume of starting air receivers, converted to free air volume, shall be added to the gross volume of the machinery space when calculating the necessary quantity of extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air

e) The opening of the tank valves and the opening of the directional valve shall correspond to two different operations

f) The appropriate period of time mentioned in [5.4.7] b shall be not less than 20 seconds. A reliable installation shall ensure the timing of the diffusion of CO_2.

5.4.11 Fire extinguishing system operating with HFC-227 ea (heptafluoropropane) - FM 200

In addition to the requirements of [5.4.2] to [5.4.9], fire extinguishing systems using HFC-227 ea as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire extinguishing system

b) Every tank containing HFC-227 ea placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service

c) Every tank shall be fitted with a device permitting control of the gas pressure

d) The level of filling of tanks shall not exceed 1,15 kg/l. The specific volume of depressurized HFC-227 ea shall be taken to be 0,1374 m3/kg

e) The concentration of HFC-227 ea in the space to be protected shall be not less than 8% of the gross volume of the space. This quantity shall be released within 10 seconds

f) Tanks of HFC-227 ea shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected

g) After discharge, the concentration in the space to be protected shall not exceed 10,5% (volume)

h) The fire-extinguishing system shall not comprise aluminium parts.

5.4.12 Fire extinguishing system operating with IG-541 (INERGEN)

In addition to the requirements of [5.4.2] to [5.4.9], fire extinguishing systems using IG-541 as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, every space shall be equipped with its own fire-extinguishing system

b) Every tank containing IG-541 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service

c) Each tank shall be fitted with a device for checking the contents

d) The filling pressure of the tanks shall not exceed 200 bar at a temperature of +15°C

e) The concentration of IG-541 in the space to be protected shall be not less than 44% and not more than 50% of the gross volume of the space. This quantity shall be released within 120 seconds.

5.4.13 Fire extinguishing system operating with FK-5-1-12 (NOVEC 1230)

In addition to the requirements of [5.4.2] to [5.4.9], fire extinguishing systems using FK-5-1-12 as an extinguishing agent shall conform to the following provisions:

a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system

b) Every tank containing FK-5-1-12 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall insure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service

c) Every tank shall be fitted with a device permitting control of the gas pressure

d) The level of filling of tanks shall not exceed 1,00 kg/l. The specific volume of depressurized FK-5-1-12 shall be taken to be 0,0719 m^3/kg

e) The concentration of FK-5-1-12 in the space to be protected shall be not less than 5,5% of the gross volume of the space. This quantity shall be released within 10 seconds

f) Tanks of FK-5-1-12 shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected

g) After discharge, the concentration in the space to be protected shall not exceed 10,0% (volume).

SECTION 15 TESTS ON BOARD

1 General

1.1 Application

1.1.1 This Section covers onboard tests, both at the moorings and during river trials. Such tests are additional to the workshop tests required in the other Sections of these Rules.

1.2 Purpose of onboard 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 in the presence of a Society 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 River trials

2.2.1 Scope of the tests

River trials are to be conducted after the trials at the moorings and are to include the following:

a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions

b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative

c) detection of dangerous vibrations by taking the necessary readings when required

d) checks either deemed necessary for vessel classification or requested by the interested parties and which are possible only in the course of navigation.

2.2.2 Exemptions

Exemption from some of the river trials may be considered by the Society in the case of vessels having a sistership for which the satisfactory behavior in service is demonstrated.

Such exemption is, in any event, to be agreed upon by the interested parties and is subject to the satisfactory results of trials at the moorings to verify the safe and efficient operation of the propulsion system.

3 Shipboard tests for machinery

3.1 Conditions of river trials

3.1.1 Displacement of the vessel

Except in cases of practical impossibility, or in other cases to be considered individually, the river trials are to be carried out at a displacement as close as possible to the deadweight (full load) or to one half of the deadweight (half load).

3.1.2 Power of the machinery

a) The power developed by the propulsion machinery in the course of the river trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been reviewed / approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.3 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the river trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by 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 manoeuvring tests

3.2.1 Speed trials

a) Where required, the speed of the vessel is to be determined using procedures deemed suitable by the Society.

b) The vessel speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.2.2 Astern trials

a) The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.

b) The stopping times, vessel headings and distances recorded on trials, together with the results of trials to determine the ability of vessels having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, shall be available on board for the use of the Master or designated personnel.

c) Where the vessel is provided with supplementary means for manoeuvring or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b).

3.3 Tests of diesel engines

3.3.1 General

a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, etc.

b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

3.3.2 Main propulsion engines driving fixed propellers

River trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 2 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 1 hours

c) operation at engine speed n = 1,032 n_0 for 30 minutes

d) operation at minimum load speed

e) starting and reversing manoeuvres

f) operation in reverse direction of propeller rotation at a minimum engine speed of n = 0,7 n_0 for 10 minutes

g) tests of the monitoring, alarm and safety systems

h) for engines fitted with independently driven blowers, emergency operation of the engine with the blowers inoperative.

Note 1: The test in c) is to be performed only where permitted by the engine adjustment.

Note 2: The test in f) may be performed during the dock or sea trials

3.3.3 Main propulsion engines driving controllable pitch propellers or reversing gears

a) The scope of the river trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of [3.3.1].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.4 Engines driving generators for propulsion

River trials of engines driving generators for propulsion are to include the following tests:

a) [operation at 100% power (rated power) for at least 2 hours]

b) [operation at normal continuous cruise power for at least 1 hours]

c) operation at 110% power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

e) starting manoeuvres

f) tests of the monitoring, alarm and safety systems.

Note 1: The test in d) may be performed during the dock or sea trials.

Note 2: 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 driven generators.

3.3.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 2 hours. During the test, the set concerned is required to operate at its rated power for at least 1 hours.

b) It is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account is to be taken of the times needed to actuate the generator overload protection system.

3.4 Tests of gears

3.4.1 Tests during river trials

During the river trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required
- test of the monitoring, alarm and safety systems.

3.4.2 Check of the tooth contact

a) Prior to the start of river trials, the teeth of the gears belonging to the main propulsion plant are to be coloured with suitable dye to enable the contact pattern to be established. During the river trials, the gears are to be checked at all forward and reverse speeds to establish their operational efficiency and smooth running as well as the bearing temperatures and the pureness of the lubricating oil. At latest on conclusion of the river trials, the gearing is to be examined via the inspection openings and the contact pattern checked. If possible the contact pattern has to be checked after conclusion of every load step. Assessment of the contact pattern is to be based on the guide values for the proportional area of contact in the axial and radial directions of the teeth given in Tab 1 and shall take account of the running time and loading of gears during the river trial.

b) In the case of multistage gear trains and planetary gears manufactured to a proven high degree of accuracy, checking of the contact pattern after river trials may, with the consent of the Society, be reduced in scope.

Table 1 : Percentage area of contact

Material Shaping of teeth	Working depth (without tip relief)	Width of tooth (without end relief)
heat-treated,hobbed, formed by generating method	33% average values	70%
surface-hardened, ground, shaved	40% average values	80%

3.5 Tests of main propulsion shafting and propellers

3.5.1 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by Ch 1, Sec 9, [1]. The type of the measuring equipment and the location of the measurement points are to be specified.

3.5.2 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.2]

3.5.3 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.5.4 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations is to be tested during the sea trials.

3.6 Tests of piping systems

3.6.1 Functional tests

During the river trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

3.6.2 Performance tests

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 river trials under the conditions stated in [3.1] in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of Ch 1, Sec 11 are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

c) If the vessel cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by the Society. In such case, the vessel speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.7.2 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 Ch 1, Sec 11, [3.2] and Ch 1, Sec 11, [3.3]

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the isolation of one power actuating system, checking the time for regaining steering capability

d) test of the hydraulic fluid refilling system

e) test of the alternative power supply required by Ch 1, Sec 11, [3.4]

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the river trials.

Note 2: For vessels of less than 500 tons gross tonnage, 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.

3.8 Tests of windlasses

3.8.1 The working test of the windlass is to be carried out in the presence of a Surveyor.

3.8.2 The anchor equipment is to be tested during river trials. As a minimum requirement, this test is required to demonstrate that the conditions specified in Ch 1, Sec 5, [3.13] can be fulfilled.

4 Inspection of machinery after river trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the river trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

   Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to the Society 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 river trials.

Part C
Machinery, Systems and Electricity

Chapter 2
ELECTRICAL INSTALLATIONS

SECTION 1 GENERAL

1 General

1.1 Scope

1.1.1 These construction Rules apply to electrical installations aboard inland vessels as well as on other water craft and floating gear on inland waters. The Society reserves the right to authorize departures from these Rules in individual cases or to stipulate special requirements for new types of installation or operating equipment.

1.2 Rules and standards

1.2.1 Besides these Rules, electrical equipment shall meet a standard approved by the Society, such as IEC and EN.

1.3 Basic requirements

1.3.1 All electrical machinery, appliances, cables and accessories are to be selected, designed and constructed for satisfactory performance under the conditions stated in Tab 1 and Tab 2.

Where other conditions are likely (e.g. in the case of inland vessels for non-European waters) proper account shall be taken of these.

1.3.2 All the electrical appliances used on board shall be so designed and constructed that they remain serviceable despite the voltage and frequency variations occurring in normal shipboard service. Unless otherwise specified, considerations may be based on the variations shown in Tab 3.

Networks or sub-networks with greater voltage variations may be approved for consumers intended for operation with greater variations.

Table 1 : Permanent inclination of vessel

Installations, components	Angle of inclination (degrees) **(1)**	
	Athwartship	Fore and aft
Main and auxiliary machinery **(2)**	12	5

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) Higher angle values may be required depending on vessel operating conditions

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +40 (+45 in tropical zone) **(1)**
On machinery components, boilers In spaces subject to higher or lower temperatures	According to specific local conditions
On exposed decks	between -20 and +40 (+45 in tropical zone)

WATER TEMPERATURE	
Coolant	Temperature (°C)
River water or, if applicable, river water at charge air coolant inlet	up to +25 in general up to +32 in tropical zone

(1) Different temperatures may be accepted by the Society in the case of vessels intended for restricted service.

Table 3 : Voltage and frequency variations

	Variable	Variations	
		Permanent	Transient
General	Frequency Voltage	± 5% + 6% - 10%	± 10% 5s ± 20% 1,5s
Battery operation	Voltage	± 20%	-

1.3.3 In equipment with electronic frequency converters, the voltage waveform may deviate from that specified in Ch 2, Sec 2, [5.2.1] provided that measures are taken to ensure that this does not interfere with the operation of consumers or other equipment such as radio and navigation facilities.

If necessary, converters or similar means should be used for separation from the mains.

The total harmonic distortion shall be less than or equal to 5%.

1.3.4 Electrical machines and appliances shall be so constructed and installed that they will not be damaged by the vibrations and shaking occurring in normal shipboard service.

The natural frequences of foundations, fastenings and suspensions for machines, appliances and electrical components (including those inside appliances) shall not lie within the frequency range 5 - 100 Hz.

If, for reasons of design, the natural frequency has unavoidably to lie within the aforementioned frequency range, the accelerations are to be sufficiently damped to exclude the likelihood of malfunctions or damage.

1.3.5 The materials used for the construction of electrical machines, cables and appliances shall be resistant to moist air and oil vapours. They shall not be hygroscopic and shall be flame-retardant. The dimensions of minimum creep distances and air clearances are to conform to IEC 60664-1 or EN 60664-1. Relaxations may be allowed for installations up to 50 V.

1.4 Protective measures

1.4.1 Protection against shock and water

The type of protection or enclosure of every machine and every other item of equipment shall be compatible with the site where it is installed. The particulars in Tab 4 are minimum requirements.

1.4.2 Protection against electric shock: direct contact

Protection against direct contact includes all the measures designed to protect persons against the dangers arising from contact with live parts of electrical appliances. Live parts are deemed to be conductors and conductive parts of appliances which are live under normal operating conditions.

Electrical appliances shall be so designed that the person cannot touch or come dangerously close to live parts, in way of the determined operation.

Protection against direct contact may be dispensed with in the case of equipment using safety voltage.

In service spaces, live parts of the electrical appliances shall remain protected against accidental contact when doors and covers which can be opened without a key or tool are opened for operation purposes.

1.4.3 Protection against electric shock: indirect contact

Electrical appliances shall be made in such a way that persons are protected against dangerous contact voltages even in the event of an insulation failure.

For this purpose, the construction of the appliances shall incorporate one of the following protective measures:

- Protective earthing (see [1.4.4])
- Protective insulation (double insulation)
- Operation at very low voltages presenting no danger even in the event of a fault.

The additional usage of Residual Current Protective Devices is allowed except for steering and propulsion plant.

1.4.4 Protective earthing

Metal casings and all metal parts accessible to touch which are not live in normal operation but may become so in the event of a fault are to be earthed except where their mounting already provides a conductive connection to the vessel's hull.

Table 4 : Minimum degrees of protection

Type of space	Minimum type of protection (in accordance with IEC Publication 60529)							
	Generators	Motors	Transformers	Switchboards, consoles, distribution boards	Measuring instruments	Switchgear	Installation material	Lamp fittings
Service spaces, machinery and steering gear spaces	IP 22	IP 22	IP 22	IP 22 **(1)**, **(4)**	IP 22	IP 22 **(1)**, **(4)**	IP 44	IP 22
Refrigerated holds		IP 44		IP 44		IP 44	IP 55	IP 55
Cargo holds		IP 55		IP 55		IP 55	IP 55	IP 55
Storage battery, paint storage and lamp room								IP 44 **(5)** and (EX)
Ventilating trunks(deck)		IP 44					IP 55	
Exposed deck, steering stations on open deck		IP 55 **(3)**		IP 55 **(3)**	IP 55 **(3)**	IP 55 **(3)**	IP 55 **(3)**	IP 55
Closed wheelhouse		IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
Accommodation and public rooms				IP 22			IP 20 IP 55 **(2)**	IP 20
Sanitary facilities and commissary spaces		IP 44	IP 44	IP 44			IP 55	IP 44

(1) IP 12 for appliances generating a large amount of heat.
(2) Where laid behind ceiling.
(3) IP 56 for appliances subject to flooding.
(4) Where the class of protection is not provided by the appliance itself, the site at which it is installed must have the level of protection stated in the Table.
(5) Electrical appliance of certified safety, e.g. in accordance with IEC Publication 60079 or EN 50014-50020.

Special earthing may be dispensed with in the case of:

a) metal parts insulated by a non-conductor from the dead or earthed parts

b) bearings of electrical machines which are insulated to prevent currents flowing between them and the shaft

c) electrical equipment whose service voltage does not exceed 50 V.

Where machines and equipment are earthed to the hull via their mountings, care is to be taken to ensure good conductivity by clean metal contact faces at the mounting. Where the stipulated earth is not provided via the mountings of machinery and equipment, a special earthing conductor is to be fitted for this purpose.

For the earthing of metal sheaths, armouring and cable braiding, see Ch 2, Sec 12, [15.1.4].

Protection shall be provided by an additional cable, an additional lead or an additional core in the power cable.

Metal cable armouring may not be used as an earthing conductor.

A conductor normally carrying current may not be used simultaneously as an earthing conductor and may not be connected with the latter by a common connection to the vessel's hull.

The cross-section of the earthing conductor shall be at least in accordance with Tab 5.

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 5 : Cross-section of earthing conductors

Cross-section of main conductors, in mm^2	Minimum cross-section of earthing conductor	
	Earthing conductor incorporated in the cable, in mm^2	Earthing conductor separated from the cable, in mm^2
0,5 up to 4	Equal to the main conductor	4
> 4 up to 16	Equal to the main conductor	Equal to the main conductor
> 16 up to 35	16	16
> 35 up to 120	Equal to the half main conductor	Equal to the half main conductor
> 120	70	70

1.4.5 Explosion protection: hazardous areas, zone 0

These areas include for instance the insides of tanks and piping with a combustible liquid with a flash point ≤ 60°C, or inflammable gases.

For electrical installations in these areas the permitted equipment that may be fitted is:

- Intrinsically safe circuits Ex ia
- Equipment specially approved for use in this zone by a test organisation recognised by the Society.

1.4.6 Explosion protection: hazardous areas, zone1

These areas include e.g.:

- paint rooms
- storage battery rooms
- areas with machinery, tanks or piping for fuels with a flash point below 60°C, or inflammable gases, see [1.4.10]
- ventilation trunks.

Areas subject to explosion hazard zone 1 also include tanks, vessels, heaters, pipelines etc. for liquids or fuels with a flash point over 60°C, if these liquids are heated to a temperature higher than 10°C below their flash point.

Electrical equipment shall not be installed or operated in areas subject to explosion hazard, with the exception of explosion-protected equipment of a type suitable for shipboard use. Electrical equipment is deemed to be explosion-protected, if they are manufactured to a recognized standard such as IEC 60079 publications or EN 50014-50020, and if they have been tested and approved by a testing authority recognized by the Society. Notes and restrictions at the certificate have to be observed.

Certified safe type equipment listed in Tab 6 is permitted.

Cables in hazardous areas zone 0 and 1 shall be armoured or screened, or run inside a metal tube.

Table 6 : Certified safe type equipment

intrinsic safety	Ex i
flameproof enclosure	Ex d
pressurized apparatus	Ex p
increased safety	Ex e
special type of protection	Ex s
oil immersion	Ex o
encapsulation	Ex m
sand filled	Ex q

1.4.7 Explosion protection: extended hazardous areas, zone 2

Areas directly adjoining Zone 1 lacking gastight separation from one another are allocated to Zone 2.

For equipment in these areas protective measures are to be taken which, depending on the type and purpose of the facility, could comprise e.g.:

- use of explosion-protected facilities, or
- use of facilities with type Ex n protection, or

- use of facilities which in operation do not cause any sparks and whose surfaces, which are accessible to the open air, do not attain any unacceptable temperatures, or
- facilities which in a simplified way are overpressure-encapsulated or are fumetight-encapsulated (minimum protection type IP 55) and whose surfaces do not attain any unacceptable temperatures.

1.4.8 Explosion protection: electrical equipment in paint rooms

In the above-mentioned rooms (Zone 1) and in ventilation ducts supplying and exhausting these areas, electrical equipment shall be of certified type as defined in [1.4.6] and comply at least with II B, T3.

Switches, protective devices and motor switchgear for electrical equipment in these areas shall be of all-poles switchable type and shall preferably be fitted in the safe area.

Doors to paint rooms have to be gastight with self-closing devices without holding back means.

1.4.9 Protective measures in the case of ignitable dust

Only lighting fittings with IP 55 protection, as a minimum requirement, may be used in areas where ignitable dusts may be deposited.

