INTERNATIONAL REGISTER OF SHIPPING

RULES AND REGULATIONS FOR CLASSIFICATION OF INLAND NAVIGATION VESSELS
2021

Part 4
Machinery, Electrical and Piping

www.intlreg.org

This page is intentionally left blank

CHANGES HISTORY

1. Refer Changes history in Part 1

CONTENTS

CHAPTER 1 MACHINERY AND SYSTEMS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 General

1.1.1 Application

This chapter applies to the design, construction, installation, tests and trials of main propulsion and essential (needed for navigation) auxiliary machinery systems and associated equipment, installed on board classed inland navigation vessels, as indicated in each section (1 to 5) of this chapter.

1.1.2 Documentation to be submitted

The drawings and documents in the relevant parts of this chapter shall be submitted to the Society for approval.

1.2 Design and construction

1.2.1 General

The machinery shall be of a design and construction for the service for which they are intended and shall be so installed and protected 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 shall take into consideration the materials used in the construction, the intended use of the equipment, the working and the environmental conditions on board.

Engines and their ancillaries shall be designed, built and installed in accordance with best standard practice.

1.2.2 Materials, welding and testing

1.2.2.1 General`

Materials, welding and testing procedures shall be in accordance with the requirements of Part 2 of Ship Rules and this chapter. In addition, for machinery components fabricated by welding, the requirements mentioned in 1.2.2.2 apply.

1.2.2.2 Welded machinery components

Welding processes shall be approved, and welders certified by the Society in accordance with Part 2 of Ship Rules. References to welding procedures adopted shall be clearly indicated on the plans submitted for approval. Joints transmitting loads shall 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 (0.118)”, 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 shall 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 shall 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 shall be performed according to the welding procedure specification.

1.2.3 Vibrations

Special consideration (refer Sec.2 [6]) shall 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.

1.2.4 Operation in inclined position

Main propulsion machinery and all auxiliary machinery essential for the propulsion and the safety of the vessel are, as fitted in the vessel, to be designed to operate when the vessel is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Table 1. Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged along ships. If this is not possible, the manufacturer shall be informed at the time the machinery is ordered.

Table 1 Permanent inclination of vessel

Installations, components	*Angle of inclination*[1]	
	Athwartships	*Fore and aft*
Main and auxiliary machinery [2]	12°	5°

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

1.2.5 Ambient conditions

Machinery and systems covered by the rules shall be designed to operate properly under the ambient conditions specified in Table 2, unless otherwise specified.

Table 2 Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range
In enclosed spaces	between 0°C and +40°C (+45°C 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°C and +40°C (+45°C in tropical zone)
WATER TEMPERATURE	
Coolant	Temperature
River water or, if applicable, river water at charge air coolant inlet	up to +25°C in general up to +32°C in tropical zone

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

1.3 Approved fuels

1.3.1 The flash point of liquid fuels for the operation of machinery and boiler installations shall be above 55°C.(131°F)

1.3.2 Liquid fuel shall be carried in oil tight tanks either form part of the hull or be solidly connected with the vessel's hull.

1.4 Power of machinery

Unless otherwise stated in 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

1.5 Astern power

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

The main propulsion machinery shall 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 shall not 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 shall be demonstrated and recorded (refer also Sec.5 [3.2]).

1.6 Safety devices

1.6.1 In case machinery overspeed, means shall be provided for safety trip the machinery.

1.6.2 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.

1.6.3 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 pressure failure, which could lead rapidly to complete breakdown, serious damage or explosion.

Remarks:

The Society may, on a case-by-case basis, permit provisions for overriding automatic shut-off devices.

1.7 Arrangement and installation on board

1.7.1 **General**

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

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

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

Engines shall be installed and fitted in such a way so that it shall be adequately accessible for operation and maintenance, and shall not endanger the persons assigned to those tasks. It shall be possible to make them secure against unintentional starting.

1.7.2 **Floors**

Floors in engine rooms shall be metallic, divided into easily removable panels.

1.7.3 **Bolting down**

1.7.3.1 Bedplates of machinery, thrust blocks and shaft line bearing foundations shall be securely fixed to the supporting structures by means of foundation bolts which shall be distributed as evenly as practicable and of a sufficient number and size to ensure a perfect fit.