In continuous service, the surface temperature of horizontal surfaces and surfaces inclined up to 60° to the horizontal shall be at least 75 K below the glow temperature of a 5 mm thick layer of the dust.

1.4.10 Explosion protection: Pipe tunnels

All equipment and devices in pipe tunnels containing fuel lines or adjoining fuel tanks shall be permanently installed irrespective of the flash point of the fuels. Where pipe tunnels directly adjoin tanks containing combustible liquids with a flash point below 60°C, e.g. in ore or oil carriers, or where pipes inside these tunnels convey combustible liquids with a flash point below 60°C, all the equipment and devices in pipe tunnels shall be certified explosion-protected in accordance with [1.4.6] (zone 1).

1.4.11 Amount of electrical facilities

Amount and ignition protection of approved electrical equipment in zones 0,1 and 2 may be restricted in the different areas where they are used. The relevant current construction Rules have to be observed for this reason.

1.4.12 Explosion protection for vessels for the carriage of dangerous goods

Regarding hazardous areas and approved electrical equipment on vessels for the carriage of dangerous goods, see Part D, Chapter 3.

1.4.13 Batteries room

See Ch 2, Sec 5.

1.4.14 Electromagnetic compatibility (EMC)

Where necessary, appropriate measures shall be taken to avoid interference due to electromagnetic energy.

This applies especially to radio equipment and electronic appliances (e.g. self-steering gear for river navigation).

Details are contained in IEC 60533.

1.5 Essential services

1.5.1 Essential services are defined in Pt A, Ch 1, Sec 1, [1.1.16]. They are subdivided in primary and secondary essential services.

1.5.2 Primary essential services

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

Examples of equipment for primary essential services are the following:

- Steering gear
- Actuating systems for controllable pitch propellers
- Scavenging air blowers, fuel oil supply pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for the propulsion
- Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps
- Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- Electric generators and associated power sources supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety devices/systems for equipment for primary essential services
- Speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion.

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

1.5.3 Secondary essential services

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

Examples of equipment for secondary essential services are the following:

- Thrusters
- Starting air and control air compressors
- Bilge pumps
- Fire pumps and other fire-extinguishing medium pumps
- Ventilation fans for engine rooms
- Services considered necessary to maintain dangerous cargo in a safe condition
- Navigation lights, aids and signals
- Internal safety communication equipment
- Fire detection and alarm systems
- Electrical equipment for watertight closing appliances
- Electric generators and associated power supplying the above equipment

- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety for cargo containment systems
- Control, monitoring and safety devices/systems for equipment for secondary essential services.

2 Documents for review/approval

2.1 New buildings

2.1.1 The drawings and documents listed below are to be submitted to the Society, at least, in triplicate for review/approval in sufficiently good time to enable them to be reviewed/approved and made available to the Building Yard and the Surveyor by the time the manufacture or installation of the electrical equipment begins.

Where non-standard symbols are used in circuit and wiring diagrams, a legend explaining the symbols is to be provided.

All documents for review/approval shall bear the yard number and the name of the shipbuilder.

The Society reserves the right to call for additional documents and drawings should those stipulated in [2.1.2] to [2.1.8] prove insufficient for an assessment of the plant.

2.1.2 Details of the nature and extent of the electrical installations including the power balance (electrical balance).

2.1.3 A general circuit diagram of the electrical plant showing the basic configuration of the power distribution system with details of the power ratings of generators, converters, transformers, storage batteries and all major consumers.

2.1.4 Cable layout or tabulated list of cables showing cable sections and types as well as generator and consumer loads (currents).

2.1.5 Circuit diagrams for:

- main switchgear installations
- emergency switchgear installations (where applicable)
- spaces with an explosion hazard with details of installed equipment
- lighting system
- navigation light system
- electrical propulsion plants, where applicable.

2.1.6 Circuit diagrams of control, alarm and monitoring installations, where applicable, such as:

- alarm systems
- fire alarm systems
- tank level indicators, alarms, shut-off facilities
- gas detector systems
- emergency shut-off facilities
- watertight door control systems
- computer systems
- communication systems
- propulsion system.

2.1.7 Steering gear circuit diagrams with details of the drive, control and monitoring systems. The steering gear includes lateral thrust propellers, active rudder equipment etc.

2.1.8 Installation plan

The plan is to provide details of the exact location of the switchboard, the size of service passageways, distances from bulkheads and frames etc.

3 Systems, Voltages and Frequencies

3.1 Systems

3.1.1 As a general principle, systems listed in [3.1.2] to [3.1.4] are permitted.

3.1.2 For direct current and single-phase alternating current:

a) 2 conductors, one of which is earthed

b) Single conductors with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)

c) 2 conductors insulated from the vessel's hull.

3.1.3 For 3-phase alternating current:

a) 4 conductors with earthed neutral and no hull return

b) 3 conductors insulated from the hull

c) 3 conductors with hull as neutral conductor, however, not in final subcircuits.

3.1.4 Other systems have to be approved by the Society in each case.

3.1.5 Special rules

Systems using the hull as neutral conductor are not permitted:

a) on tankers (see Pt D, Ch 3, Sec 3, [4] and Pt D, Ch 3, Sec 2, [5])

b) on floating craft or vessels whose hull can be dismantled.

The power supply lines from one barge to another in pusher tug trains shall be insulated on all poles.

3.2 Voltage and frequencies

3.2.1 Standard voltages

The use of standard voltages and frequencies is recommended.

Generators may have rated voltages up to 5 % higher than the rated voltage of the consumers.

3.2.2 Operating voltages

The operating voltages indicated in Tab 7 may not be exceeded.

In special installations (e.g. radio equipment and ignition equipment) higher voltages are permitted subject to compliance with the necessary safety measures.

4 Type approvals

4.1 General

4.1.1 The installations, equipment and assemblies mentioned in [4.1.5] are subject to mandatory type approval.

4.1.2 Type tests shall be carried out in the presence of Society's Surveyor 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 shall be used within the scope of valid construction Rules only. The suitability for the subject application shall be ensured.

4.1.5 Installations, apparatuses and assemblies subject to type testing

Following installations, apparatuses and assemblies are subject to type testing:

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 Requirement Class 3 and higher

g) Cables and insulated wires

4.2 Exceptions

4.2.1 Instead of the stipulated type approvals in well-founded cases routine tests in the presence of a Surveyor may be carried out. An agreement with the Society prior to testing is required.

Table 7 : Maximum permissible operating voltages

Type of installation	Maximum permissible operating voltage		
	DC	1-phase AC	3-phase AC
Power and heating installations including the relevant sockets	250 V	250 V	500 V
Lighting, communications, command and information installations including the relevant sockets	250 V	250 V	-
Sockets intended to supply portable devices used on open decks or within narrow or damp metal lockers, apart from boilers and tanks: • In general • Where a protective circuit-separation transformer only supplies one appliance • Where protective-insulation (double insulation) appliances are used • Where ≤ 30 mA default current circuit breakers are used.	 50 V **(1)** - 250 V -	 50 V **(1)** 250 V **(2)** 250 V 250 V	 - - - 500 V
Mobile power consumers such as electrical equipment for containers, motors, blowers and mobile pumps which are not normally moved during service and whose conducting parts which are open to physical contact are grounded by means of a grounding conductor that is incorporated into the connecting cable and which, in addition to that grounding conductor, are connected to the hull by their specific positioning or by an additional conductor	250 V	250 V	500 V
Sockets intended to supply portable appliances used inside boilers and tanks	50 V **(1)**	50 V **(1)**	-

(1) Where that voltage comes from higher voltage networks galvanic separation shall be used (safety transformer).
(2) All of the poles of the secondary circuit shall be insulated from the ground.

SECTION 2 DESIGN AND CONSTRUCTION OF POWER GENERATING PLANT

1 General requirements

1.1

1.1.1 Every power supply system on inland vessels shall comprise at least one main and one auxiliary power source.

2 Power source

2.1 Design

2.1.1 The power source may take the form of:

a) Two diesel sets

Special restrictions for the supply of steering gear systems see Ch 2, Sec 8, [1.4.8].

b) One diesel set and one power supply battery (in accordance with c).

c) One generator driven by the main propulsion unit (shaft generator) is accepted as a main source provided a power supply battery is installed as the auxiliary source.

This design may be accepted if, in all sailing and manoeuvring conditions, including propeller being stopped, this generator is not less effective and reliable than an independent generating set.

The power supply battery shall be capable of supplying essential consumers for at least 30 minutes automatically and without intermediate recharging.

It shall be possible to recharge the battery with the means available on board even when the main engine is stationary, e.g. by using charging generators (lighting dynamos) driven by auxiliary machinery or by shore power via a battery charger.

d) Other energy generating systems can be permitted by the Society.

3 Power balance

3.1 Power requirements

3.1.1 A power balance for the electrical plant shall be furnished as proof that the generator rating is sufficient.

The power requirements are to be determined for day/night running service and emergency supply, if any.

A table is to be compiled listing all the installed electrical consumers together with their individual power ratings:

a) Account is to be taken of the full power rating of those consumers permanently required for the operation of the vessel.

b) The installed capacity of consumers kept in reserve is to be listed. The consumption of those consumers which operate only following the failure of a unit of the same kind need not be included in the calculation.

c) The aggregate power consumption of all consumers intermittently connected to the supply is to be multiplied by a common simultaneity factor and the result added to the sum of the permanently connected consumers.

The simultaneity factor may be applied only once in the course of the calculation.

Consumers with a relatively high power consumption, such as the drive units of bow thrusters, are to be included in the calculation at their full rating even though they may be used only intermittently.

The sum of the loads represented by a) and c), with due allowance for the battery charging capacity, is to be used when deciding the generator rating.

Unless some other standby capacity such as a floating battery is available, some spare capacity is to be designed into the system to cover short-lived peak loads like those caused by the automatic start-up of large motors.

4 Emergency power source on passenger vessels

4.1 General

4.1.1 For emergency power source on passenger vessels, see Pt D, Ch 1, Sec 6, [4.3].

5 Generator ratings control

5.1 DC generators

5.1.1 The following may be used to supply DC shipboard networks:

- Regulated single or 3-phase AC generators connected to a rectifier
- Compound-wound generators
- Shunt generators with automatic voltage regulator.

5.1.2 Generators shall be designed so that, even with the battery disconnected, their voltage characteristic and harmonic content remain within the prescribed limits over the whole load range and they themselves suffer no damage.

They should be so designed that a short circuit at the terminals produces a current not less than three times the rated current. They shall be able to withstand the sustained short-circuit current for 1 second without suffering damage. Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the vessel's network is assured at even lower sustained short-circuit currents, possibly in conjunction with a parallel-connected power supply battery.

The regulator characteristic of the generators shall ensure that connected power supply batteries are without fail fully charged over the whole load range and overcharging is avoided.

5.2 Single and 3-phase AC generators

5.2.1 Generator design

The apparent output of 3-phase generators shall be rated such that no unacceptable voltage dips occur in the shipboard supply as a result of the starting currents affecting normal operation. On no account may the start-up of the motor with the greatest starting current give rise to an undervoltage causing consumers already in service to cut out.

The waveform of the no-load phase-to-phase voltage should be sinusoidal as far as possible. The deviation from the sinusoidal fundamental wave should at no time be greater than 5 % in relation to the peak value of the fundamental wave.

The root-mean-square (r.m.s.) values of the phase voltage with symmetrical loading shall not vary from each other by more than 0,5%.

If the neutral points of generators running in parallel are connected, the waveforms of the phase voltages should coincide as nearly as possible. The use of generators of the same type is recommended. As a general principle, it is necessary to ensure that the equalizing current determined by the harmonic content does not exceed 20% of the rated current of the machine with the lowest capacity.

The generators and their exciters are to be so designed that for two minutes the generator can be loaded with 150% of its rated current with an inductive power factor of 0,5 while approximately maintaining the rated voltage. Generators may suffer no damage as a result of a short-circuit and the short circuits which may occur in the supply network in later service. The design shall take account of the short time delay of the generator switches which is necessary to the selectivity of the system and during which the short-circuit current is sustained.

With voltage-regulated generators it is necessary to ensure that an input data failure cannot lead to unacceptable high terminal voltages.

5.2.2 Conditions

Under balanced load conditions, 3-phase alternators and their exciters are required to meet the following conditions:

a) Steady conditions

When the alternator is operated with the associated prime mover, the voltage shall not deviate from the rated value by more than ± 2,5% from no-load up to the rated output and at the rated power factor after the transient reactions have ceased. For this purpose the prime mover shall be set to its rated speed at rated output.

b) Transient control conditions

With the generator running at rated speed and rated voltage, the voltage shall not deviate below 85% or above 120% of its rated value as the result of the sudden connection or disconnection of balanced loads with a specified current and power factor. It shall regulate within the limits stated in a) in not more than 1,5 seconds. Under test conditions, the generator may in this connection be driven at practically constant speed, e.g. by a suitable electric motor.

Unless the client specifies particular load changes, the above requirements are to be satisfied under the following conditions:

The idling generator, excited to its rated voltage, is to be suddenly connected to a load equal to 60% of its rated current with a (lagging) power factor not greater than 0,4. Once steady-state control conditions have been attained, the load is to be suddenly disconnected.

c) Sustained short-circuit current

The sustained short-circuit current at a single, two or 3-phase terminal short shall not be less than three times the rated current. The generator and its exciter shall be able to carry the sustained short-circuit current for a period of one second without suffering damage.

Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the vessel’s network is assured at even lower sustained short-circuit currents.

5.2.3 Three-phase AC generators for parallel operation

Where generators of the same output are run in parallel with the active load shared equally, the reactive power of each machine shall not deviate from its percentage share by more than 10% relative to its rated reactive power.

Where the generators differ in output, the deviation from the proportional share within the aforementioned load range shall not exceed the smaller of the following values, assuming proportionally equal sharing of the active load:

a) 10% of the rated reactive power of the largest machine

b) 25% of the rated reactive power of the smallest machine.

6 Generator prime movers

6.1 Design and control

6.1.1 The design and control of generator prime movers are to conform to Ch 1, Sec 2, construction Rules for Machinery.

6.2 Parallel operation

6.2.1 The governing characteristics of prime movers in the case of single or 3-phase alternator sets of the same output operating in parallel shall ensure that, over the range from 20% to 100% of the total active power, the share of each machine does not deviate from its proportionate share by more than 15% of its rated active power.

Where the units are differently rated, the deviation from the proportionate share within the load range stated shall not exceed the lesser of the following values:

a) 15% of the rated active power of the largest machine

b) 25% of the rated active power of the smallest machine.

6.3 Cyclic irregularity

6.3.1 The permissible cyclic irregularity is to be agreed upon between the prime mover and generator manufacturers. The following has to be ensured:

a) Faultless parallel operation of 3-phase generators

b) Regular or irregular load variations shall not give rise to fluctuations in active power output exceeding 10% of the rated output of the machine concerned

c) Practically non-flicker lighting at all working speeds.

7 Special rules

7.1 General

7.1.1 Notwithstanding the conditions set out above, other speed and control characteristics may be approved for generators with outputs of up to 10 kW (kVA) provided that troublefree operation remains assured.

Where generators are backed up by floating batteries it is necessary to ensure that the absence of the battery voltage cannot damage the generators and controllers.

SECTION 3 ELECTRICAL MACHINES

1 Construction

1.1 General

1.1.1 Unless otherwise stated in the following Rules, all motors and generators shall conform to a standard accepted by the Society.

1.1.2 In conjunction with the protective equipment to be provided, generators shall be capable of withstanding the dynamic and thermal stresses produced by a short circuit. All machines are to be so designed and constructed that the permissible temperature rises stated in Tab 1 are not exceeded.

The insulation classes have to correspond to the ratings IEC 60085.

In the case of laminated insulations, the highest temperature permitted for each individual insulating material shall not be exceeded.

All windings shall be effectively protected against the effects of moist or salty air and oil vapours.

On DC machines, the commutating pole windings are to be connected symmetrically to the armature, wherever possible. Anti-interference capacitors are to be connected directly to the armature terminals. Anti-interference capacitors on generators shall have built-in cutouts.

1.1.3 The carbon brushes shall be compatible with the slipring and commutator materials and, in the case of the latter, with the commutating conditions.

The working position of the brushholder is to be clearly marked.

1.1.4 The terminals shall be located in an easily accessible position and shall be dimensioned to suit the cross-section of the cables to be connected. The terminals are to be clearly marked.

The class of protection shall match that of the machine and shall be at least IP 44.

Exceptions to this Rule may be permitted for machines with a working voltage of ≤ 50 V.

1.1.5 The manufacturer shall provide every generator and motor with a name and data plate containing the machine's serial number and all essential operating data.

1.1.6 Commutators, sliprings and, wherever possible, windings shall be easily accessible for the purposes of inspection, maintenance and repair. On larger machines with plain bearings it shall be possible to check the air gap.

2 Testing of electrical machines

2.1 Workshop certificates

2.1.1 For generators and electrical motors with rated power less than 50 kVA or 50 kW, which have not been tested in the presence of a Surveyor, workshop certificates are to be submitted.

2.2 Scope of tests

2.2.1 Temperature rise test (heat test)

a) A heat test shall be performed until the steady-state temperature corresponding to the required mode of operation is reached. The steady-state temperature pass for reached when the temperature rises by not more than 2 K per hour.

   Machines with separate cooling fans, air filters and heat exchangers shall be tested together with this equipment. The heat run shall be completed with the determination of the temperature rise. The maximum permissible values shown in Tab 1 shall not be exceeded.

b) An extrapolation of the measured values to the disconnection time (t = 0) is not necessary if the reading takes place within following periods:
   - up to 50 kVA/kW 30 s
   - over 50 up to 200 kVA/kW 90 s
   - over 200 up to 5000 kVA/kW 120 s

c) Heat tests on machines of identical construction made not more than 3 years previously can be recognized.

   The referenced temperature rise shall be at least 10% lower than that listed in Tab 1.

The following tests shall be carried out at approximately normal operating temperatures.

2.2.2 Load characteristics

On generators the voltage and on motors the speed is measured as a function of the applied load.

2.2.3 Overload test

a) For generators:

   1,5 times the rated current for two minutes

b) For standard motors:

   1,6 times the rated torque for 15 seconds. During the test, the motor speed may not drop below its pull out speed

c) For windlass motors:

   1,6 times the rated torque for 2 minutes. Overload tests already performed on motors of identical construction may be recognized.

   The current of the operating stage corresponding to twice the rated torque shall be measured and indicated on the rating plate.