Propulsion plants shall be mounted and secured to their shipboard foundations according to Part 5A Ch 2 Sec 1.6 of Ship Rules

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

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

Particular care shall be taken to obtain a perfect levelling and general alignment between the propulsion engines and their shafting.

1.7.3.2 Chock resins shall be type-approved.

1.8 Safety devices on moving parts

Suitable protective safety guards shall be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid injuries to personnel.

1.9 Gauges

All gauges shall be grouped, as far as possible, near each maneuvering position; in any event, they shall be clearly visible.

1.10 Ventilation in machinery spaces

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

Air shall be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions.

The quantity and distribution of air shall be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation shall be so arranged as to prevent any accumulation of flammable gases or vapors.

1.11 Hot surfaces and fire protection

Surfaces, having temperature exceeding 60 °C(140 °F), with which the crew are likely to come into contact during operation shall be suitably protected or insulated.

Surfaces of machinery with temperatures above 220 °C(428°F) , e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, shall be effectively insulated with non-combustible material or equivalently protected to prevent the ignition of combustible materials coming into contact with them.

Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation shall be encased in steel sheathing or equivalent material.

Fire protection, detection and extinction shall comply with the requirements of Ch.7.

1.12 Tests and trials

1.12.1 Works tests

Equipment and its components are subjected to works tests which are detailed in the relevant parts of this chapter and shall be witnessed by the Surveyor.

Remark:

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 shall be informed in advance and the tests shall be carried out in accordance with Ship Rules Pt.2 – relative to incomplete tests.

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

1.12.2 Tests on board

Trials on board of machinery are detailed in Sec.5.

SECTION 2 PROPELLING AND AUXILIARY MACHINERY

Contents

2.1 Symbols

N = speed of the shaft for which the check is carried out [rev./min]

N_N = nominal speed of the engine [rev./min]

Λ = speed ratio

= N/N_N

2.2 Internal combustion engines

2.2.1 General

2.2.1.1 Scope

The rules contained in the following apply to internal combustion engines used as main propulsion units and auxiliary units.

For these rules, internal combustion engines are diesel engines, refer 2.2.1.3

2.2.1.2 Rated Power

Engines shall be designed such that their rated power running at rated speed can be delivered as a continuous net brake power. Engines shall be capable of continuous operation within power range (1) of Figure 1 and of short-period operation in power range (2). The extent of the power range shall be stated by the engine manufacturer.

In determining the power of all engines used on board inland waterway vessels with unlimited range of service, the ambient conditions given in Table 1 shall 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

The maximum continuous power is the maximum power at ambient reference conditions refer Table 1 which the engine can deliver continuously, at nominal maximum speed, in the period of time between two consecutive overhauls.

After running on the test bed, the fuel delivery system of main engines shall be so adjusted that after installation on board overload power cannot be delivered.

Subject to the prescribed conditions, engines driving electrical generators shall be capable of overload operation (110% rated power) to utilize 100% of rated load in parallel operation.

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

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

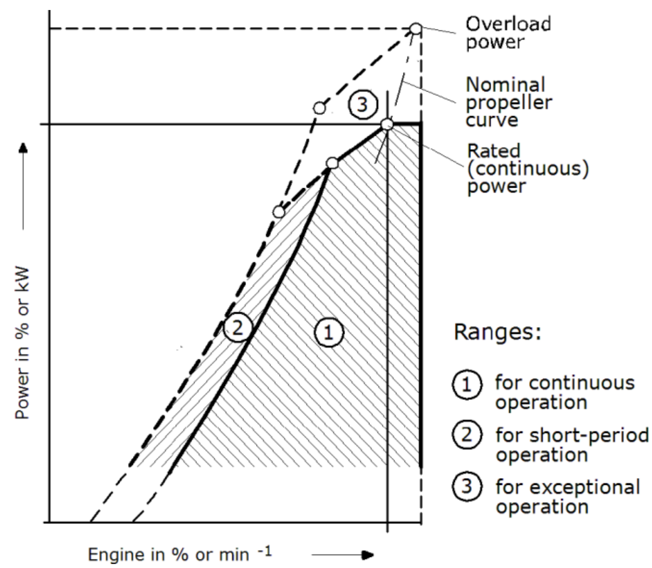


Figure 1 Power/speed diagram

2.2.1.3 **Fuels**

The use of liquid fuels shall comply with the requirements in Sec.1 [2.6].

Only internal combustion engines burning liquid fuels having a flash point of more than 55 °C(131°F) may be installed.

The use of gaseous fuels is subject to a further design approval.

Remark:

The International Code of Safety for ships using gases or other Low - flashpoint Fuels (IGF Code) is currently under development at IMO. Therefore, acceptance by the flag administration is necessary for each individual installation.

For fuel systems, Refer Ch.2 Sec.1 [7].

2.2.1.4 **Accessibility of engines**

Engines shall be so arranged in the engine room that all the installation and inspection ports provided by the engine manufacturer for inspections and repairs are accessible or easily be made accessible (Refer Sec.1 [3.1]).

2.2.1.5 **Installation and mounting of engines**

Engines shall be mounted and secured to their shipboard foundations in compliance with Part 5A Ch 2 Sec 1.6 of Ship Rules

2.2.1.6 **Documents for approval**

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

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

— manufacturer's type designation

— cylinder bore

— piston stroke

— method of injection (direct, indirect)

— valve and injection operation (by cams or electronically controlled)

— working cycle (4-stroke, 2-stroke)

— method of gas exchange (naturally aspirated or supercharged)

— max continuous rated power per cylinder at rated speed and mean effective working pressure

— method of pressure charging (pulsating pressure system or constant pressure system)

— charge air cooling system

— cylinder arrangement (in-line, vee)

For approved engine types, only those documents listed in Table 2 is required to be resubmitted for approval in case of design modifications.

Table 2 Documents for approval

Serial No.	A/FI	Description	Quantity	Remarks
1	FI	Details required on the Society's forms when applying for approval of an internal combustion engine	3	
2	FI	Engine transverse cross section	3	
3	FI	Engine longitudinal section	3	
4	FI	Bedplate or crankcase	1	
5	FI	Engine block	1	
6	FI	Tie rod	1	
7	FI	Cylinder cover assembly	1	
8	FI	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	FI	Connecting rod, assembly	3	1)
14	FI	Piston assembly	1	
15	FI	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	FI	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	FI	Operation and service manuals	1	
Only necessary if sufficient details are not shown on the transverse cross section and longitudinal section For attended engine: only engines with a cylinder bore of ≥ 250 mm Only for engines with a cylinder diameter of > 200 mm, or a crankcase volume exceeding 0.6 m^3				

2.2.2 **Crankshaft design**

2.2.2.1 Design methods

Crankshafts shall be designed to withstand the stresses occurring when the engine runs at rated power. Calculations shall be based on Part 4 of Ship Rules

Remark:

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 afore mentioned 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 ($r \geq 0.06 \cdot d$) or a taper.

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

2.2.2.2 Split crankshaft

Fitted bolts or equivalent fastenings shall be used for assembling split crankshafts.

2.2.2.3 Torsional vibration, critical speeds

Refer Sec 2.6

2.2.3 **Materials**

2.2.3.1 Approved materials

The mechanical characteristics of materials used for the components of diesel engines shall meet the requirements of. Ship Rules Pt 2. The materials approved for the various components are shown in Table 3 together with their minimum required characteristics.

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

Table 3 Approved materials

Minimum required characteristics	Components
	Crankshafts
Forged steel	Connecting rods
Rm ≥ 360 N/mm^2	Tie rods
	Bolts and studs
Rolled steel rounds Rm ≥ 360 N/mm^2	Tie rods Bolts and studs
Nodular cast iron, preferably ferritic grades	Engine blocks Bedplates Cylinders covers Flywheels
	Valve bodies and similar parts
	Engine blocks
Lamellar cast iron Rm ≥ 200 N/mm^2	Bedplates Cylinder covers Liners
	Flywheels
Shipbuilding steel All grade D for plates ≤ 25 mm (0.98Inch)thick	Welded bedplates Welded engine blocks
Shipbuilding steel All grade D for plates > 25 mm (0.98 Inch) thick or equivalent structural steel, cast in the fully killed condition and normalized	
Weldable cast steel	Bearing transverse girders

2.2.3.2 Testing of materials

For the following components:

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

evidence shall be supplied that the materials used meet the requirements of Ship Rules Pt.2. This evidence may take the form of a manufacturer’s work certificate.

In addition, crankshafts and connecting rods shall be subjected to non-destructive crack tests at the work shop and the test results to be submitted.