Table 1 : Permitted temperature-rises of air cooled machines at an ambient temperature of 40°C (difference values in K)

N°	Machinery component		Method of measurement **(3)**	Installation class				
				A	E	B	F **(1)**	H **(1)**
1	AC windings of machines		R	60	75	80	105	125
2	Commutator windings		R	60	75	80	105	125
3	Field windings of AC and DC machines with DC excitation, other than those specified under 4		R	60	75	80	105	125
4	a) Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors		R	-	-	90	110	130
	b) Stationary field windings of DC machines having more than one layer		R	60	75	80	105	125
	c) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer		R Th	60	75	80	100	120
	d) Single-layer field windings of AC and DC machines with exposed bare or varnished metal surfaces and single-layer compensation windings of DC machines		R Th	60	80	90	110	130
5	Permanently short-circuited, insulated windings		Th	60	75	80	100	120
6	Permanently short-circuited, uninsulated windings		The temperature rises of these parts shall in no case reach such values that there is a risk of injury to any insulation or other material on adjacent parts or to the item itself					
7	Iron cores and other parts not in contact with windings							
8	Iron cores and other parts in contact with windings		Th	60	75	80	100	120
9	Commutators and slip rings, open or closed		Th	60	70	80	90	110
10	Plain bearings	measured in the lower bearing shell or in the oil sump after shutdown		50				
11	Roller bearings Roller bearings with special grease	measured in the lubrication nipple bore or near the outer bearing seat		50 80				
12	Surface temperature			Reference 40 **(2)**				

(1) The values may need correction in the case of high-voltage AC windings

(2) Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidentally touched and there is a risk of burns (> 80°C), the Society reserves the right to request means of protection such as a handrail to prevent accidental contacts

(3) R = resistance method
Th = thermometer method

2.2.4 Short-circuit test on 3-phase AC generators

a) On all synchronous generators, the steady short-circuit current shall be determined with the exciter unit in operation (see Ch 2, Sec 2, [5.2.2] c).

b) A short-circuit withstand test may be demanded:
- to determine the reactances
- if there is any concern regarding mechanical and electrical strength.

Synchronous generators which have undergone a short-circuit withstand test shall be thoroughly examined after the test for any damage.

2.2.5 High-voltage test (winding test)

a) The test voltage shall be as shown in Tab 2.

It shall be applied for one minute for each single test. The voltage test shall be carried out between the windings and the machine housing, the machine housing being connected to the windings not involved in the test. This test shall be performed only on new, fully assembled machines fitted with all their working parts. The test voltage shall be a practically sinusoidal AC voltage at system frequency.

The maximum anticipated no-load voltage or the maximum system voltage is to be used as reference in determining the test voltage.

b) Any repetition of the voltage test which may be necessary shall be performed at only 80% of the nominal test voltage specified in Tab 2.

Table 2 : Test voltages for the winding test

N°	Machine or machinery component	Test voltage (r.m.s) dependent on rated voltage U of the subject winding, in V
1	Insulated windings of rotating machines of output less than 1 kW (kVA), and of rated voltages less than 100 V with the exception of those in items 3 to 6	2U + 500
2	Insulated windings of rotating machines with the exception of those in item 1 and items 3 to 6	2U + 1000, with a minimum of 1500
3	Separately excited field windings of DC machines	1000 + twice the maximum excitation voltage but not less than 1500
4	Field windings of synchronous generators, synchronous motors and rotary phase converters: a) Rated field voltage up to 500 V over 500 V	 10 times the rated voltage, with a minimum of 1500 4000 + twice rated field voltage
	b) When a machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of the winding	10 times the rated field voltage, minimum 1500, maximum 3500
	c) When a machine is intended to be started either with the field winding connected across a resistance of value equal to or more than ten times the resistance of the winding, or with the field windings on open-circuit with or without a field dividing switch	1000 + twice the maximum value of the r.m.s. voltage, which can occur under the specified starting conditions, between the terminals of the field winding, or in the case of a sectionalized field winding between the terminals of any section, with a minimum of 1500
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheiostatic starting) a) for non-reversing motors or motors reversible from standstill only	1000 + twice the open-circuit standstill voltage as measured between slip rings or secondary terminals with rated voltage applied to the primary windings
	b) for motors to be reversed or braked by reversing the primary supply while the motor is running	1000 + four times the open circuit secondary voltage as defined in item 5a)
6	Exciters (exception below) a) Exception 1 Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting	As for the windings to which they are connected twice rated exciter voltage + 1000, with a minimum of 1500
	b) Exception 2 Separately excited field windings of exciters	as under item 3

2.2.6 Overspeed test

As proof of mechanical strength, a two minute overspeed test is to be carried out as follows:

a) for generators with their own drive, at 1,2 times the rated speed

b) for generators coupled to the main propulsion system, at 1,25 times the rated speed

c) for constant-speed motors, at 1,2 times the no-load speed

d) for variable-speed motors, at 1,2 times the maximum no-load speed

e) for motors with series characteristics, at 1,2 times the maximum speed shown on the name plate, but at least at 1,5 times the rated speed.

The overspeed test may be dispensed with in the case of squirrelcage induction motors.

2.2.7 Measurement of insulation resistance

Measurement of insulation resistance is to be performed, wherever possible, on the machine at service temperature at the end of the test schedule. The test is to be carried out using a DC voltage of at least 500 V. The minimum insulation resistance shall be not less than 1 Megaohm.

2.3 Testing in the presence of a Surveyor

2.3.1 All electrical machines are to be tested at the manufacturer's works. When test procedure is not specified, requirements of IEC 60034 apply.

2.3.2 All generators and electrical motors with an output of 50 kVA or 50 kW and over are to be tested at the manufacturer's works in the presence of a Surveyor.

The Society reserves the right to stipulate that a works test be performed on new types of machines which are to be installed for the first time on a vessel with class or where there are special grounds for specifying such a test.

Individual tests may be replaced by type tests.

SECTION 4 TRANSFORMERS AND REACTORS

1 General

1.1 General requirements

1.1.1 Transformers are to be installed in well ventilated locations or spaces. Transformers with exposed live parts are to be installed in special spaces accessible only to the responsible personnel. The installation of liquid-cooled transformers requires the Society's special approval.

1.1.2 As a general principle, the primary and secondary windings of transformers are to be separated electrically. For the adjustment of the secondary voltage, taps are to be provided corresponding to ± 2,5% of the rated voltage.

Starting transformers are excepted from this rule.

1.1.3 Power transformers have to be tested according to IEC 60076.

Transformers with a power rating of 50 kVA or more are to undergo a test at the manufacturer's works in the presence of a Surveyor.

Individual tests may be replaced by One's Own Responsibility Test made by the manufacturer.

1.1.4 The manufacturer is to fit to transformers/reactors a name and date plate containing the serial number of the unit and all essential operating data.

SECTION 5 STORAGE BATTERIES

1 General

1.1 Application

1.1.1 These regulations apply to permanently installed storage batteries.

1.1.2 Only storage batteries suitable for vessels use can be used.

2 Design and construction of cells

2.1 General

2.1.1 Cells shall be so designed that they retain their normal operation at inclination of up to 15° and no electrolyte leaks out at inclination of up to 40°. Cells should be combined in cabinets, containers or racks if the weight of single cells allows this.

The weight of a battery or battery element shall not exceed 100 kg.

3 Data plate and operation instructions

3.1 General requirements

3.1.1 Each battery or battery element shall be marked with maker's name and type of battery, containing all relevant data for operation.

3.1.2 For each type of battery an operation manual shall be delivered. It shall contain all informations for proper maintenance and operation.

4 Installation and location

4.1 General requirements

4.1.1 Storage batteries are to be installed in such a way that they are accessible for cell replacement, inspection, testing, topping-up and cleaning.

The installation of batteries in the accommodation area, in cargo holds and wheelhouses is not permissible. Gastight batteries can be seen as an exception, e.g. in case of internal power source of emergency lighting fittings.

4.1.2 Storage batteries are not to be installed in locations where they are exposed to unacceptably high or low temperatures, spray or other effects liable to impair their serviceability or reduce their life essentially. They are to be installed in such a way, that adjacent equipment is not damaged by the effects of escaping electrolyte vapours.

4.1.3 Lead-acid batteries and alkaline storage batteries are not to be installed in the same room or in the immediate vicinity of each other.

4.1.4 Measures are to be taken to prevent storage batteries from shifting. The braces used shall not impede ventilation.

4.1.5 For the installation of storage batteries the total power of associated charger has to be considered.

The charging power is to be calculated from the maximum current of the battery charger and the rated voltage of the battery.

For automatic IU-charging, the charging power may be calculated as stated under [6.3].

5 Battery room equipment

5.1 General requirements

5.1.1 Only explosion protected lamps, switches, fan motors and space heating appliances shall be installed in Battery Rooms. The following minimum requirements shall be observed:

- Explosion group II C
- Temperature class T 1.

Other electrical equipment is permitted only with the special approval of the Society.

5.1.2 Where leakage is possible, the inner walls of Battery rooms, cabinets and containers shall be protected against the injurious effects of the electrolyte.

6 Ventilation

6.1 General requirements

6.1.1 All battery installations in rooms, cabinets and containers shall be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

Gastight NiCd-, NiMH- or Li- batteries may not be ventilated.

6.2 Batteries installed in switchboards charging power up to 0,2 kW

6.2.1 Lead batteries with charging power up to 0,2 kW may be installed without separation to the switchgear, if:

a) the batteries are of valve regulated type (VRL), provided with solid electrolyte and

b) the switchboards are not closed completely (IP 2X will be suitable) and

c) the charger is an automatic IU-charger with a maximum continuous charging voltage of 2,3 V/cell and rated power is limited on 0,2 kW.

6.3 Ventilated spaces, battery charging power up to 2 kW

6.3.1 Batteries with charging power up to 2 kW may be installed in ventilated cabinets or containers arranged itself in ventilated rooms (except in rooms according to [4.1.1] and [4.1.2]). The unenclosed installation (IP 12) in well ventilated positions in machinery spaces is permitted. The charging power for automatic IU-charging should 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

Battery's gassing voltage shall not be exceeded. If several battery sets are be used, the sum of charging power has to be calculated.

The room free air volume should be calculated depending on battery size as follows:

V = 2,5 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 shall be calculated.

The air ducts for natural ventilation shall 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 should be calculated based on lower air speed (≤ 0,5m/s).

6.4 Ventilated rooms, battery charging power more than 2 kW

6.4.1 If the charging power of batteries exceeds 2 kW, it has to be installed either in closed cabinets, containers or a Battery room to be ventilated to the open deck. Lead batteries up to 3 kW still may be ventilated by natural ventilation.

Battery rooms are to exhaust to open deck area. It should be used forced ventilation.

Doors to battery rooms have to be gastight with self-closing devices without holding back means.

6.5 Ventilation requirements

6.5.1 Ventilation inlet and outlet openings shall be so arranged to ensure that fresh air flows over the surface of the storage battery.

The air inlet openings shall be arranged below and air outlet openings shall be arranged above.

If batteries are installed in several floors, the free distance between them shall be at least 50 mm.

Devices which obstruct the free passage of air, e.g. fire dampers and safety screens, shall not be mounted in the ventilation inlet and outlet ducts. If necessary, weathertight closures shall be carried out otherwise.

Air ducts for natural ventilation shall lead to the open deck directly. Openings shall be at least 0,9 m above the cabinet/ container. The inclination of air ducts shall not exceed 45° from vertical.

6.6 Forced ventilation

6.6.1 If natural ventilation is not sufficient or required cross-sections of ducts according to Tab 1 are too big, forced ventilation shall be provided. The air quantity Q shall be calculated according to [6.3]. The air speed shall not exceed 4 m/s.

Where storage batteries are charged automatically, with automatic start of the fan at the beginning of the charging, arrangements shall be made for the ventilation to continue for at least 1 h after completion of charging.

Wherever possible, forced ventilation exhaust fans shall be used. The fan motors shall be either explosion-proof and resistant to electrolyte or, preferably, located outside of the endangered area.

The fan impellers shall be made of a material which does not create sparks on contact with the housing, and dissipates static charges.

The ventilation systems shall be independent of the ventilation systems serving other rooms.

Air ducts for forced ventilation shall be resistant to electrolyte and shall lead to the open deck.

Table 1 : Cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU- charging)			
Battery charging power	Cross-section, in cm²		
[W]	Lead battery solid electrolyte VRL	Lead battery fluid electrolyte	Nickel-Cadmium battery
< 500	40	60	80
500 < 1000	60	80	120
1000 < 1500	80	120	180
1500 < 2000	80	160	240
2000 < 3000	80	240	forced ventilation
> 3000	forced ventilation		

7 Warning signs

7.1 General

7.1.1 At doors or openings of battery rooms, cabinets or containers warning notices have to be mounted drawing attention to the explosion hazard in those areas and that smoking and handling of open flames are prohibited.

8 Starter batteries

8.1 General requirements

8.1.1 Storage batteries for starting internal combustion engines shall be designed to have sufficient capacity for at least six starting operations in 30 minutes without intermediate recharging.

8.1.2 Starter batteries shall be capable of being recharged with the means available on board and may only be used to start engines and supply energy to the monitoring systems allocated to them.

8.1.3 Starting internal combustion engines with the vessel's supply battery is permitted only in emergencies.

8.1.4 Wherever possible storage batteries used for starting and preheating internal combustion engines are to be located close to the machines.

9 Rating of storage battery chargers

9.1 General requirements

9.1.1 Charging equipment shall be so rated that discharged storage batteries can be charged to 80% of their rated capacity within a period not greater than 15 hours without exceeding the maximum permissible charging currents.

Only automatic chargers shall be used with charging characteristic adapted to the type of batteries.

If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120% of the rated voltage. The power demand of the consumers shall be considered for the selection of the chargers.

Battery charger's with rating power of 2 kW upwards have to be tested in manufacturer's work in the presence of Society's Surveyor.

SECTION 6 POWER DISTRIBUTION

1 Subdivision of the distribution network

1.1 General

1.1.1 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.

2 Hull return

2.1 General

2.1.1 In systems using hull return, the final subcircuits for space heating and lighting are to be insulated on all poles. The earth for the hull return connection is to be formed by connecting the earth busbar in the main or subsidiary distribution board to the vessel's hull. The earth connection shall be located in an easily accessible position so that it can easily be tested and disconnected for the purpose of testing the insulation of the circuit. Earth connections shall be at least equal in cross-section of the supply leads. Bare leads may not be used. Casings and their retaining bolts may not be used for the earth return or for connecting the return lead to the vessel's hull. The connecting surface of the cable lug shall be metallically clean. The cable lug is to be tinned. The terminal screws are to be made of brass and are to be compatible with the cable cross-sections. The smallest permissible size is M 6.

3 Final subcircuits

3.1 General

3.1.1 Final lighting subcircuits and plug socket circuits within the accommodation and day rooms are to be fitted with fuses rated for not more than 16 A. The load on each lighting subcircuit shall not exceed 10 A.

The number of lighting points supplied by a final sub-circuit shall not exceed the numbers given in Tab 1.

Table 1 : Maximum number of lighting points

Voltage	Maximum number of lighting points
Up to 55 V	10
from 56 V to 120 V	14
from 121 V to 250 V	24

3.1.2 Plug sockets (outlets) are to be connected to separate circuits wherever possible.

Final subcircuits for lighting in accommodation spaces may, as far as practicable, include socket outlets.

In that case, each socket outlet counts for 2 lighting points.

3.1.3 In main machinery spaces and other important service spaces and control stations, the lighting shall be supplied by at least two different circuits.

The lamps are to be so arranged that adequate lighting is maintained even if one of the circuits fails.

4 Navigation lights and signal lamps

4.1 General

4.1.1 The switchboard for navigation lights and signal lamps shall be mounted in the wheelhouse and shall be supplied by a separate cable from the main switchboard, if no change-over to a separate feeder is provided.

4.1.2 Navigation light, each shall be individually supplied, protected and controlled from the navigation lights switchboard.

4.1.3 The navigation lights switchboard may be enlarged to provide connections for other signal lamps. No other consumers may be connected to this switchboard.

4.1.4 A number of locally grouped signal lamps may be jointly supplied, controlled and monitored provided that the monitoring system indicates or signals the failure of even one such lamp.

4.1.5 The switchboard is to be fitted with a device which indicates or signals the extinction of a navigation light. Where pilot lamps are used as indicators, special precautions shall be taken to ensure that the navigation light is not extinguished if the pilot lamp burns out.

4.1.6 Navigation lights shall be designed for the standard voltages: 24 V, 110 V or 220 V.

4.1.7 The voltage at the lamp socket shall not permanently deviate by more than 5 % above or below the standard voltages mentioned in [4.1.6].

5 Shore connection

5.1 General

5.1.1 Shore line terminal containers are to be connected to the main switchboard by a permanently laid cable. The shore connection is to be protected at the main switchboard by a switch or contactor with control switch and fuses or a power circuit breaker with overload protection. Switch, contactor or power circuit breaker are to be interlocked with the generator circuit in such a way as to prevent the vessel's generator operating in parallel with the shore mains.

5.1.2 When using plug-type shore connectors with a current rating of more than 16 A, an interlocking device with switch is to be fitted so that the connection on board can only be made in the dead condition. Short-circuit protection at the connection can then be dispensed with.

In order to prevent contact with live parts, plug-type shore connectors are to be designed as appliance connectors comprising a coupler plug mounted on board and a coupler socket supplied from the shore.

With a connecting voltage of more than 50 V a provision is to be made for connecting the vessel's hull to earth. The connection point shall be marked.

On vessels with DC-power system with hull return the negative pole of the shore side power source shall be connected to the vessel's hull.

5.1.3 The main switchboard is to be equipped with an indicator showing whether the shore connection cable is live.

5.1.4 Instruments shall be available for comparing the polarity of a DC power supply or the phase sequence of a 3-phase power supply from the shore with that of the vessel's network. The installation of a phase change overswitch is recommended.

5.1.5 The following details are to be given on a data plate in the shore line terminal box:

- Kind of current, rated voltage and frequency for alternating current
- The concerning measures are to be taken for the shore connection.

5.1.6 To reduce the load on the terminals, the shore line is to be provided with a tension relief device.

5.1.7 Only flexible, oil-resistant and flame retardant cables are to be used as feeder cables.

6 Power supply to other vessels

6.1 General

6.1.1 A separate junction box is to be provided in the case of supplying power to other vessels. The branch is to be fitted with fuses and an on-load switch or with a power circuit breaker with overcurrent and short-circuit protection. Where voltages of more than 50V and/or currents of more than 16A are transmitted, it is necessary to ensure that the connection can only be made in the dead condition. Where a connecting line carrying a voltage of more than 50 V is wrenched out of its connector, it shall immediately be deenergized by a forcing circuit. The same applies to a rupture of the connecting cable.

Vessel hulls have to be conductively connected.

Facilities have to be provided to allow this.