2.2.4 Tests and trials

2.2.4.1 Pressure tests

Appointed components of internal combustion engines shall be subjected at the works to pressure tests at the test pressures indicated in Table 4 or to equivalent tests.

Table 4 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 $1.5 \cdot p_{e,perm}$
Exhaust valve, cooling water space		4 bar, at least $1.5 \cdot p_{e,perm}$
Piston, cooling water space(after assembly with piston rod, if applicable)		7 bar
Fuel injection system	Pump body, delivery side	$1.5 \cdot p_{e,perm}$ or $p_{e,perm}$+ 300 bar (whichever is less)
	Valves Pipes	$1.5 \cdot p_{e,zul}$ or $p_{e,perm}$+ 300 bar (whichever is less)
Exhaust gas turbocharger, cooling water space		4 bar, at least $1.5 \cdot p_{e,perm}$
Exhaust gas line, cooling water space		4 bar, at least $1.5 \cdot p_{e,perm}$
Component		*Test pressure, p_P 1)*
Main engine-driven compressor: Cylinder, cover, intercooler	Air side	$1.5 \cdot p_{e,perm}$
Aftercooler	Water side	4 bar, at least $1.5 \cdot p_{e,perm}$
Cooler, both sides (charge air cooler only on water side)		4 bar, at least $1.5 \cdot p_{e,perm}$
Main engine-driven pumps (Oil, water, fuel and bilge pumps)		4 bar, at least $1.5 \cdot p_{e,perm}$
Starting and control air system		$1.5 \cdot p_{e,perm}$ before installation
1) Component shall normally be hydraulically tested. Other equivalent test methods may be accepted. $p_{e,perm}$= maximum permissible working pressure of component concerned [bar]		

2.2.4.2 **Test bed trials**

In general, engines shall be subjected, under the Society's supervision, to a test bed trial of the scope stated below.

Main engines for direct propeller drive:

1. 100% power (rated power)

   at rated speed n_0: 60 minutes

2. 100% power

   at $n = 1.032 \cdot n_0$: 30 minutes

3. 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.

4. Starting and reversing maneuver

5. Test of governor and independent over speed protection device

6. Test of engine shut-down devices

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

a) 100% power

(rated power): 60 minutes

b) 110% power: 30 minutes

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

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

d) Start-up tests

For auxiliary driving engines and engines driving electric generators, tests shall be performed in accordance with the above paragraph (main engines for indirect propeller devices). The manufacturer's test bed reports are acceptable for propulsion- and auxiliary driving engines rated at ≤ 300 kW.

2.2.5 **Safety devices**

2.2.5.1 **Speed control and engine protection against over speed**

a) Main and auxiliary engines

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

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

b) Engine driving electric generators

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

In the case when a step load equivalent to the rated output of the generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause the intervention of the over speed device as required by next passage.

In addition to the governor, each diesel engine with a rated power of 220 kW or over shall be equipped with an over speed 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.4 Sec.2 [6].

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

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

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

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

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

Remark:

- *The rated power and the corresponding rated speed relate to the conditions under which the engines are operated in the system concerned.*
- *Additional over speed protection device means a system all of whose component parts, including the drive, function independently of the governor.*

c) Use of electrical/electronic governors

The electrical/electronic governors used shall have been type-tested by 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 shall be supplied from the floating shipboard supply battery or from a permanently assigned battery of suitable capacity.

Arrangements shall be made to ensure that the batteries are always kept charged and monitored. When an engine is taken out of service, the supply to its governor shall cut out automatically.

2.2.5.2 **Crankcase airing and venting**

The airing of crankcases is not allowed.

Crankcases shall 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 shall be led into the open and protected to prevent the entry of water.

Engines with a swept volume of up to 50 dm^3 per row of cylinders shall be fitted with vent pipes which shall 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 vapors, e.g. for monitoring the oil vapor concentration, the negative pressure in the crankcase may not exceed 2.5 mbar.

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

2.2.5.3 **Crankcase safety devices**

Safety valves to safeguard against overpressure in the crankcase shall be fitted to all engines with a cylinder bore of > 200 mm or a crankcase volume of > 0.6 m^3.

Crankcase safety devices shall be approved according to the requirements given in Part 5A Chapter 8, Sec-4, [4.7] of Ship Rules

All other spaces communicating with the crankcase, e.g. gear or chain casings for camshafts or similar drives, shall be equipped with additional safety valves if the volume of these spaces exceeds 0.6 m^3.

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

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

Engines with a cylinder bore of > 300 mm shall have at least one safety valve close to each crank throw. Each safety valve shall have a free cross-sectional area of at least 45 cm^2.

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

Remark:

- *In estimating the gross volume of the crankcase, the volume of the fixed parts which it contains may be deducted.*
- *A space linked to 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 shall be disregarded.*
- *Each safety valve required may be replaced by not more than two safety valves of smaller cross-sectional area provided that the free cross-sectional area of each safety valve is not less than 45 cm^2.*

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

Safety device shall respond to as low an overpressure in the crankcase as possible (maximum 0.2 bar).

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

Crankcase doors and hinged inspection ports shall be equipped with appropriate latches to effectively prevent unintended closing.

A warning signboard shall be fitted either on the control stand or, preferably, on a crankcase door on each side of the engine. It shall specify that the crankcase doors or sight holes, in case of detected oil mist, shall not be opened before a reasonable time has passed. The time shall be sufficient to permit adequate cooling after stopping in the engine.

2.2.5.4 **Safety devices in the starting air system**

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

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

b) Engines with cylinder bore of > 230 mm shall be equipped with flame arresters or bursting discs as follows:

  - on directly reversible engines, in front of each start-up valve of each cylinder
  - on non-reversing engines, in the main starting air line to each engine

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

2.2.5.5 **Safety devices in the lubricating oil system**

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

This alarm shall be clearly distinguishable from the alarm required under Sec.1 [3.8].

2.2.5.6 Turning gear

Engines shall be equipped with suitable and adequately dimensioned turning appliances. The turning appliances shall be of the self-locking type. An automatic interlocking device shall be provided to ensure that the engines cannot start while the turning gear is at engaged position

2.2.6 Pipes and filters

2.2.6.1 General

The general engine piping system is subject to the requirements of Ch.2.

2.2.6.2 Fuel lines

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

External high-pressure fuel delivery pipes of diesel engines, between the high-pressure fuel pumps and fuel injectors, shall be protected with a jacketed piping system capable of containing fuel from a high- pressure pipe failure. The jacketed piping system shall include a means for the collection of leakages, and arrangements shall be provided for an alarm to be given of a fuel pipe failure, except that an alarm is not required for engines with no more than two cylinders.

Jacketed piping systems need not be applied to engines on open decks operating windlasses and capstans. If pressure variations of > 20 bar occur in the fuel return lines, these shall also be shielded.

Leaking fuel shall be safely drained away at zero excess pressure. Care shall be taken not to mix with the engine lubricating oil.

2.2.6.3 Filters

a) Lubricating oil filters for main engines

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

Lubricating oil piping system installed such 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 300 kW, fitted with a lubricating oil line supplied from the engine oil sump, simplex filters may be fitted provided that they are equipped with a pressure alarm behind the filter and provided also that the filter can be changed during operation. For this purpose, a by-pass with manually operated shut-off valves shall be provided.

The switch positions shall be clearly recognizable.

b) Lubricating oil filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

c) Fuel filters for main engines

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

d) Fuel filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

e) Filter arrangements

Fuel and lubricating oil filters which shall be mounted directly on the engine shall not 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 shall be sufficiently shielded.

Drip trays of suitable size shall be mounted under fuel and lubricating oil filters, to avoid escape of oil when the filters are opened.

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

2.2.6.4 **Exhaust pipes**

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

The pipes shall be so installed that no exhaust gases can penetrate accommodation spaces. Allowance shall be provided for thermal expansion when installing the lines.

Where exhaust pipes are led overboard near the water line, means shall be provided to avoid water entering the engine.

All hot surfaces shall be properly insulated and/or water cooled in such a way that the surface temperature cannot exceed 220 °C(428°F) at any point. Insulating materials shall be non-combustible.

Insulation material used in engine rooms shall be protected against the intrusion of fuel, lubricant, and fuel lubricant vapors

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

2.2.7 Starting equipment

2.2.7.1 **Electric starting equipment**

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

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

Electrical starters for auxiliary engines shall be provided with independent batteries. The capacity of the batteries shall be sufficient for at least 3 start-up operations within 30 minutes.

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

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

Arrangements shall be made to confirm that batteries are always kept charged and monitored.