Connecting cable suspensions shall be tension-relieved.

SECTION 7 SWITCHGEAR INSTALLATIONS AND SWITCHGEAR

1 Switchboards

1.1 General rules

1.1.1 Switchboards shall contain all the gear, switches, fuses and instruments necessary for operating and protecting the generators and main power distribution systems. They shall be clearly, easily and safely accessible for the purposes of maintenance, repair or renewal.

1.1.2 Built-in gear, instruments and operating equipment are to be indelibly marked. The current ratings of fuses and the response values of protective devices are to be indicated.

1.1.3 The replacement of fuse elements shall be possible without removing panels or covers. Different voltages and types of current are to be clearly indicated.

1.1.4 Where switchgear or fuses carrying a voltage of more than 50 V are located behind doors, the live parts of appliances mounted on the door (switches, pilot lights, instruments) shall be protected against being touched by accident (see Ch 2, Sec 1, [1.4]).

1.1.5 Busbars and bare connections shall be made of copper. Even under adverse operating conditions, their temperature rise may not exceed 40°C. Busbars are to be fastened and secured in such a way that they are able to withstand the mechanical stresses produced by the greatest possible short-circuit currents.

1.1.6 All screwed joints and connections are to be secured against spontaneous loosening. Screws up to M 4 size may be secured with lacquer or enamel.

1.1.7 With the exception of the connections between switchgear and outgoing terminals, switchboards may only contain lines with cross-sections of up to 50 mm². If larger cross-sections are required, a main busbar system is to be provided for connecting generators and consumers.

1.1.8 The power feed for the control of consumers is to be picked up on the consumer side downstream of the main fuses. Exceptions will be permitted only in special cases.

1.1.9 Where fuses and switches are used, the sequence shall be busbar - fuse - switch.

1.1.10 Neutral conductors in 3-phase systems shall have at least half the cross-section of the outer conductors. For line cross-sections of up to 16 mm², neutral conductors shall have the full cross-section of the outer conductors. Equalizer lines for 3-phase alternator exciters shall be designed to carry half the exciting current of the largest alternator and shall be laid separately from other lines.

1.1.11 The smallest permissible cross-section for wiring inside the switchboard, including measuring wires and control lines, is generally 0,5 mm². Smaller cross-sections are allowed only in automation and telecommunication equipment and for data bus/data cables. Lines without fuse protection from the main busbar to fuses and protective switches shall be as short as possible not longer than 1 m. They may not be laid and fastened together with other lines.

Shunt circuits within the switchboard shall be laid separately from other lines and shall generally not be protected by fuses.

Important control lines shall be laid and protected in such a way they cannot be damaged by arcing due to switching operations or, as far as possible, short-circuits.

1.1.12 It shall be possible to observe meters and indicators and to operate the switchgear from the front of the switchboard with the doors closed.

1.1.13 Operating handles shall generally not be located less than 300 mm above floor level. The operating handles of generator switches are to be located at a distance of at least 800 mm from the floor.

1.2 Installation of switchboards

1.2.1 Switchboards are to be installed in easily accessible and adequately ventilated spaces in which no flammable gases can gather. They are to be protected against water and mechanical damage.

Switchboards on the floorplates over the bilges shall be closed from below.

Pipes and air trunks are to be so arranged that any leakage does not endanger the switchgear. Where the routing of pipes and trunks close to switchboards cannot be avoided, they are to have no flanged or screwed joints in this section.

Cabinets and recesses for housing switchboards shall be made of non-combustible material (see Ch 1, Sec 14, [1.4.2] for definition) or shall be protected by a metal or other fireproof lining. The doors of cabinets and recesses are to bear a notice drawing attention to the switchboard installed therein. A service passageway at least 0,6 m wide is to be provided in front of switchboards.

1.2.2 A service passageway of not less than 0,5 m behind the switchboard is called for only when required by its construction or maintenance.

1.2.3 In the case of voltages over 50 V, insulating gratings or mats shall be placed behind the switchboards and in front of their control sides. No live parts may be mounted on the front side of switchboards.

Parts located to the rear of an open switchboard and carrying voltages of more than 50 V shall be protected against contact up to a height of 0,3 m.

1.3 Distribution boards

1.3.1 The Rules set out in [1.1] apply in analogous manner.

1.3.2 Where a number of distribution boards are supplied via a common feeder cable without intermediate protection, the busbars and the connecting terminals shall be dimensioned to withstand the total load.

1.3.3 Distribution circuits shall be protected in accordance with [3.1] and [3.9] against damage due to short-circuit and overload. Final subcircuits with fuses rated at more than 63 A shall be fitted with on-load switches. On-load switches may be dispensed with in final subcircuits with fuses rated up to 63A provided that each connected consumer can be disconnected by a switch located nearby.

1.3.4 Distribution boards for the supply of mobile consumers, e.g. container plug sockets shall be individually supplied from the distribution board and shall be individually fused and individually disconnectable.

A pilot light or voltmeter is to be provided to show whether the distribution board is live.

1.3.5 Motor switchgear shall be accessible for the purposes of inspection and repair without the need to disconnect other important circuits.

Mechanical devices, anmeters or indicator lights shall show whether the motor is switched on.

Motor switchgear units or their control switches are normally to be located close to their respective motors. Where for operational reasons they are placed out of sight of the motor, personnel working on the motor shall be provided with means of protecting themselves against the unauthorized switching on of the motor.

Motors shall be disconnected on all poles as a matter of principle.

1.4 Switchboard testing

1.4.1 Before being installed on board, every switchboard together with all its equipment is to be subjected to the following test ([1.4.2] to [1.4.5]).

1.4.2 A test at the manufacturer's works in the presence of a Society Surveyor is to be carried out on main switchboards for a connected generator output of more than 100 kW/ kVA, and on all switchboards for emergency generator sets. The Society reserves the right to call for a works test on other switchboards where there are special reasons for this.

1.4.3 Operational test

As far as possible, the proper operation of the equipment is to be checked in accordance with the design.

1.4.4 High-voltage test

High-voltage test is to be performed for a period of one minute at the test voltage shown in Tab 1.

Measuring instruments and other ancillary equipment may be disconnected during the test.

Table 1 : Test voltages for main circuits

Rated insulation voltage Ui, in V	Test voltage A.C. (r.m.s), in V
$Ui \leq 60$	1000
$60 < Ui \leq 300$	2000
$300 < Ui \leq 690$	2500

1.4.5 Insulation resistance measurement

Insulation resistance measurement is to be performed using at least 500 V DC. For the purpose of this test, large switchboards may be divided into a number of test sections. The insulation resistance of each section shall be at least 1 Megohm.

2 Switchgear

2.1 General

2.1.1 As a general principle, switchgear shall be designed and constructed in accordance with standard IEC, EN or to other standards recognized by the Society.

2.2 Selection of switchgear

2.2.1 Switchgear is to be selected not merely by reference to its rated current but also on the basis of its thermal and dynamic strength and its making and breaking capacity.

On-load breakers shall be designed to carry at least the rated current of the series-connected fuse.

Circuit breakers shall act on all live conductors simultaneously. It shall be clearly apparent whether the breaker is in the open or closed position.

Installation switches in lighting systems up to 16A are exempted from this rule.

2.3 Power circuit breaker

2.3.1 Power circuit breakers are to be provided with trip-free release. Their rated making and breaking capacity shall be sufficient to make or break short-circuit currents at the installation site.

2.4 Fuses

2.4.1 The fuse elements or cartridges shall have an enclosed fusion space. They shall be made of a ceramic material or a material recognized by the Society as equivalent. The fuse element shall be embedded in a heat-absorbing material.

2.4.2 It shall be possible to replace the fuse elements or cartridges without exposing the attendant to the danger of touching live components or suffering burns. Where grip-type fuses are used, a detachable grip is permissible.

3 Switchgear, protective and monitoring equipment

3.1 General

3.1.1 Generators, power consumers and circuits shall be protected in each one of their non-earthed poles or conductors against damage due to overload or short-circuit. In insulated DC and single-phase AC circuits and in insulated 3-phase circuits with balanced load, the overload protection may be dispensed with in one conductor.

3.1.2 The protective devices are to be coordinated in such a way that, in the event of a fault, only the defective circuit is disconnected and the supply to the sound circuits is maintained.

3.1.3 All non-earthed poles shall be connected and disconnected simultaneously. In earthed systems, lines are to contain neither switches nor fuses in their earthed pole or conductor.

3.2 Equipment for 3-phase AC generators

3.2.1 Switchgear and protective devices for individual operation 3-phase AC generators are to be provided with 3-pole power circuit breakers with delayed-action overcurrent trip and short-delayed short-circuit trip to obtain selectivity. This protective equipment is to be designed as follows:

a) The overload trip, which is to be set at an overcurrent of between 10% and 50%, shall open the power circuit breaker with a maximum time delay of two minutes.

   A setting of more than 50% overcurrent may be approved if required by the operating conditions and compatible with the generator or primemover design.

b) The short-circuit trip is to be set at an overcurrent of more than 50% but less than the sustained short-circuit current. It shall operate with a short delay of up to about 500 ms adjusted to suit the selectivity of the system.

c) On generators rated at less than 50 kVA, fuses and contactors or on-load switches may be used provided that the requirements of a) and b) are satisfied in an analogous manner. For this purpose the contactors shall also have a delayed drop-out.

   The contactors are to be designed for at least twice the rated generator current.

3.2.2 Switchgear and protective devices for parallel operation

The following equipment is to be provided in addition to the switchgear and protective devices specified above [3.2.1].

a) 3-phase AC generators rated at 50 kVA and above shall be provided with reverse-power protection with a time delay of 2 to 5 seconds.

   The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4% to 10% of the rated current for diesel-driven generators. The protection should, wherever possible, be set to 50% of the prime mover trailing power. A voltage drop to 60% of the rated voltage shall not render the reverse-power protection ineffective within the specified range.

b) The generator switches shall be fitted with undervoltage protection which prevents the contact assemblies from closing when the generator is deenergized. If the voltage drops to between 70% and 35% of the rated voltage, the generator switch shall open automatically. Undervoltage trips shall have a short time delay matched to the short-circuit trip called for in [3.2.1]b).

c) A synchronizing device is to be fitted. Where automatic synchronizing equipment is fitted, provision shall also be made for manual independent synchronization.

d) In the case of parallel operating generators with individual output rating of more than 50 kVA, protection is to be provided against the effects of paralleling the generators when in phase opposition.

   For example, the following may be used for this purpose:

   - a reactor which limits to a permissible degree the electrical and mechanical stresses arising from faulty synchronization. It is to be disconnected when the generator switch is closed or
   - a synchronizing interlock which allows the generator switch to cut in only up to an angular deviation of 45° (electrical) maximum, and also blocks the connection in case of too large a difference frequency. The permissible difference frequency depends on the characteristics of the generator switch and its drive and shall not generally exceed 1 Hz.

3.3 Equipment for DC generators

3.3.1 Switchgear and protective devices for individual operation

a) DC generators are generally to be provided with power circuit breakers with delayed-action overcurrent trip and short-delayed short-circuit trip to obtain selectivity. The switchgear and protective devices are to conform to [3.2.1] (for individual operation) with the difference that the short-circuit trip is to have a short time delay of up to about 200 ms.

b) A polarity-reversing facility, if necessary.

3.3.2 Switchgear and protective devices for parallel operation

The following equipment is to be provided in addition to the switchgear and protective devices specified in [3.3.1]:

a) DC generators equipped for parallel operation with each other or with a storage battery shall be fitted with reverse-current protection with no-delay action or with a short delay of up to 1 second.

   The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4% to 10% of the rated output for diesel-driven generators.

b) Undervoltage protection as described in [3.2.2] b) for parallel operation.

c) In the case of compound-wound generators, the power circuit breaker shall be provided with an equalizer circuit contact assembly which, on making, closes simultaneously with, or in advance of, the contacts of the power circuit breaker and, on breaking, opens simultaneously with, or after, the contacts of the power circuit breaker, and is designed to carry at least half the rated current.

3.4 Special rules

3.4.1 On-load switches, power circuit breakers and, generally speaking, reverse-current cutouts can be dispensed with in the case of generators with outputs of up to 10 kW (kVA) and a voltage of 50 V or less which, because of their control equipment, do not need to be subjected to switching operations in service. Further exemptions may be allowed depending on the design of the equipment.

3.5 Disconnection of non-essential consumers

3.5.1 It is recommended that a device be installed which, when the generator reaches its rated output, emits a warning signal after about 5 s and automatically cuts off consumers whose temporary disconnection will not jeopardize the safety of the vessel and its machinery installation. The disconnection of the loads may be effected in one or more steps. The automatic disconnection of non-essential consumers is mandatory on larger passenger vessels and on vessels with automated engine operation.

3.6 Measuring and monitoring equipment

3.6.1 The measuring error of switchboard instruments may not exceed 1,5% of the scale terminal value. Directionally sensitive instruments are to be used for DC generators and storage batteries.

The scale of voltmeters shall cover at least 120% of the rated voltage, that of ammeters at least 130% of the maximum amperage to be expected in continuous operation. Ammeters are to be designed to avoid damage due to motor starting currents.

The scale of watt meters shall cover at least 120% of the rated power. For generators operating in parallel, the scale shall also cover at least 12% of the reverse power. In the case of power meters with only one current path, the measurement shall be performed in the same phase on all generators. Where the total power input to all consumers connected to one phase reaches more than 10% of the output of the smallest alternator, the power meters shall be equipped with multiple movements to register also the unbalanced load on the outer conductors.

Frequency meters are to be capable of registering deviations of down to ± 5 Hz from the rated frequency. Vibrating reed instruments with 21 reeds are recommended.

The main switchboard (main distribution board) is to be provided with ammeters for major consumers, unless these are mounted at the consumers themselves. One instrument may be used for more than one circuit. The rated currents are to be marked on the instrument scales, or on a separate panel in the case of multi-circuit instruments with change-over switch. The rated service values are to be marked in red on the scales of all instruments.

3.6.2 Generator measuring and monitoring equipment

a) Each DC generator is to be provided with:

1 voltmeter

1 ammeter

1 blue pilot light (generator live)

Where circuit breakers are used, the following additional lights are to be provided:

1 green pilot light (circuit breaker closed)

1 red pilot light (circuit breaker open)

b) Battery

1 centre zero ammeter

c) Bus-bar

1 voltmeter

d) Each 3-phase AC generator is to be provided with:

1 voltmeter, where necessary capable of switching to the other generators

1 ammeter, connectable to each phase conductor

1 wattmeter (active power meter) for generators with outputs of 50 kVA and over

1 frequency meter, where necessary capable of switching to the other generators

Pilot lights as specified for DC generator here above.

3.6.3 Special rules

Instead of the ammeter and the blue pilot light specified in b), a charging pilot light may be provided for installations with an output of up to 10 kW/ kVA and a voltage of ≤ 50 V.

3.6.4 Protection of generator monitoring and control circuits

The following circuits are to be supplied by the generator direct and are to be individually fused (using fusible cutouts):

- Generator protective relay and generator switch undervoltage trip
- Measuring instruments
- Synchronizing equipment
- Pilot lights
- Speed adjuster
- Electrical generator switch drive
- Automatic power supply system (measuring voltage).

3.6.5 Earth fault indication

Every non-earthed primary or secondary system is to be equipped with devices for checking the insulation resistance against vessel's hull.

Where filament lamps are used as indicators, their power input may not exceed 15 W. The lamps may be earthed only during testing by means of a pushbutton switch.

An insulation monitoring system may be dispensed with in the case of secondary circuits such as control circuits.

3.6.6 Insulation monitoring equipment

Where insulation monitoring devices are used, they shall provide a continuous indication of the insulation resistance and shall trip an alarm if the insulation resistance of the network drops below 100 ohms per volt of the network voltage.

With a full earth fault the measuring current may not exceed 30 mA.

3.7 Transformer protection

3.7.1 The windings of transformers shall be protected against short circuit and overload by multi-pole power circuit breakers or by fuses and on-load switches in accordance with the above Rules. Transformers for parallel operation shall be fitted with isolating switches on the secondary side.

Overload protection primary side may be dispensed with where it is protected on the secondary side.

3.8 Motor protection

3.8.1 Motors rated at more than 1 kW shall be individually protected against overloads and short circuits.

For steering gear motors see Ch 2, Sec 8, [1].

It is permissible to provide common short-circuit protection for a motor and its own individual supply cable.

The protective devices shall be suited to the particular operating modes of the motors concerned and shall provide reliable thermal protection in the event of overloads.

If the current-time characteristic of the overload protection is not compatible with the starting characteristics of a motor, the overload protection may be disabled during start-up. The short-circuit protection shall remain operative.

The switchgear of motors whose simultaneous restarting on restoration of the voltage after a power failure might endanger the operation of the installation shall be fitted with a facility which:

- interrupts the circuit in response to a voltage drop or power failure and prevents automatic restarting, or
- causes the motor to start up again automatically without any inadmissible starting current on restoration of the voltage. Where necessary, the automatic restarting of a number of motors is to be staggered in time.

The undervoltage protection shall work reliable between 70% and 35% of the rated voltage.

3.9 Circuit protection

3.9.1 Every distribution circuit shall be protected against damage due to overloads and short circuits by means of multi-pole power circuit breakers or fuses in accordance with the above Rules. Final subcircuits supplying power to a consumer fitted with its own overload protection may be provided with only short-circuit protection at the feed point. Under continuous service conditions fuses for this purpose may be two stages higher than for the rated service of the consumer in question; for short-period and intermittent service, the rated current of the fuse may not be greater than 160% of the rated consumer current. The corresponding switches are to be designed for the rated amperage of the fuse.

For steering gear circuits see Ch 2, Sec 8, [1]. Automatic cutouts and protective motor switches shall, where necessary, be backed up by the series-connected fuses specified by the manufacturer. In the case of important consumers, automatic cutouts without selectively staggered disconnecting delay may not be arranged in series.

3.10 Storage battery protection

3.10.1 Batteries, except starter batteries, shall be provided with short-circuit protection situated near the batteries, but not in battery's cabinet or container. Emergency batteries supplying essential services may only be provided with short- circuit protection sufficient for their cables. The value of the fuses may be two stages higher than the corresponding values for the rated cable current shown in Ch 2, Sec 12, Tab 3 and Ch 2, Sec 12, Tab 4, column 3, or of power circuit breakers with suitably adjusted short-circuit protection.

3.11 Protection of measuring instruments, pilot lights and control circuits

3.11.1 Indicators, measuring instruments and pilot lights are to be protected by fuses. Pilot lights with operating voltage over 24 V are to be fused separately from control circuits in every case so that a short circuit in the lamp does not cause failure of the control circuits. Pilot lights connected via short-circuit-proof transformers may be fused jointly with control circuits.

3.12 Exciter circuits

3.12.1 Exciter circuits and similar circuits whose failure might endanger the operation of essential systems may not be protected, or may be protected only against short circuits.

3.13 Emergency disconnecting switches

3.13.1 Oil burner equipment, fuel pumps, boiler fans, separators, machinery space and pump room ventilators shall be provided with an individual emergency disconnecting switch located at a central position outside the machinery space unless other means are available for rapidly interrupting the fuel and air supply outside the room in which the equipment is installed.

4 Control and starting equipment

4.1 Operating direction of handwheels and levers

4.1.1 Handwheels and levers of starters and drum controllers not intended for reversing are to be arranged to turn clockwise for starting the motors. Motor speed and generator voltage control is to be so effected that clockwise rotation increases the speed/voltage. The linear movement of handles upwards or to the right shall produce the same effect as clockwise rotation.

4.2 Hand-operated controllers, resistors

4.2.1 The temperatures of handles and other parts which have to be touched in order to operate equipment may not exceed the following values in service:

- Metal parts 50°C
- Insulating material 60°C

Resistor casings whose temperature is liable to exceed 60°C are to be so mounted that they cannot be touched by accident.

The temperature rise of the air flowing from the casing may not exceed 165°C in the case of resistors integral to starters and controllers or 190°C for separately mounted resistors.

SECTION 8 STEERING GEARS, LATERAL THRUST PROPELLER SYSTEMS AND ACTIVE RUDDER SYSTEMS

1 Steering gear

1.1 General requirements

1.1.1 As a general principle, two steering gears, as constructionally independent as possible, are to be provided, i.e.:

- 1 main and 1 auxiliary steering gear system
- 2 main steering gear systems.

1.2 Definitions

1.2.1 Main steering gear system

The main steering gear system comprises all the system components needed to steer the vessel under normal design conditions.

1.2.2 Auxiliary steering gear system

The auxiliary steering gear system generally comprises equipment which, if the main steering gear system malfunctions, is able to assume its duty with reduced or equal capacity.

1.3 Design features

1.3.1 In general, all parts of main and auxiliary steering gears shall be designed in conformity with Ch 1, Sec 11.

1.3.2 The rated output of the electrical machinery is to be related to the maximum torque of the steering gear. For hydraulic steering gears, the rated output of the drive motors is to be determined by reference to the maximum pump delivery against the maximum pressure produced by the steering gear (safety valve setting) with due allowance for pump efficiency.

The stalling torque of the motor shall equal at least 1,6 times the rated torque.

Steering gear drive units shall comply at least with the following modes of operation:

a) Steering gears with intermitted power demand

   S 6: 25% for converters and motors of electrohydraulic steering gears

   S 3: 40% for motors of electromechanical steering gears

b) For steering gears with a constant power demand the machines are to be designed for continuous service S 1.

Note 1: For definition of service factor S, see IEC 60024.

1.3.3 With power-driven steering gears, the auxiliary drive shall be largely independent of the main drive so that a failure in one system does not render the other one inoperative.

1.4 System requirements

1.4.1 Basically, systems may be differentiated as follows:

a) Hydraulically driven main steering gear with electrohydraulic auxiliary steering gear

b) Electrohydraulic main steering gear comprising two equivalent rudder drives

c) Hydraulic main and auxiliary steering gear systems.

1.4.2 Electrical and electrohydraulic power unit shall be supplied via separate cable. The necessary fuse junctions and switchgear devices are to be housed in separate switch containers. If installed together in switchboards, they are to be suitably isolated from the feeder panels of other consumers.

1.4.3 The systems are to be so designed that each drive unit can be put into operation either individually or jointly from the wheelhouse. The feed for the remote control of the motor switchgear shall be taken from the appropriate supply fuse.

1.4.4 Where a system is supplied from a battery, a voltage monitor is to be fitted which acts with a time delay to trip a visual and audible alarm signal on the bridge if the supply voltage drops more than 10%.

1.4.5 If the auxiliary steering gear is supplied from a battery, the latter shall be capable of sustaining the supply for 30 minutes without intermediate recharging.

1.4.6 The changeover from the main to the auxiliary steering gear system shall be able to be effected within 5 seconds.

1.4.7 Following a power failure, the steering gear drive systems shall automatically re-start as soon as the power supply is restored.

1.4.8 If the steering gear is operated only by electrically driven power units or electrohydraulic power units, then at least one of the power units or rudder drives shall, in the event of failure of the vessel's network, be automatically supplied by a battery until an auxiliary diesel set has been started and has taken over the power supply.

The battery is not required, in case that the standby auxiliary diesel set starts automatically and takes over the power supply within 5 seconds after black-out.

1.4.9 Installations other than that described require the Society's special approval.

1.5 Protective equipment

1.5.1 The control circuits and motors of steering gear systems are to be protected against short circuits only.

1.5.2 Where fuses are used, their rated current is to be two stages higher than that corresponding to the rated current of the motors. However, in the case of motors for intermittent service, the value shall not be greater than 160% of their rated current.

1.5.3 Where power circuit breakers are used, their short-circuit quick release device shall be set at not more than 10 times the rated current of the electric drive motor.

Thermal trips are to be disabled or are to be set to twice the rated current of the motor.

1.5.4 Control circuits shall be fused for at least twice the maximum circuit current rating.

They are to be located on the load side of the main fuse of the electrical drive concerned.

1.5.5 The protective devices are to be coordinated in such a way that in the event of a fault only the defective circuit is disconnected while the supply to the intact circuits is maintained.

All non-earthed poles are to be fitted with fuses and are to be connected and disconnected simultaneously.

1.5.6 On relays and magnetic valves rectifiers or capacitors in parallel are to be fitted to quench arcs.

1.6 Indicating and monitoring equipment

1.6.1 As a general principle, separate indicators or monitors, as appropriate, are to be provided which respond to the operative/inoperative state of the control circuits, a drop in potential below the supply voltage (in the case of battery supply) and an inadmissible fall in the hydraulic oil level in the compensating tank.

1.6.2 A failure of the control voltage and any departure from the limit values prescribed for safe operation shall trip a visual and audible signal in the wheelhouse. It shall be possible to cancel the audible signal. The cancellation of an audible alarm shall not prevent the signalling of a fault affecting the other working parts of the steering gear systems.

1.6.3 Operative signals and alarms:

a) 1 green indicator light each for the main and auxiliary steering gears (or for each main steering gear, where applicable) showing that the equipment is operative

b) 1 red indicator light for the main and auxiliary steering gears to signal a failure or a fault

c) 1 red indicator light responding to a drop in potential of 10% below the rated network voltage. The signal response is to be subjected to a time delay in order to bridge voltage dips caused by starting operations (where a system is supplied by a battery).

1.6.4 In addition, 3-phase AC systems are to be provided with yellow indicator light signalling overload and phase failure.

The phase failure monitor may be dispensed with if the system is supplied exclusively via power circuit breakers. The overload alarm may be dispensed with for drive systems used exclusively for inching duty. The alarm may also be combined with other steering gear alarms.

Where bimetallic relays are used to signal overloading of the motors, these are to be set at 0,7 times the rated current of the motor.

1.7 Rudder control

1.7.1 It shall be possible to control the main and auxiliary steering gears from the main steering station.

The controls are to be so arranged that the rudder angle cannot be altered unintentionally.

1.7.2 Where more than one power drive is installed, the wheelhouse is to be provided with at least two mutually independent steering gear control systems.

Separate cables and lines are to be provided for these control systems.

The mutual independence of the steering gear control systems may not be impaired by the fitting of additional equipment such as autopilot systems.

1.7.3 A common selector switch is to be provided for switching from one control system to another.

1.8 Auto pilot systems

1.8.1 An indicator light showing that the auto pilot is operative has to be installed.

A failure of the control voltage and a deviation of the rated rpm of the gyro shall trip a visual and audible alarm.

The auto pilot system and its associated alarms have to be supplied separately from each other.

1.9 Rudder angle indicator

1.9.1 The actual position of the rudder shall be clearly indicated in the wheelhouse and at every steering station. In the case of electrical or hydraulic control systems, the rudder angle shall be indicated by a device (rudder angle transmitter) which is independent of the control system and actuated either by the rudderstock itself or by parts rigidly connected to it.

The system shall have a separate power supply and the indication shall be continuous.

Additionally installed transmitters for position indicators of autopilot systems shall have a separate power supply and shall be electrically isolated from the above mentioned system.

2 Lateral thrust propellers and active rudder systems

2.1 General

2.1.1 The short-circuit protection of the supply is to conform to [1.5].

2.2 Drives

2.2.1 Active rudder systems are to be rated for continuous service.

Lateral thrust propeller systems are to be rated in accordance with the vessel's operating conditions, but at least for short-term duty (S 2 - 30 min).

Lateral thrust propellers and active rudder systems are to be protected against short circuits and overloads. The overload protection is to be so designed that in the event of an overload a warning is first given followed by a reduction of the output or the shutdown of the system should the overload persist.

Motors for short-term duty shall be monitored for critical winding temperature. An exceeding of temperature limits shall be alarmed. If the maximum permissible temperature is reached the output shall be automatically reduced or the motor shall be switched off.

2.3 Monitoring

2.3.1 The wheelhouse is to be equipped with the monitors and indicators described in [2.3.2] to [2.3.6].

2.3.2 A blue indicator light signalling that the system is operative.

2.3.3 A yellow indicator light for signalling an overload.

2.3.4 Depending on the type of system, further indicators are to be provided for signalling operational level and the desired direction of movement of the vessel.

2.3.5 The controls of lateral thrust propeller systems shall take the form of pushbuttons or levers. The operating direction shall correspond to the desired direction of movement of the vessel. The electrical control system shall be fed from the supply to the main drive.

2.3.6 Where fuses are used for short-circuit protection, a phase monitor shall ensure that the system cannot be started up in the event of a phase failure.

SECTION 9 ELECTRIC HEATING APPLIANCES

1 General

1.1

1.1.1 The use of portable, unsecured heating and cooking appliances is not permitted except for appliances which are under constant supervision when in use, e.g. soldering irons, flat irons and appliances where special precautions are taken to prevent the build-up of heat to ignition temperature (e.g. electric cushions and blankets).

1.1.2 The installation and use of electric heaters is not allowed in spaces where easily flammable gases or vapours may accumulate or in which ignitable dust may be deposited.

2 Space heaters

2.1 Arrangement of heaters

2.1.1 No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

2.1.2 Where heaters are fitted in the bulkhead lining, a trough made of non-combustible material (see Ch 1, Sec 14, [1.4.2] for definition) shall be mounted behind each heater in such a way as to prevent the accumulation of heat behind the lining.

2.1.3 Only waterproof heaters according to IEC 60335 may be used in washrooms, bathrooms and other damp spaces as well as in machinery spaces.

2.2 Enclosures

2.2.1 Heater enclosures are to be so designed that no objects can be deposited on them and air can circulate freely round the heating elements.

2.3 Thermal design of heaters

2.3.1 Electrical space heaters are to be so designed that, at an ambient temperature of 20°C, the temperature of the outer jacket or cover and the temperature of the air flowing from the heater do not exceed 95°C.

For the maximum permissible temperature of control components and their immediate vicinity, see Ch 2, Sec 7, [4.2.1].

2.4 Electrical equipment of heaters

2.4.1 Only heating elements with sheathed or ceramic-encased coils may be used.

To prevent the build-up of heat leading to excessive temperature rises, every heater is to be equipped with thermal protection which interrupts the current as soon as the maximum permissible heater temperature is exceeded. Automatic restarting shall be prevented.

2.4.2 Self regulating material in heating elements may be dispensed with.

2.4.3 The operating switches shall disconnect all live conductors when in the off position. The off position and the positions for the various operating levels shall be clearly marked on the switches.

2.4.4 Every space heater shall normally be connected to a separate circuit. However, a number of small space heaters may be connected to a common circuit provided that their total current input does not exceed 16 A.

3 Oil and water heaters

3.1 General

3.1.1 See Ch 1, Sec 3.

4 Electric ranges and cooking equipment

4.1 Cooking plates

4.1.1 Only enclosed-type cooking plates may be used.

4.2 Switches

4.2.1 The switches of the individual cooking plates shall disconnect all live conductors when in the off position. The switch steps shall be clearly marked.

Switches and other control elements shall be so fitted that they are not exposed to radiant heat from the cooking plates or heating elements. The maximum permissible temperature limits specified in Ch 2, Sec 7, [4.2.1] are applicable.

SECTION 10 LIGHTING INSTALLATIONS

1 General

1.1

1.1.1 Lighting installations are to be designed in compliance with the paragraphs listed below:

- Ch 2, Sec 1, [3.2], Voltages and frequencies
- Ch 2, Sec 6, [3.1], Final subcircuits
- Ch 2, Sec 6, [4.1], Navigation lights
- Ch 2, Sec 1, [1.4.2], Ch 2, Sec 1, [1.4.3] and Ch 2, Sec 1, [1.4.5] to Ch 2, Sec 1, [1.4.12], Explosion proofing
- For additional requirements on lighting installations on passenger vessels, see Pt D, Ch 1, Sec 6, [4.7].

2 Design of lighting installations

2.1

2.1.1 The number of lamps and their distribution shall be such as to ensure satisfactory illumination.

2.1.2 In machinery and service spaces, service passageways, cargo holds and commissary spaces, lighting fixtures are to be provided which are sufficiently robust for this application. The lighting fixtures shall be fitted with impact resistant covers.

2.1.3 Wherever possible, separate circuits are to be provided for plug sockets.

2.1.4 The use of normal shore type light fittings is permitted in accommodation, day rooms and commissary spaces provided that they comply with the Rules contained in [3].

3 Design of lighting fixtures

3.1

3.1.1 Lighting fixtures shall have a base which reflects and dissipates the heat produced by the light source. The mountings used shall provide a gap of at least 5 mm to allow cooling air to circulate between the base of the fixture and a combustible surface to which it is fastened.

Lighting likely to be exposed to more than ordinary risk of mechanical damage shall be protected against such damage or to be of a special robust construction.

3.1.2 The temperature of lighting fixtures should not exceed 60°C where they can be touched easily.

3.1.3 Heat-resistant leads are to be used for the internal wiring of lamp-holders.

3.1.4 Metal lighting fixtures shall be fitted with an earthing screw in the casing or base. All metal parts inside a lighting fixture are to be conductively connected to each other.

The connecting terminals shall be directly fastened to the lighting fixture.

3.1.5 Every lighting fixture shall be permanently marked with the maximum permissible wattage of the lamps to be fitted.

4 Mounting of lighting fixtures

4.1 General

4.1.1 All lighting fixtures are to be mounted in such a way that combustible structural elements such as wood etc. will not be ignited by the heat produced and the lighting fixtures themselves are not exposed to damage.

4.1.2 In bathrooms and shower rooms lighting fixtures shall be mounted in accordance with IEC.

5 Lighting in cargo holds

5.1 General

5.1.1 Where a lighting system is permanently installed, each final subcircuit or each section is to be equipped with switches having clearly marked settings or with pilot lamps showing whether the system is switched on. The switches are to be located outside the holds in positions where they are only accessible to authorized personnel.

The lighting fixtures are to be fitted with sufficiently robust wire guards or impact-resistant covers.

Their method of mounting is to ensure that they cannot be damaged while work is in progress.

For explosion protection see also Ch 2, Sec 1, [1.4.5] to Ch 2, Sec 1, [1.4.12].

6 Lighting of engine rooms

6.1 General

6.1.1 The lighting equipment of engine rooms is to be distributed on two or more circuits so that there still remains sufficient lighting to enable work to continue if there is failure of a circuit.

SECTION 11 INSTALLATION MATERIAL

1 Design and mounting

1.1

1.1.1 Installation appliances shall be adequately protected against mechanical damage and shall be made of corrosion-resistant materials.

Where appliances with casings of brass or other copper alloys are fixed to aluminium surfaces, they shall be insulated from the latter to protect them against corrosion.

1.1.2 The cable entries of the appliances shall be of a size compatible with the cables to be connected and shall be selected to suit the type of cable concerned.

1.1.3 The space inside appliances shall be sufficient to enable insulated conductors to be connected without having to make sharp bends. Corners, edges and projections shall be well rounded.

1.1.4 Mobile appliances are to be provided with means of relieving tension in the cable so that the conductors are not subjected to tensile load.

1.1.5 Terminals, screws and washers shall be made of brass or another corrosion-resistant material.

2 Plug connections and switches

2.1

2.1.1 The live contact components of sockets (outlets) and plugs shall be so enclosed that they cannot be touched under any circumstances, even during insertion of the plug.

2.1.2 The sockets for amperages over 16 A shall be interlocked with a switch in such a way that the plug can be neither inserted nor withdrawn as long as the socket contact sleeves are live.

2.1.3 Where a vessel is provided with sockets for a variety of distribution systems differing in voltage or frequency, use is to be made of sockets and plugs which cannot be confused in order to ensure that an appliance cannot be connected to a socket belonging to the wrong system.

2.1.4 Plug connections shall conform to the required class of enclosure irrespective of whether or not the plug is in or out.

2.1.5 Wherever possible, appliances are to be so designed and mounted that the plugs are inserted from below.

2.1.6 Apart from the sockets standardized and specifically approved for use in shipbuilding practice, accommodation and day rooms may also be provided with sockets designed for use on shore provided that they are mounted in a dry position.

2.1.7 Only sockets with a permissible operating voltage in accordance with Ch 2, Sec 1, Tab 7 are allowed in washrooms and bathrooms. No sockets or switches may be fitted in shower cubicles, shower cabinets or close to bathtubs. Exempted from this rule are razor sockets with an isolating transformer.

2.1.8 Switches shall simultaneously connect and disconnect all the non-earthed conductors of a circuit. Single-pole disconnection is permitted only in the accommodation area for the switches of lighting circuits not carrying more than 16 A.

2.1.9 No plug connections are normally to be provided in cargo holds.

Where power sockets are essential in special cases, e.g. for supplying power to refrigerated containers, they are to be supplied from their own subdistribution boards with fused outlet switches which can be centrally disconnected and are located outside the cargo holds.

The subdistribution boards shall be provided with devices indicating when they are live and which outlets are connected/disconnected.

Sockets may only be installed at locations which give adequate protection against mechanical damage.

SECTION 12 CABLES AND INSULATED WIRES

1 General

1.1

1.1.1 As a general principle, the use of the types of cables and wires according to IEC 60092 is permitted. In addition, equivalent cables and lines may be approved by the Society.