2.2.7.2 **Starting with compressed air**

Main engines which are started with compressed air shall be equipped with at least two starting air compressors. At least one of the air compressors shall be driven independently of the main engine and shall supply at least 50% of the total capacity required.

The total capacity of the starting air compressors shall 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 shall be installed.

The total volume of the starting air receiver 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 starting is not allowed.

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

Remark:

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 maneuvering equipment and to the air requirements of typhon units.*

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

2.2.7.3 **Air compressor equipment**

Coolers shall be so designed that the temperature of the compressed air does not exceed 160°C(320°F) at the discharge of each stage of multi-stage compressors or 200 °C(392°C) at the discharge of single-stage compressors.

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

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

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

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

2.2.8 **Control equipment**

2.2.8.1 **Main engines room control platform**

As a minimum requirement, the engine room control stand shall be equipped with the following main engine indicators, which shall 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 shall be provided for the following on the control stand and/or directly on the engine:

—lubricating oil temperature

—coolant temperature

—fuel temperature at engine inlet only for engines working 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 shall be extended accordingly.

On the pressure gauges the permissible pressures, and on the tachometers any critical speed ranges, shall be marked in red.

A machinery alarm system shall be installed for the parameters specified above, with the exception of the charge air pressure, the control air pressure and the exhaust gas temperature.

Refer also Ch.5 Sec.1 Table 1.

2.2.8.2 **Main engines control from the bridge**

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

In addition, the alarm system required under [2.2.8.1] shall signal faults on the bridge. Faults may be signaled in accordance with Sec.1 [3.8]. An indicator in the engine room and on the bridge shall show that the alarm system is operative.

2.2.8.3 **Auxiliary engines**

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

—engine speed

—lubricating oil pressure

—lubricating oil temperature

—cooling water pressure

—cooling water temperature

In addition, engines of over 50 kW power shall 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.

Refer also Ch.5 Sec.1 Table 1.

2.2.9 Auxiliary systems

2.2.9.1 **Lubricating oil system**

General requirements relating to lubricating oil systems are contained in Ch.2 Sec.1 [8]; for filters, refer [2.2.6.3].

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

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

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

2.2.9.2 Cooling system

General requirements relating to the design of cooling water systems are contained in Ch.2 Sec.1 [9].

Main cooling water pumps driven by the engine shall 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 shall 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.

Refer also Sec.1 [3.6].

2.2.9.3 Exhaust gas turbochargers

Exhaust gas turbochargers shall not indicate any critical speed ranges over the entire operating range of the engine.

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

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

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

2.2.9.4 Charge air cooling

Means shall 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 shall be provided with sufficient means of drainage.

2.2.10 Installation and mounting of engines

Engines shall be mounted and secured to their shipboard foundations in compliance with the Classification Guide for seating. Equivalent solutions may be accepted on a case by case basis.

2.3 Main shafting

2.3.1 General

2.3.1.1 Scope

The following requirements apply to typical and proven types of main shafting. Novel designs will be handled on a case-by-case basis.

The Society reserves the right to require propeller shaft dimensions in excess of those specified in the following if the propeller arrangement exceeds permissible bending stresses.

2.3.1.2 Documents for approval

General drawings of the entire shafting, from the main engine coupling flange to the propeller, and detail drawings of the shafts, couplings and other component parts transmitting the propelling engine torque, are each to be submitted to the Society for approval.

2.3.2 Materials

2.3.2.1 Approved materials

Propeller-, intermediate- and thrust shafts together with flanged connections and couplings shall normally be made of forged steel or, where appropriate, couplings may be made of cast steel or nodular cast iron with a ferritic matrix.

Plain, flangeless shafts may be made from rolled round steel. In general, the tensile strength of steels used for shafting shall be between 400 N/mm^2 and 800 N/mm^2. However, the value of R_m used for calculating the material factor C_W defined in [2.3.3.2] for propeller shaft shall not be greater than 600 N/mm^2.

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

2.3.2.2 Materials testing

All materials of torque transmitting shafting components shall possess the properties specified in Pt. 2 of Ship Rules. This may be proven by an acceptance test certificate issued by the manufacturer.

2.3.3 Shaft dimensions

2.3.3.1 General

All parts of the shafting shall be dimensioned in accordance with the following formulas in compliance with the requirements relating to critical speeds refer Sec [2.6].