1.1.2 Except for lighting and space heating, only cables with multi-strand conductors are to be used.

1.1.3 The voltage rating of a cable may not be less than the rated working voltage of the relevant circuit.

In insulated distribution systems the outer conductor voltage of the system is to be deemed to be the rated voltage of the cable between a conductor and the vessel's hull, because in the event of a fault, e.g. outer conductor shorting to earth, this voltage may occur for a prolonged period between an intact outer conductor and the vessel's hull.

2 Choice of cables

2.1 Temperatures

2.1.1 In positions liable to be subjected to high ambient temperatures, only cables whose permissible temperature is at least 10 K above the maximum ambient temperature to be expected may be used. A correction factor is to be applied to the permissible loading (see Tab 1).

Cables on diesel engines, heaters etc. liable to be exposed to high temperatures are to be routed so that they are protected against excessive external heating. If this is not possible, oil-resistant cables with high heat resistance are to be used. Cables not previously used are to be submitted to the Society for approval before installation.

2.2 Fire resistance

2.2.1 Cables and insulated wires shall be flame-retardant (IEC 60332) and self-extinguishing.

2.3 Cable sheaths

2.3.1 On open decks, in damp or wet rooms, in service rooms and wherever condensation or harmful vapours (oil vapours) may occur, only cables with impermeable sheaths resistant to the environmental influences may be used.

PVC (polyvinyl chloride), CSP (chlorosulphonated polyethylene) and PCP (polychloroprene) sheaths are deemed to fall into this category, although they are unsuitable for long-term immersion in liquids.

2.4 Movable connections

2.4.1 Machines or equipment mounted on rubber or spring vibration absorbers are to be connected via cables or wires with sufficient flexibility.

Mobile equipment is in all cases to be supplied by heavy, flame-retardant and oil-resistant rubber-sheathed flexible cords such as HO7RN-F-CENELEC HD 22 or equivalent.

For working voltages above 50 V, the movable connecting cables or wires for non-double-insulated equipment shall include an earthed conductor, which is to be specifically marked.

In spaces in the accommodation area, lightweight flexible cords are also permitted.

3 Determination of conductor cross sections

3.1 General requirements

3.1.1 The sizes of cables and wires are to conform to the details in Tab 3 respectively in Tab 4 unless other conductor cross-sections are necessitated by the permissible voltage drop for particular equipment items (see [3.1.3]) or by the elevated ambient temperature or by a special permissible working temperature (see also [3.2.1] - Minimum cross sections). See Tab 1 for the correction factor.

Table 1 : Correction factors for cables in higher ambient temperatures

Maximum permissible conductor operating temperature		Ambient temperature, in °C				
°C	Table	40	45	50	60	70
60	Tab 3	1	0,87	0,71	-	-
85	Tab 4	1	0,94	0,89	0,74	0,57

3.1.2 Parallel cables may be calculated with the sum of their permissible loads and may be fused in common provided that the current is equally shared between all the parallel cables.

In every case, only cables of the same cross-sectional area and length shall be used as parallel cables.

3.1.3 The cross-section of cables and wires is to be determined not only by reference to the permissible current load but also according to the permissible voltage drop. The voltage drop between the main switchboard and the most unfavourable point of the system under consideration may not exceed 5% for lighting or 7% for power and heating circuits. In the case of transient loads, caused for example by start-ups, it is necessary to ensure that the voltage drop in the cable does not occasion any malfunction of the system.

3.2 Minimum cross-sections

3.2.1 The minimum cross-section of permanently laid cables and wires in power, heating, lighting systems and control circuits for power plants shall be 1,0 mm²; in control circuits of safety systems 0,75 mm²; in automation and telecommunication equipment 0,5 mm²; in telecommunication systems not relevant to the safety of the vessel and for data bus/data cables 0,2 mm².

Within accommodation and day rooms, flexible leads with a conductor cross-section of 0,75 mm² and over may also be used for the mobile connection of appliances with a current input of up to 6 A.

3.3 Hull return conductors

3.3.1 See Ch 2, Sec 6, [2.1]

3.4 Protective earth wires

3.4.1 See Ch 2, Sec 1, [1.4.4]

3.5 Neutral conductors of 3-phase systems

3.5.1 The cross-section of neutral conductors of 3-phase systems is to equal at least half that of the outer conductors. Where the cross-section of the outer conductors is 16 mm² or less, the cross-section of the neutral conductor shall equal that of the outer conductors.

4 Cable overload protection

4.1 General requirements

4.1.1 All cables and wires with the exception of hull return, neutral and earthing conductors are to be fitted with fuses in accordance with Tab 3 respectively Tab 4.

4.1.2 Where protection is afforded by power circuit breakers with overcurrent and short-circuit trip, the overcurrent trip is to be set in accordance with the maximum permissible current loads shown in Tab 3 respectively Tab 4. The short-circuit trip shall be set to 4-6 times the indicated amperages.

For short-circuit protection, see also Ch 2, Sec 7, [3.9.1].

4.1.3 The exciter conductors of DC motors and DC generators operating in parallel may not be fitted with fuses except in the case of special installations. The exciter conductors of individually connected DC generators and 3-phase synchronous machines may be fused only where there are special grounds for doing so, e.g. where the cables are run through several of the vessel's main vertical zones.

5 Cable laying

5.1 General

5.1.1 Cables from generators and all cables going out from the main or emergency switchboard up to the distribution boards or the power consumers themselves shall be laid undivided and in a single length. The same applies to all connecting cables in essential systems. Exemptions are subject to the Society's express approval (e.g. for vessel extensions or barrier containers at the movable cable loop below the wheelhouse).

For elastically mounted machinery and equipment, adequate freedom of movement shall be ensured by compensation bends.

5.1.2 In DC systems without hull return multi-core cables are to be used for the smaller cross-sections. When using single-core cables for large cross-sections, the outgoing and return lines shall be laid as close as possible to each other over their entire length to avoid stray magnetic fields.

5.1.3 In 3-phase systems without hull return, 3-core cables are to be used for 3-phase connections; and 4-core cables are to be used for circuits with charged neutral. The use of a 3-core cable and a separate neutral conductor is only permissible if the current in the latter does not exceed 20 A.

5.1.4 In single or 3-phase AC systems, single-core cables carrying a current above 20 A are to be avoided. If such a method of installation cannot be avoided, the measures to be taken are to be agreed with the Society.

5.1.5 Cables whose maximum permissible temperature of the conductor differ by more than 5 K from each other may be laid in a common bundle only if the permissible loadings of the lowest-capacity type are taken as the basis for all cables.

5.1.6 Should it be impossible to use multi-core cables in accordance with [5.1.3] in single or 3-phase AC systems because of the connection difficulties associated with high power ratings, approval may be given for the laying of single-core cables and wires subject to compliance with special requirements which are to be agreed with the Society in each case.

5.1.7 Tab 2 indicates the minimum internal radius of curvature of cable bends according to the type and outside diameter of the cable concerned.

Table 2 : Minimum internal radius of curvature

Outer diameter of cable (D), in mm	Cables without metal sheath or braid	Cables with metal sheath or braid
up to 25	4 D	6D
over 25	6 D	6D

Table 3 : Current rating of cables with a maximum permissible conductor temperature of 60°C at an ambient temperature of 40°C

1	2	3	4	5	6	7
Nominal cross-section of the copper conductor, in mm²	Continuous service		Short time service S 2 = 30 min.		Short time service S 2 = 60 min.	
	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current
	[A]	[A]	[A]	[A]	[A]	[A]
Single-core cables						
1,0	9	10	10	10	10	10
1,5	14	16	15	15	15	15
2,5	19	20	20	20	20	20
4	26	25	28	25	28	25
6	34	36	36	36	36	36
10	46	50	49	50	49	50
16	62	63	66	63	66	63
25	82	80	87	80	87	80
35	101	100	108	100	107	100
50	126	125	136	160	134	160
70	156	160	171	160	165	160
95	189	160	217	224	202	200
120	219	224	251	250	234	224
150	251	250	294	300	271	250
185	287	250	353	315	311	300
240	337	315	420	-	371	-
300	388	355	500	-	435	-
Two-core cables						
1,0	8	6	9	10	9	10
1,5	11	10	12	16	12	16
2,5	17	16	18	20	18	20
4	22	20	23	25	23	25
6	29	25	31	25	31	25
10	39	36	41	36	41	36
16	53	50	60	63	56	63
25	70	63	83	80	75	80
Three or four-core cables						
1,0	6	6	7	10	7	10
1,5	9	10	10	10	10	10
2,5	14	16	15	16	15	16
4	18	20	19	20	19	20
6	24	25	25	25	25	25
10	32	36	36	36	34	36
16	43	36	50	50	46	50
25	57	50	70	63	60	63
35	71	63	88	80	75	80
50	89	80	115	100	100	100
70	109	100	151	125	125	125
95	132	125	194	200	161	160
120	153	160	234	225	161	200
5 to 24-core cables 1,5 mm²						
5	8	6				
7	7	6				
10	6	6				
12	6	6				
14	6	6				
16	6	6				
19	5	4				
24	5	4				

Table 4 : Current rating of cables with a maximum permissible conductor temperature of 85°C at an ambient temperature of 40°C

1	2	3	4	5	6	7
Nominal cross-section of the copper conductor in mm²	Continuous service		Short time service S 2 = 30 min.		Short time service S 2 = 60 min.	
	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current
	[A]	[A]	[A]	[A]	[A]	[A]
Single-core cables						
1,0	17	16	18	16	18	20
1,5	22	20	23	20	23	20
2,5	30	25	32	25	32	36
4	40	36	42	36	42	50
6	52	50	55	50	55	63
10	72	63	76	63	76	80
16	96	100	102	100	102	100
25	127	125	135	125	135	160
35	157	160	168	160	166	224
50	196	200	212	224	208	250
70	241	224	264	300	255	300
95	292	300	327	315	311	315
120	338	315	387	-	362	-
150	389	400	455	-	420	-
185	443	425	532	-	481	-
240	522	500	650	-	574	-
300	600	630	765	-	672	-
Two-core cables						
1,0	14	10	15	16	15	16
1,5	19	20	20	20	20	20
2,5	26	25	28	25	28	25
4	34	36	36	36	36	36
6	44	36	47	50	47	50
10	61	63	65	63	65	63
16	82	80	93	100	87	100
25	108	100	127	125	115	125
Three or four-core cables						
1,0	12	10	13	16	13	16
1,5	15	16	16	16	16	16
2,5	21	20	22	25	22	25
4	28	25	30	36	30	36
6	36	36	38	36	38	36
10	50	50	56	63	53	50
16	67	63	75	80	71	63
25	89	80	110	100	96	80
35	110	100	138	125	120	100
50	137	125	178	160	153	125
70	169	160	235	224	194	160
95	205	200	300	300	250	250
120	237	224	365	315	296	300
5 to 24-core cables 1,5 mm²						
5	13	10				
7	11	10				
10	10	10				
12	10	10				
14	9	6				
16	9	6				
19	8	6				
24	8	6				

6 Cable runs

6.1 General

6.1.1 Cable runs are to be so selected that cables can, wherever possible, be laid in straight lines and are not exposed to mechanical damage. Continuous cable runs shall not be routed along the shell plating and its frames.

6.1.2 Sources of heat such as boilers, hot pipes etc. shall be by-passed to avoid exceeding the permissible end temperature of the cable conductors. Where this is not possible, the cables are to be shielded from radiant heat.

6.1.3 Where, for safety reasons, an installation is provided with double feeder cables, these are to be laid as far apart as possible.

Cable runs are to be protected against corrosion.

7 Fastening of cables and wires

7.1 General

7.1.1 Cables are to be fastened to trays or carriers. Individually run cables are to be fixed with clips.

7.1.2 Cables and wires are to be fastened with clips, straps or bindings made of galvanized steel strip, copper or brass strip.

Other established fastenings approved by the Society may also be used.

Cadmium coated or galvanized steel screws and galvanized clips or fastenings of other suitable materials are to be used for fixing cables to aluminium surfaces.

Clips used for mineral-insulated copper-sheathed cables shall be made of copper alloy if in electrical contact with the cable-sheath.

8 Tension relief

8.1 General

8.1.1 Cables are to be fastened in such a way that any tensile loads are kept within the permissible limits. This is particularly applicable to cables with a small cross-section and to those installed in vertical trays or vertical ducts.

9 Protection against mechanical damage

9.1 General

9.1.1 Cables in cargo holds, on deck and in locations where they are particularly exposed to the danger of mechanical damage, including especially cables laid up to a height of 500 mm above floor, are to be provided with additional protection in form of sheaths or ducts.

Cable coverings are to be conductively connected to the vessel's hull.

10 Laying of cables and wires in conduits or enclosed metal ducts

10.1 General

10.1.1 Conduits and ducts shall be smooth on the inside and shall have ends shaped to avoid damaging the cable covering or sheath. They are to be provided with drainage holes measuring at least 10 mm in diameter.

Bores and bending radii shall be such as to enable the cables to be inserted without difficulty.

10.1.2 Cables may only occupy up to a maximum of 40% of the clear cross-section of conduits and ducts, the aggregate cross-section of the cables being the sum of the individual cross-sections calculated from the cable diameters.

10.1.3 Extensive cable ducts and conduits are to be fitted with inspection and draw containers.

11 Laying in non-metallic conduits and ducts

11.1 general

11.1.1 The conduits or ducts shall be made of flame-retardant material.

12 Bulkhead and deck penetrations

12.1 General

12.1.1 Where cables pass through bulkheads or decks, the cable penetrations shall not impair the mechanical strength, watertightness or fire resistance of the bulkheads and decks concerned.

12.1.2 Cable lead-throughs in watertight bulkheads or decks are to take the form of individual gland-type lead-throughs or, in the case of cable bundles, collective lead-throughs of a type approved by the Society. Sealing may be effect with casting resins or elastic plugs.

If casting resin is used, the cables shall be run and encased in the resin over a length of at least 150mm inside the lead-through.

13 Cables laid in refrigerated spaces

13.1 General

13.1.1 Cables may be laid neither in nor directly upon the thermal insulation of these spaces. They are to be installed on perforated metal plates or spacing clips clear of the covering of the insulating layer. Excepted from this are individual cables with plastic outer sheathing, which may be laid directly on the insulation covering.

14 Cable laying to wheelhouses using extending cable feeds (moveable cable loops)

14.1 General

14.1.1 The following points are to be specially considered when selecting and laying the cables for variable-height wheelhouse and control platforms:

- Choice of cable types possessing the necessary flexibility and resistance to oil and to high and low temperatures (e.g. HO7RN-F)
- Use of increased bending radii at locations subject to severe mechanical loads
- Cable attachment using metal cable straps or clips
- Suitable protection against mechanical damage.

15 Cable junctions and branches

15.1 General

15.1.1 Branches from cables and wires may only be made inside containers.

15.1.2 Junction and distribution containers shall be located in easily accessible positions and shall be clearly marked.

15.1.3 As a general principle, only one circuit shall be led through any one box. Should it be necessary to lead a larger number of circuits through one box, the terminals are to be so arranged that similar circuits are adjacent to each other. The terminals for dissimilar systems or for systems with different working voltages are to be separated from each other by partitions. All terminals are to be clearly and indelibly marked. A terminal connection diagram is to be mounted on the box cover.

15.1.4 It is necessary to effect the continuous conductive connection of all metal cable sheaths, particularly inside cable distribution and junction containers.

Metal cable sheaths, armouring, screening and shielding shall normally be conductively connected to the vessel's hull at both ends. In the case of single-core cables in single phase AC systems, only one end is to be earthed. The earthing at one end only of cables and wires in electronic systems is recommended.

SECTION 13 CONTROL, MONITORING, ALARM AND SAFETY SYSTEMS

1 Scope

1.1 General requirements

1.1.1 This Section sets out requirements for the control, monitoring, alarm and safety systems necessary to operate essential equipment for vessel's propulsion, steering and safety.

1.2 Planning and design

1.2.1 The design of safety measures, open and closed loop controls and monitoring of equipment must limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

1.2.2 Where appropriate, the following basic requirements shall be observed:

- compatibility with the environmental and operating conditions
- compliance with accuracy requirements
- recognizability and constancy of the parameter settings, limiting and actual values
- compatibility of the measuring, open and closed loop controls and monitoring systems with the process and its special requirements
- immunity of system elements to reactive effects in overall system operation
- non-critical behaviour in the event of power failure, restoration and of faults
- unambiguous operation
- maintainability, the ability to recognize faults and test capability
- reproducibility of values.

1.2.3 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

1.2.4 If dangers to persons or the safety of the vessel arising from normal operation or from faults or malfunctions in machinery or plant, or in control, monitoring and measuring systems, cannot be ruled out, safety devices or safety measures are required.

1.2.5 If dangers to machinery and systems arising from faults or malfunctions in control, monitoring and measuring systems cannot be ruled out, protective devices or protective measures are required.

1.2.6 Where mechanical systems or equipment are either completely or partly replaced by electric / electronic equipment, the requirements relating to mechanical systems and electric / electronic equipment shall be met accordingly.

1.3 Design and construction

1.3.1 Machinery alarm systems, protection and safety systems, together with open and closed loop control systems for essential equipment shall be constructed in such a way that faults and malfunctions affect only the directly involved function. This also applies to measuring facilities.

1.3.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities must be provided to permit independent manual operation.

Manual operation shall override all remote and automatical control.

1.3.3 In the event of disturbances automatically switched off plants shall not be released for restarting until having been manually unlocked.

1.4 Application of computer systems

1.4.1 If computer systems are used, Ch 2, Sec 16 has to be observed.

1.5 Maintenance

1.5.1 Access must be provided to systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps etc. are to be provided to allow functional checks to be carried out and faults to be located.

1.5.2 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

1.5.3 Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign must be fitted to indicate the risk.

1.5.4 Circuit boards and plug-in connections must be protected against unintentional mixing up. Alternatively they must be clearly marked to show where they belong to.

2 Machinery control and monitoring installations

2.1 Safety devices

2.1.1 The design of safety devices shall be as simple as possible and must be reliable and inevitable in operation. Proven safety devices which are not depending on a power source are to be preferred.

2.1.2 The suitability and function of safety devices must be demonstrated in the given application.

2.1.3 Safety devices shall be designed so that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, vessel or machinery.

These faults and also the tripping of safety devices shall be signalled by an alarm.

2.1.4 The adjustment facilities for safety devices shall be designed so that the last setting can be detected.

2.1.5 Where auxiliary energy is needed for the function of safety devices, this has to be monitored and a failure has to be alarmed.

2.2 Safety systems

2.2.1 Safety systems shall be independent of open and closed loop control and alarm systems. Faults in one system shall not affect other systems.

Deviations from this requirement may be allowed for redundant equipment where this would entail no risk to human life and where vessel safety would not be compromised.