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

2.3.3.2 Minimum diameter

The minimum diameter shall be determined by applying the following formula:

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

d = minimum required outside diameter of shaft [mm]

d_i = diameter of the shaft bore, where present [mm]

If $d_i \leq 0.4 \cdot d_a$

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

d_a = actual outside shaft diameter [mm]

P_W = shaft power [kW]

n = Shaft speed [rev/min]

F = factor for the type of propulsion installation

= 90 for turbine installations, engine installations with slip couplings and electrical propulsion

installations

= 94 for all other types of propulsion installations

C_W = material factor

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

R_m = tensile strength of the shaft material [N/mm^2]

k = factor for the type of shaft

= 1.0 for intermediate shafts with integral forged coupling flanges or with shrink-fitted keyless

coupling flanges

= 1.10 for intermediate shafts with keyed coupling hubs. At a distance of at least 0.2·d from the end of the keyway, such shafts can be reduced to a diameter corresponding to k = 1.0

= 1.10 for intermediate shafts with radial holes with a diameter less than $0.3 \cdot d_a$

= 1.10 for thrust shafts near the plain bearings on either side of the thrust collar, or near the axial bearings where an antifriction bearing design is used

= 1.15 for intermediate shafts designed as multi-splined shafts where d is the outside diameter of the splined shaft. Outside the splined section, the shafts can be reduced to a diameter corresponding to k = 1.0

= 1.20 for intermediate shafts with longitudinal slots where the length and width of the slot do not exceed $0.8 \cdot d_a$ and $0.1 \cdot d_a$ respectively

= 1.22 for propeller shafts from the area of the aft stern tube or shaft bracket bearing to the forward load-bearing face of the propeller boss subject to a minimum of 2.5·d, if the propeller is shrink- fitted, without key, on the tapered end of the propeller shaft using a method approved by the Society, or if the propeller is bolted to a flange forged on the propeller shaft

= 1.26 for propeller shafts in the aft area as specified for k = 1.22, with tapered key/keyway connection

= 1.40 for propeller shafts in the area specified for k = 1.22, if the shaft inside the stern tube is lubricated with grease

= 1.15 for propeller shafts forward part outside the bearing area but inside the stern tube. The portion of the propeller shaft located forward of the stern tube can be reduced to the size of the intermediate shaft

Parts of the propeller shaft exposed to water and without effective corrosion protection shall be strengthened by additional 5%.

2.3.4 Design

2.3.4.1 Changes in diameter

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

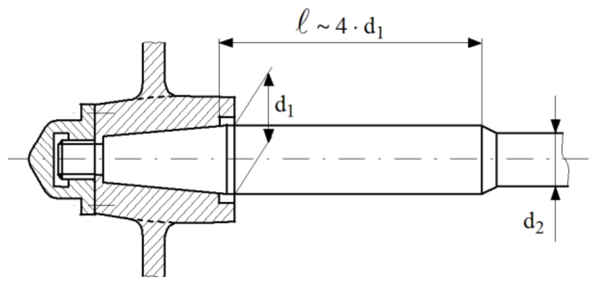


Figure 2 Propeller shaft

2.3.4.2 Sealing

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

Means shall be provided so that polluting lubricants do not spread into the water.

2.3.4.3 Shaft tapers and propeller nut threads

Keyways in the shaft taper for the propeller should be so designed that the forward end of the groove makes a gradual transition to the full shaft section. In addition, the forward end of the keyway should be spoon shaped. The edges of the keyway at the surface of the shaft taper for the propeller may not be sharp.

The forward end of the keyway shall lie well within the seating of the propeller boss. Threaded holes to accommodate the securing screws for propeller keys should be located only in the aft half of the keyway (Refer Fig.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 shall be between 1:10 and 1:15. Where the oil injection method is used to mount the propeller on the shaft, a taper of the cone between 1:15 and 1:20 shall be preferred.