2.2.2 Safety systems shall be assigned to systems which need protection.

2.2.3 Where safety systems are provided with overriding arrangements, these shall be protected against unintentional operation. The actuation of overriding arrangements shall be indicated and recorded.

2.2.4 The monitored open-circuit principle shall be used for safety systems. Alternatively, the closed circuit principle shall be applied where the provisions of national Regulations demand it. (e.g. boiler and oil fired systems).

Equivalent monitoring principles are permitted. Faults, and also the tripping of safety systems shall be indicated by an alarm and recorded.

2.2.5 Safety systems shall be designed for preference using conventional technology (hard wired).

2.2.6 The power supply shall be monitored and loss of power shall be indicated by an alarm and recorded.

The power supply to the safety system is to be maintained for at least 15 minutes following a possible failure of the vessel's general supply network. Separate provision shall be made for this.

2.2.7 Safety systems are to perform the following functions when hazard limits are reached:

a) Temporary adaptation of operation to the remaining possibilities (slow down or signal to reduce power)

b) Protection of machinery and boilers from critical operating conditions (shutdown or signal to shut down).

Within certain limits, safety systems provide redundancy for the alarm system.

2.3 Open loop control

2.3.1 Main engines and essential equipment shall be provided with effective means for the control of its operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems, see also [1.2.2].

2.3.2 Control equipment must have built-in protection features where incorrect operation would result in serious damage or in the loss of essential functions.

2.3.3 The consequences of control commands must be indicated at the respective control station.

2.3.4 Controls shall correspond with regard to their position and direction of operation to the system being controlled respective to the direction of motion of the vessel.

2.3.5 It shall be possible to control the essential equipment at or near to the equipment concerned.

2.3.6 Where controls are possible from several control stations, the following shall be observed:

- Competitive commands shall be prevented by suitable interlocks. The control station in operation must be recognizable as such.
- Taking over of command shall only be possible with the authorization of the user of the control station which is in operation.
- Precautions shall be taken to prevent changes to desired values due to a change-over in control station.

2.3.7 Open loop control for speed and power of main engines are subject to mandatory type testing.

2.4 Closed loop control

2.4.1 Closed loop control shall keep the process variables under normal conditions within the specified limits.

2.4.2 Closed loop controls must maintain the specified reaction over the full control range. Anticipated variations of the parameters must be considered during the planning.

2.4.3 Defects in a control loop shall not impair the function of operationally essential control loops.

2.4.4 The power supply of operationally essential control loops shall be monitored and power failure must be signalled by an alarm.

2.4.5 Closed loop control for speed and power of main engines are subject to mandatory type testing.

2.5 Alarm systems

2.5.1 Alarm systems shall indicate unacceptable deviations from operating figures optically and audibly. The operative state of the system is to be indicated in the wheelhouse and on the equipment.

2.5.2 Alarm delays shall be kept within such time limits that any risk to the monitored system is prevented if the limit value is exceeded.

2.5.3 Optical signals shall be individually indicated. The meaning of the individual indications must be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal must remain visible until the fault has been eliminated. It must be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

2.5.4 It must be possible to acknowledge audible signals.

The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes. Alarms must be discernible under all operating conditions.

Where this cannot be achieved, for example due to the noise level, additional optical signals, e.g. flashing lights must be installed.

2.5.5 Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

2.5.6 Alarm systems shall be designed according to the closed-circuit principle or the monitored opencircuit principle. Equivalent monitoring principles are permitted.

2.5.7 The power supply shall be monitored and a failure shall cause an alarm. Test facilities are required for the operation of light displays.

The alarm system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

2.5.8 Alarms are to be given at manned location in the machinery control position, if any, or in the wheelhouse and are to take the form of individual visual displays and collective audible signals. The audible alarm shall sound throughout the whole machinery space, at manned location in the machinery control position and at the wheelhouse. If this cannot be ensured because of the noise level, additional visual alarms such as flash signals shall be installed.

Simultaneously with a collective alarm signal, an acknowledgeable audible alarm shall be given at manned location in the machinery control position and in the wheelhouse which, following acknowledge, shall be available for further signals. It must be possible to stop audible signals independently of acknowledging the visual signal. Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the concerned process is been given.

2.5.9 Where the alarm system contents individual visual displays in the machinery space, the visual fault signals in the wheelhouse may be arranged in at least three groups as collective alarms in accordance with their urgency, if this is necessary due the scope of the plant.

- Group 1: Alarms signalling faults which require immediate shutdown of the main engine (red light).
- Group 2: Alarms signalling faults which require a reduction in power of the main engine (red light).
- Group 3: Alarms signalling faults which do not require Group 1 or Group 2 measures (yellow light).

2.5.10 Pressure alarms may in general not be delayed by more than 2 s. Level alarms are to be delayed sufficiently to ensure that the alarm is not tripped by brief fluctuations in level.

2.5.11 A failure of the power supply or disconnection of the system shall not alter the limit value settings at which a fault is signalled.

2.5.12 The fault signalling systems of main engines with engine-driven pumps are to be so designed that variations in operating parameters due to manoeuvres do not trip the alarm.

2.5.13 It is recommended that input devices approved by the Society should be used.

2.5.14 It is recommended that the alarm signals should be automatically suppressed when the main engine and auxiliaries are taken out of service.

2.6 Integration of systems for essential equipment

2.6.1 The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

2.6.2 A defect in one of the subsystems (individual module, unit or subsystem) of the integrated system shall not affect the function of other subsystems.

2.6.3 Any failure in the transfer of data of autonomous subsystems which are linked together shall not impair their independent function.

2.6.4 Essential equipment must also be capable of being operated independently of integrated systems.

2.7 Control of machinery installations

2.7.1 Machinery installations are to be equipped with monitoring equipment as detailed in Tab 1.

2.7.2 The remote control shall be capable to control speed, direction of thrust, and as appropriate torque or propeller pitch without restriction under all navigating and operating conditions.

2.7.3 Single lever control is to be preferred for remote control systems. Lever movement shall be in accordance to the desired course of the vessel. Commands entered into the remote control system from the wheelhouse must be recognizable at all control stations.

2.7.4 The remote control system shall carry out commands which are ordered, including emergency manoeuvres, in accordance with the propulsion plant manufacturer's specifications.

Where critical speed ranges are incorporated, their quick passing is to be guaranteed and a reference input within them have to be inhibited.

2.7.5 With each new command, stored commands must be erased and replaced by the new input.

2.7.6 In the case of set speed stages, a facility must be provided to change the speed in the individual stages.

2.7.7 An overload limitation facility is to be provided for the propulsion machinery.

2.7.8 It must be possible to stop the propeller thrust from the wheelhouse independently of the remote control system.

2.7.9 Following emergency manual shutdown or automatic shutdown of the main propulsion plant, a restart shall only be possible via the stop position of the command entry.

2.7.10 The failure of the remote control system and of the control power shall not result in any sudden change in the propulsion power nor in the speed and direction of rotation of the propeller. In individual cases, the Society may approve other failure conditions, whereby it is assumed that:

- there is no increase in vessel's speed
- there is no course change
- no unintentional start-up processes are initiated.

Local control must be possible from local control positions. The local control positions are to be independent from remote control of propulsion machinery and continue to operate 15 minutes after a blackout.

2.7.11 The failure of the remote control system and of the control power is to be signalled by an alarm.

2.7.12 Wheelhouse and engine room are to be fitted with indicators indicating that the remote control system is operative. The wheelhouse and the machinery space are to be provided with indicators showing:

- propeller speed and direction of rotation
- pitch of controllable pitch propeller.

2.7.13 Remote control systems for main propulsion plants are subject to mandatory type approval.

2.7.14 The transfer of control between the wheelhouse and machinery space shall be possible only in the machinery area.

2.7.15 It shall be ensured that control is only possible from one control station at any time. Transfer of command from one control station to another shall only be possible when the respective control levers are in the same position and when a signal to accept the transfer is given from the selected control station. A display at each control station shall indicate whether the control station in question is in operation.

2.7.16 Each local control position, including partial control (e.g. local control of controllable pitch propellers or clutches) is to be provided with means of communication with the remote control position.

Table 1 : Control of machinery installations

Symbol convention H = High, HH = Very high L = Low I = Individual alarm G = Group alarm		Monitoring				
Identification of system parameter		Alarms	Indication local	Alarms wheelhouse **(4)**	Indication wheelhouse	Shut down
MAIN ENGINE						
Engine speed	All engines		x			
	Engine power > 220kW	HH	x	G		x
Shaft revolution indicator			x			
Lubricating oil pressure		L	x	G		
Lubricating oil temperature		H	x	G		
Fresh cooling water system inlet pressure **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Fuel oil temperature for engines running on HFO		L	x	G		
Exhaust gas temperature (single cylinder when the dimensions permit)			x			
Starting air pressure		L	x	G	x	
Charge air pressure			x			
Control air pressure			x			

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

Symbol convention H = High, HH = Very high L = Low I = Individual alarm G = Group alarm		Monitoring				
Identification of system parameter		Alarms	Indication local	Alarms wheelhouse **(4)**	Indication wheelhouse	Shut down
Exhaust gas temperature at turbocharger inlet/outlet (where the dimensions permit)			x			
Manual emergency stop of propulsion		x	x			x **(3)**
Fault in the electronic governor		x	x	G		
REDUCTION GEAR						
Tank level			x			
Lubricating oil temperature			x			
Lubricating oil pressure			x			
AUXILIARY MACHINE (2)						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Lubricating oil pressure		L	x	G		
Fault in the electronic governor		x	x	G		
DIESEL BOW THRUSTER (2)						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system **(1)**		L	x	G		
Fresh cooling water system outlet temperature **(1)**		H	x	G		
Direction of propulsion			x			
Lubricating oil pressure		L	x	G		
Lubricating oil temperature			x			
Fault in the electronic governor		x	x	G		
PROPULSION						
Propulsion remote control ready			x			
Pitch control			x			
ELECTRICITY						
Earth fault (when insulated network)		x	x	G		
Main supply power failure		x	x	G		
FUEL OIL TANKS						
Fuel oil level in service tank or tanks supplying directly services essential for safety or navigation		L	x	G		
STEERING GEAR						
Rudder angle indicator			x		x	
Level of each hydraulic fluid		L	x	I	x	
Hydraulic fluid temperature		H	x	I	x	

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

Symbol convention H = High, HH = Very high L = Low I = Individual alarm G = Group alarm	Monitoring				
Identification of system parameter	Alarms	Indication local	Alarms wheelhouse **(4)**	Indication wheelhouse	Shut down
Indication that electric motor of each power unit is running		x		x	
Failure of rate of turn control	x		I	x	
Overload failure	x	x	I	x	
Phase failure	x	x	I	x	
Loss of power supply	x	x	I	x	
Loss of control supply	x	x	I	x	
STEAM BOILER OR HEATING OIL					
High pressure	HH				x
FIRE					
Fire detection	x			x	
Fire manual call point	x			x	
Automatic fixed fire extinguishing system activation, if fitted	x			x	
FLOODING					
Level of machinery space bilges/drain wells	x			x	
ALARM SYSTEM					
Alarm system power supply failure	x	x		x	

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

SECTION 14 POWER ELECTRONICS

1 General

1.1

1.1.1 For power electronics in electrical propulsion plants, see Ch 2, Sec 15.

2 Construction

2.1 General

2.1.1 The rules set out in Ch 2, Sec 1 to Pt D, Ch 2, Sec 8 are to be observed, wherever applicable.

2.1.2 Each power-electronics system shall be provided with separate means for disconnection from the mains.

In the case of consumers up to a nominal current of 315 A the combination fuse-contactor may be used. In all other cases a circuit breaker shall be provided on the mains side.

2.1.3 Equipment shall be readily accessible for purposes of measurement and repair. Devices such as simulator circuits, test sockets, indicating lights, etc. are to be provided for functional supervision and fault location.

2.1.4 Control and alarm electronics must be galvanically separated from power circuits.

2.1.5 External pulse cables are to be laid twisted in pairs and screened, and kept as short as possible.

3 Rating and Design

3.1 General

3.1.1 Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation, see Ch 2, Sec 4, [1] and Ch 2, Sec 8, [1].

3.1.2 Rectifier systems must guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, see Ch 2, Sec 4, [1]. In the event of unacceptably large frequency and/or voltage variations in the supply voltage, the system must shut-off or remain in a safe operating condition.

3.1.3 The semiconductor rectifiers and the associated fuses shall be so selected that their load current is at least 10% less than the limit current determined in accordance with the coolant temperature, the load and the mode of operation.

3.1.4 Electrical charges in power electronic modules must drop to a voltage of less than 50 V in a period of less than 5s after disconnection from the mains supply. Should longer periods be required for discharge, a warning label is to be affixed to the appliance.

3.1.5 If the replacement of plug-in printed circuit boards while the unit is in operation can cause the destruction of components or the uncontrolled behaviour of drives, a caution label must be notifying to this effect.

3.1.6 The absence of external control signals, e.g. due to a circuit break, shall not cause a dangerous situation.

3.1.7 Control-circuit supplies are to be safeguarded against unintended disconnection, if this could endanger or damage the plant.

3.1.8 It is necessary to ensure that, as far as possible, faults do not cause damage in the rest of the system, or in other static converters.

3.1.9 Special attention shall be paid to the following points:

- mutual interference of static converters connected to the same busbar system
- to voltage distortion and reacting to other consumers
- the selection of the ratio between the subtransient reactance of the system and the commutating reactance of the static converter
- consideration of reactions from rectifier installations on the commutation of DC machines
- influence by harmonics and high-frequency interference.

Where filter circuits and capacitors are used for reactive current compensation, attention is to be paid to the following:

- reaction on the mean and peak value of the system voltage in case of frequency fluctuations
- inadmissible effects on the voltage regulation of generators.

4 Cooling

4.1 General

4.1.1 Natural cooling is preferred.

4.1.2 The safety in operation shall be proved for liquid cooling and forced cooling.

4.1.3 An impairment of cooling shall not result in unacceptable overtemperatures, an overtemperature alarm shall be provided.

5 Control and monitoring

5.1 General

5.1.1 Control, adjustment and monitoring must ensure that the permissible operating values of the facilities are not exceeded.

6 Protection equipment

6.1 General

6.1.1 Power electronic equipment shall be protected against exceeding of their current and voltage limits.

For protective devices, it must be ensured that upon actuating:

- the output will be reduced or defective part-systems will be selectively disconnected
- drives will be stopped under control
- the energy stored in components and in the load circuit cannot have a damaging effect, when switching off.

6.1.2 Special semiconductor fuses shall be monitored. After tripping the equipment has to be switched off, if this is necessary for the prevention of damage. Activating of a safety device shall trigger an alarm.

6.1.3 Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semiconductor components.

7 Tests

7.1 General

7.1.1 Power electronics assemblies shall be individually tested at the maker's works. A Works Test Report shall be rendered on the tests carried out. Essential equipment from 50 kW/kVA upwards shall be tested in the presence of a Society Surveyor.

7.2 Extent of routine tests

7.2.1 Voltage test

Prior to the start of the operational tests a high-voltage test shall be carried out. The RMS value of the alternating test voltage is:

$U = 2U_n + 1000\ v \geq 2000V$

duration: 1 minute

where:

U_n : Maximum nominal voltage between any two points on the power electronics device

For this purpose, switchgear in power circuits shall be bridged, and the input and output terminals of the power electronics devices and the electrodes of the rectifiers shall be electrically connected with each other. The test voltage shall be applied between the input/output terminals or between the electrodes and:

- the cabinet
- the mains connection side, if the power electronics device is electrically isolated from the mains.

7.2.2 Test of insulation resistance

Following the voltage test, the insulation resistance shall be measured at the same connections as for the voltage test. The measurement shall be performed at a voltage of at least 500 V DC. The resistance shall be at least 1 kOhm/V.

7.2.3 Operational test

The function shall be demonstrated as far as possible.

SECTION 15 ELECTRICAL PROPULSION PLANTS

1 General

1.1

1.1.1 A vessel has an electrical main propulsion plant if the main drive to the propeller is provided by at least one electrical propulsion motor.

1.1.2 If a propulsion plant has only one propulsion motor and the vessel has no additional propulsion system which ensures sufficient propulsive power, this plant shall be so structured that following a fault in the static converter or in the regulation- and control system at least a limited propulsion capability remains.

1.1.3 Auxiliary propulsion plants are additionally propulsion systems.

1.1.4 The engines driving the generators for the electrical propulsion plant are main engines. Motors driving the propeller shaft are propulsion motors.

1.1.5 If electrical main propulsion plants are supplied from the vessel's general mains, the Rules in this Section apply also to the generators and the associated switchgear. For auxiliary propulsion plants, the Rules of this Section are to be met correspondingly.

2 Drives

2.1 Basis for dimensioning

2.1.1 The electrical machinery and plants must, in accordance with their service and operating conditions, be designed for short periods of overload and for the effect of manoeuvres.

2.1.2 The lubrication of machinery and shafting shall be designed to be adequate for the entire speed range of rotation in both directions including towing.

2.2 Main engines

2.2.1 The main engines must also conform to the requirements of Part C, Chapter 1, Machinery and systems.

2.2.2 The diesel governors must allow safe operation over the whole speed range and under all running and manoeuvring conditions, this for both, single operation and parallel operation.

2.2.3 The main engines shall be so constructed that under the consideration of the plant conception they can absorb the reverse power arising during reversing manoeuvres.

2.3 Propulsion motors

2.3.1 The propulsion motors must also conform to the requirements of Ch 2, Sec 1 to Ch 2, Sec 13.

2.3.2 The effects of the harmonics of currents and voltages is to be taken into consideration for the design of the propulsion motors.

2.3.3 The winding insulation shall be designed to withstand the overvoltages which may arise from manoeuvres switching operations.

2.3.4 Machines with forced ventilation shall be so dimensioned that in case of ventilation failure a limited operation is still possible. Versions deviating from this principle require an agreement with the Society.

2.3.5 Electrical propulsion motors must be able to withstand without damage a short circuit at their terminals and in the system under rated operating conditions until the protection devices respond.

3 Static converter installations

3.1

3.1.1 Power-electronic equipment must also conform to the requirements of Ch 2, Sec 14.

3.1.2 Static converters must be designed for the load to be expected under all operating and manoeuvring conditions, including overloads and short circuits.

3.1.3 If static converters are separately cooled, the plant must be capable to continue operation at reduced power level if the cooling system fails.

3.1.4 The circuits for main power supply and exciter equipment must be supplied directly from the switchboard and shall be separate for each motor and each winding.

3.1.5 Exciter circuits whose failure can endanger the operation shall only be protected against short circuit.

3.1.6 The static converters must be easily accessible for inspection, repair and maintenance.

4 Control stations

4.1

4.1.1 Should the remote control system fail, local operation must be possible. Changeover must be possible within a reasonably short time. This operation can be made, e.g. from the control cabinet of the propulsion plant. Voice communication with the bridge shall be provided.

4.1.2 The main control station on the bridge shall be provided with an emergency stop device independent of the operating elements of the main control system. Also an emergency stop device in the engine room shall be provided.

4.1.3 All operating functions shall be made logical and simple, to prevent maloperation. The operating equipment shall be clearly arranged and marked accordingly.

4.1.4 A defect in a system for synchronizing or in a position equalization device for control operating levers of several control stations shall not result in the failure of the remote control from the main control position.

5 Vessel's mains

5.1

5.1.1 It must be possible to connect and disconnect generators without interrupting the propeller drive.

5.1.2 If a power management system is available, the automatic stop of main engines during manoeuvring shall be prevented.

6 Control and regulating

6.1

6.1.1 If computer systems are used, the requirements of Ch 2, Sec 16 shall be observed.

6.1.2 An automatic power limitation of the propulsion motors must ensure that the vessel mains will not be overloaded.

6.1.3 The reverse power during reversing or speed-reducing manoeuvres shall be limited to the acceptable maximum values.

7 Protection of the plant

7.1

7.1.1 Automatic stop of the propulsion plant, which impairs the vessel's manoeuvring capability, shall be limited to such failures which would result in serious damage within the plant.

7.1.2 Protection devices must be set to such values that they do not respond to overload occurring during normal operation, e.g. while manoeuvring.

7.1.3 Defects in reducing and stopping devices shall not impair the limited operation in accordance with [1.1.2].

7.1.4 In the event of failure of an actual or reference value it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will be not reversed or dangerous operating conditions arise. The same applies to failure of the power supply for control and regulating.

7.1.5 The following additional protection equipment shall be provided:

- Where drives uncontrolled can be mechanically blocked, they must be provided with protection devices which prevents damage to the plant
- Overspeed protection
- Protection against overcurrent and short circuit
- Differential protection and earth fault monitoring for propulsion motors with an output of more than 1500 kW.

7.1.6 The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition must remain recognizable even after switching-off.

8 Measuring, indicating, monitoring and alarms equipment

8.1 General

8.1.1 Failures in measuring, monitoring and indicating equipment must not cause a failure of control and regulating.

8.2 Measuring equipment and indicators

8.2.1 Propulsion motors and generators shall be provided with at least the measuring equipment and indicators at control stations in compliance with [8.2.2]and [8.2.3].

8.2.2 At local control station:

- ammeter and voltmeter for each supply and each load component
- ammeter and voltmeter for each exciter circuit
- revolution indicator for each shaft
- plant ready for switching on
- plant ready for operation
- plant disturbed
- power reduced
- control from the bridge
- control from local control station.

8.2.3 At main control station on the bridge:

- revolution indicator per shaft
- indication of the power remaining available for the propulsion plant in relation to the total available vessel's main power; the indication of remaining power may be omitted in the case of power management system
- plant ready for switching on
- plant ready for operation
- plant disturbed
- power reduced
- request to reduce
- control from the bridge
- control from the local control station.

8.3 Monitoring equipment

8.3.1 Abnormal values of the different parameters of the equipment listed here below should trigger an alarm which has been signalled optically and audibly:

a) Monitoring of the ventilators and temperatures of the cooling air for forced-ventilation of machines, transformers and static converters.

b) Monitoring of the flow rate and leakage of coolants of machines and static converters with closed cooling systems.

c) Instead of the monitoring of air flow and flow rate (a and b) of machines and transformers, winding-temperature monitoring can be provided.

d) For machines above 1500 kW, temperature monitoring for the stator windings and the bearings.

e) Pressure- or flow monitoring for the lubricating oil of friction bearings (except in the case of ring).

f) Insulation resistance in the case of unearthed networks.

8.4 Power reduction

8.4.1 In the case abnormal operating power may be automatically reduced, this information is to be indicated at the propulsion control position.

9 Cables and cable installation

9.1 General

9.1.1 The cable network for electrical propulsion plants must comply with the requirements of Ch 2, Sec 12. If there is more than one propulsion unit, the cables of any one unit shall, as far as is practicable, be run over their entire length separately from the cables of the other units.

10 Testing and trials

10.1 General

10.1.1 A quality assurance plan has to be submitted to the Society.

10.1.2 Tests of machines, static converters, switchgear, equipment and cables shall be carried out at the maker's works in accordance with applicable requirements of Ch 2, Sec 1 to Ch 2, Sec 14.

10.1.3 Shaft material for generators and propulsion motors

Tests of steel and Iron materials, shall be made by a shaft material test as for vessel's shafting.

10.1.4 The testing of other important forgings and castings for electrical main propulsion plants, e.g. rotors and pole shoe bolts, shall be agreed with the Society.

10.2 Tests after installation

10.2.1 Newly-constructed or enlarged plants require testing and trials on board.

The scope of the trials is to be agreed with the Society.

10.2.2 Dock trial

For scope and extent of dock trials, see Ch 2, Sec 17, [3.1.8].

10.2.3 River trial

For river trial programme, see Ch 2, Sec 17, [4.2].

SECTION 16 COMPUTER SYSTEMS

1 General

1.1 Scope

1.1.1 These Rules apply additionally, if computers are used for tasks essential to the safety of the vessel, cargo, crew or passengers and are subject to classification.

1.2 References to other Rules and Regulations

1.2.1 IEC 61508 or EN 61508 "Functional safety of electrical/ electronic/ programmable electronic safety related systems".

1.3 Requirements applicable to computer systems

1.3.1 Computer systems shall fulfill the requirements of the process under normal and abnormal operating conditions. The following shall be considered:

- danger to persons
- environmental impact
- endangering of technical equipment
- usability of computer systems
- operability of all equipment and systems in the process.

1.3.2 If process times for important functions of the system to be supervised are shorter than the reaction times of a supervisor and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

1.3.3 Computer systems shall be designed in such a way that they can be used without special previous knowledge. Otherwise, appropriate assistance shall be provided for the user.

2 Requirement classes

2.1 General requirements

2.1.1 Computer systems are assigned, on the basis of a risk analysis, to requirement classes as shown in Tab 1. This assignment shall be accepted by the Society. Tab 2 gives examples for such an assignment.

2.1.2 The assignment is divided into five classes considering the extent of the damage caused by an event.

2.1.3 Considered is only the extent of the damage directly caused by the event, but not any consequential damage.

2.1.4 The assignment of a computer system to a corresponding requirement class is made under the maximum possible extent of direct damage to be expected.

2.1.5 In addition to the technical measures stated in this section also organizational measures may be required if the risk increases. These measures shall be agreed with the Society.

2.2 Risk parameters

2.2.1 The following aspects may lead to assignment to a different requirement class, see Tab 1.

a) Dependence on the type and size of vessel:
   - Number of persons endangered
   - Transportation of dangerous goods
   - Vessel's speed.

b) Presence of persons in the endangered area with regard to duration respectively frequency:
   - rarely
   - often
   - very often
   - at all times.

c) Averting of danger

   To evaluate the possibility of danger averting, the following criteria shall be considered:
   - operation of the technical equipment with or without supervision by a person
   - temporal investigation into the processing of a condition able to cause a damage, the alarming of the danger and the possibilities to avert the danger.

d) Probability of occurrence of the dangerous condition

   This assessment is made without considering the available protection devices.

   Probability of occurrence:
   - very low
   - low
   - relatively high.

e) Complexity of the system:
   - Integration of various systems
   - Linking of functional features.

2.2.2 The assignment of a system into the appropriate requirement class shall be agreed on principle with the Society.

2.3 Measures required to comply with the requirement class

2.3.1 The measures to comply with the requirements of classes 4 and 5 may require for computer equipment and conventional equipment a separation or for the computer equipment a redundant, diversified design.

Table 1 : Definition of requirement classes

Requirement class	Extent of damage		
	Effects on persons	Effects on the environment	Technical damage
1	none	none	insignificant
2	slight injury	insignificant	minor
3	serious, irreversible injury	significant	fairly serious
4	loss of human life	critical	considerable
5	much loss of human life	catastrophic	loss

Table 2 : Examples of assignment into requirement classes

Requirement class	Examples
1	Supporting systems for maintenance Systems for general administrative tasks Information and diagnostic systems
2	"Off line" cargo computers Navigational instruments Machinery alarm and monitoring systems Tank capacity measuring equipment
3	Controls for auxiliary machinery Speed governors "On line" cargo computers, networked (bunkers, draughts, etc.) Remote control for main propulsion Fire detection systems Fire extinguishing systems Integrated monitoring and control systems Control systems for tank and fuel Rudder control systems Course control systems Machinery protection systems/ equipment
4	Burner control systems for boilers and thermal oil heater Electronic injection systems
5	Systems where manual intervention to avert danger in the event of failure or malfunction is no longer possible and the extent of damage under requirement class 5 can be reached

2.3.2 Protection against modification of programs and data

The measures required depend on the requirement class and the system configuration (see Tab 3).

Computer systems shall be protected against unintentional or unauthorized modification of programs and data.

For large operating systems and programs, other storage media such as hard disks may be used by agreement.

Significant modifications of program contents and system specific data, as well as a change of version, shall be documented and must be retraceable.

Table 3 : Program and data protection measures in relation to the requirement class (examples)

Requirement class	Program/Data memory
1	Protection measures are recommended e.g. diskette, magnetic disk etc.
2	Protection against unintentional/unauthorised modification e.g. buffered RAM etc.
3	Protection against unintentional/unauthorised modification and loss of data e.g. EEPROM etc.
4	No modifications by the user possible e.g. EPROM etc.
5	No modifications possible e.g. ROM etc.

For systems of requirement class 4 and 5 all modifications, the modifications of parameters too, shall be submitted for review / approval.

The examples of program and data protection shown in Tab 3 may be supplemented and supported by additional measures in the software and hardware, for example:

- user name, identification number
- code word for validity checking, key switch
- assignment of authorizations in the case of common use of data / withdrawal of authorizations for the change or erasing of data
- coding of data and restriction of access to data, virus protection measures
- recording of workflow and access operations.

Note 1: A significant modification is a modification which influences the functionality and/or safety of the system.

3 System configuration

3.1 General requirements

3.1.1 The technical design of a computer system is given by its assignment to a requirement class. The measures listed below for example, graded according to the requirements of the respective requirement class, shall be ensured.

3.1.2 For functional units, evidence shall be proved that the design is self-contained and produces no feedback.

3.1.3 The computer systems must be fast enough to perform autonomous control operations and to inform the user correctly and carry out his instructions in correct time under all operating conditions.

3.1.4 Computer systems shall monitor the program execution and the data flow automatically and cyclically e.g. by means of plausibility tests, monitoring of the program and data flow over time.

3.1.5 In the event of failure and restarting of computer systems, the process shall be protected against undefined and critical states.

3.2 Power supply

3.2.1 The power supply shall be monitored and failures shall be indicated by an alarm.

3.2.2 Redundant systems shall be separately protected against short circuits and overloads and shall be selectively fed.

3.3 Hardware

3.3.1 The design of the hardware shall be clear for easy access to interchangeable parts for repairs and maintenance.

3.3.2 Plug-in cards and plug-in connections shall be appropriately marked to protect against unintentional transposition or, if inserted in an incorrect position, shall not be destroyed and not cause any malfunctions which might cause a danger.

3.3.3 For integrated systems, it is recommended that subsystems be electrically isolated from each other.

3.3.4 Computers shall preferably be designed without forced ventilation. If forced ventilation of the computers is necessary, it shall be ensured that an alarm is given in the case of an unacceptable rise of temperature.

3.4 Software

3.4.1 Examples of software are:

- operating systems
- application software
- executable code
- database contents and structures
- bitmaps for graphic displays
- logic programs in PAL's
- microcode for communication controllers.

3.4.2 The manufacturer shall prove that a systematic procedure is followed during all the phases of software development.

3.4.3 After drafting the specification, the test scheduling shall be made (listing the test cases and establishment of the software to be tested and the scope of testing). The test schedule lays down when, how and in what depth testing shall be made.

3.4.4 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests must be retraceable.

3.4.5 The version of the Software with the relevant date and release have to be documented and shall be recognizable of the assignment to the particular requirement class.

3.5 Data communication links

3.5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and specified accordingly.

3.5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

3.5.3 The data communication link shall be continuously self-checking, for detection of failures on the link itself and for data communication failure on the nodes.

3.5.4 When the same data communication link is used for two or more essential functions, this link shall be redundant.

3.5.5 Switching between redundant links shall not disturb data communication or continuous operation of functions.

3.5.6 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

3.5.7 If approved systems are extended, proof of trouble free operation of the complete system shall be provided.

3.6 Integration of systems

3.6.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

3.6.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

3.6.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

3.7 User interface

3.7.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

3.7.2 The status of the computer system shall be recognizable.

3.7.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

3.7.4 For using computer systems, a general comprehensible user guide shall be provided.

3.8 Input devices

3.8.1 The feedback of control commands shall be indicated.

3.8.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

3.8.3 Operator panels located on the bridge shall be individually illuminated. The lighting must be adapted non-glare to the prevailing ambient conditions.

3.8.4 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices.

3.8.5 If the operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

- use of a special key lock
- use of two or more keys.

3.8.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

3.8.7 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

3.9 Output devices

3.9.1 The size, colour and density of text, graphic information and alarm signals displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all lighting conditions.

3.9.2 Information shall be displayed in a logical priority.

3.9.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

3.10 Graphical user interface

3.10.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

3.10.2 When general purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

3.10.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

4 Testing of computer systems

4.1 General

4.1.1 Computer systems of requirement class 3 and higher are subject to mandatory type approval.

4.1.2 Evidence, tests and assessments of computer systems have to be carried out in accordance to the requirement class.

4.1.3 By the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

4.1.4 If other proofs and tests are provided by the manufacturer which are of an equivalent nature, they may be recognized.

4.1.5 The test schedule of system testing has to be specified and submitted before the hardware and software test will be carried out.

4.1.6 Modifications after completed tests which have influence on the functionality and/or the safety of the system have to be documented and retested in accordance to the requirement class.

4.2 Tests in the manufacturer's work

4.2.1 Following tests shall be carried out in the manufacturer's works:

- function tests
- operating conditions simulation
- fault simulation
- simulation of the application environment.

SECTION 17 TESTS ON BOARD

1 General

1.1

1.1.1 The tests are divided into:
- tests during construction
- tests during commissioning
- tests during trial voyages.

2 Tests during construction

2.1

2.1.1 During the period of construction of the vessel, the installations shall be checked for conformity with the documents reviewed by the Society and with the Rules for construction.

2.1.2 Test certificates for tests which have already been performed shall be presented to the Surveyor on request.

2.1.3 Protective measures

a) protection against foreign bodies and water

b) protection against electric shock, such as protective earthing, protective separation or other measures as stated in Ch 2, Sec 1

c) measures of explosion protection.

2.1.4 Testing of the cable network

Inspection and testing of cable installation and cable routing with regard to:

a) acceptability of cable routing with regard to:
   - separation of cable routes
   - fire safety
   - reliable supply of emergency consumers (where applicable)

b) selection and fixation of cables

c) construction of bulkhead and deck penetrations

d) insulation resistance measurement.

3 Testing during commissioning of the electrical equipment

3.1

3.1.1 General

Proofs are required of the satisfactory condition and proper operation of the main and emergency power supply systems, the steering gear and the aids of manoeuvring, as well as of all the other installations specified in the Rules for construction.

Unless already required in the Rules for construction, the tests to be performed shall be agreed with the Society's Surveyor in accordance with the specific characteristics of the subject equipment.

3.1.2 Generators

A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on appropriate form.

3.1.3 Storage batteries

The following shall be tested:

a) installation of storage batteries

b) ventilation of battery rooms, cupboards/containers, and cross-sections of ventilation ducts

c) storage-battery charging equipment

d) the required caution labels and information plates.

3.1.4 Switchgear

The following items shall be tested under observance of:

a) accessibility for operation and maintenance

b) protection against the ingress of water and oil from ducts and pipes in the vicinity of the switchboards, and sufficient ventilation

c) equipment of main and emergency switchboards with insulated handrails, gratings and insulating floor coverings

d) correct settings and operation of protection devices and interlocks.

The Society reserves the right to demand the proof of selective arrangement of the vessel supply system.

3.1.5 Power electronics

The following items shall be tested:

a) ventilation of the place of installation

b) function of the equipment and protection devices.

3.1.6 Power plants

The following items shall be tested:

a) Motor drives together with the driven machines, which shall, wherever possible, be subjected to the most severe anticipated operating conditions

   This test shall include a check of the settings of the motors' short-circuit and overcurrent protection devices

b) The emergency remote stops of equipment such as engine room fans and boiler blowers

c) Closed loop controls, open loop controls and all electric safety devices.

3.1.7 Control, monitoring and vessel's safety systems

For these systems operational tests shall be performed.

3.1.8 Electrical propulsion plant

Functioning of the propulsion plant shall be proved by a dock trial before river trials.

At least the following trials/measurements shall be carried out in the presence of the Society Surveyor:

- start-up, loading and unloading of the main and propulsion motors in accordance with the design of the plant and a check of regulation, control and switchgear
- verification of propeller speed variation and all associated equipment
- verification of protection, monitoring and indicating/alarm equipment including the interlocks for sufficient functioning
- verification of insulation condition of the main-propulsion circuits.

3.1.9 Computer systems

Regarding scope of tests see Ch 2, Sec 16.

4 Testing during trial voyages

4.1 General

4.1.1 Proof is required that the power supply meets the requirements under the various operating conditions of the vessel. All components of the system must function satisfactorily under service conditions, i.e. at all main engine speeds and during all manoeuvres.

4.2 Electrical propulsion plant

4.2.1 Trial programme

The trial programme shall at least include:

a) Continuous operation of the vessel at full propulsion load until the entire propulsion plant has reached steady-state temperatures.

   The trials shall be carried out at rated engine speed and with an unchanged governor setting:

   - at 100 % power output (rated power): at least 3 hours
   - with the propeller running astern during the dock test or during the river trial at a minimum speed of at least 70 % of the rated propeller speed: 10 minutes.

b) Reversal of the plant out of the steady-state condition from full power ahead to full power astern and maintaining of this setting until at least the vessel has lost all speed. Characteristic values such as speed, system currents and voltages, and the load sharing of the generators, shall be recorded. If necessary, oscillograms shall be made

c) Performance of typical manoeuvres

d) Checking of the machinery and plant in all operating conditions

e) Checking of the network qualities in the vessel's propulsion network and mains.