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

2.3.4.4 **Shaft liners**

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

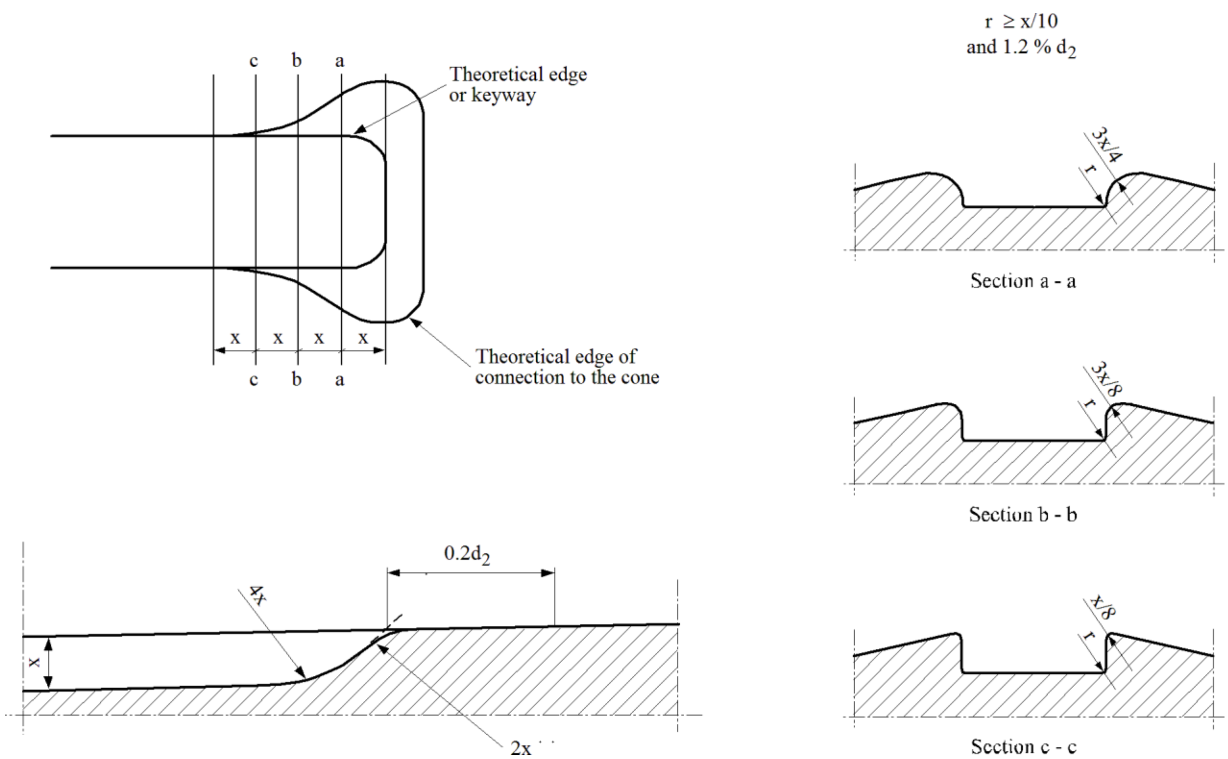
Metal liners, in accordance with the requirement here above, shall be made in a single piece. Only with the express consent of the Society may particularly long liners be made up of two parts, provided that, after fitting, the abutting edges are connected and made watertight by a method approved by the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

The minimum wall thickness, t [mm] of metal shaft liners in way of bearings shall be determined using the following formula:

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

d = shaft diameter under the liner [mm]

In the case of continuous liners, the wall thickness between the bearings may be reduced to 0.75·t.



d_2 = propeller shaft diameter

Figure 3 Design of keyway in propeller shaft

2.3.5 Couplings

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

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

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

The radius at integrally forged flanges shall be at least 0.08·d [mm].

In [2.3.5.2] to [2.3.5.6], the following symbols are used:

A = effective area of shrink fit seating [mm^2]

c_A = coefficient for shrink-fitted joints

= 1.0 for gear drives and electric motors

= 1.2 for direct diesel drives

C = conicity of shaft ends

= difference in taper diameter/length of taper

d = shaft diameter in area of clamp-type coupling [mm]

d_f, d_k = diameters of fitted bolts and plain bolts [mm]

D = diameter of pitch circle of bolts [mm]

f = coefficient for shrink-fitted joints

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

n = propeller speed [rev/min]

p = interface pressure of shrink fits [N/mm^2]

Q = peripheral force at the mean joint diameter of a shrink-fitted joint [N]

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

T_D = drive torque [N·m]

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

P_W = shaft power [kW]

d_m = mean joint diameter of the shrink fit [mm]

S = safety factor against slipping of shrink fits in the shafting

= 3.0 between motor and gearing

= 2.5 for all other applications

z = number of fitted or plain bolts

R_m = tensile strength of fitted or plain bolt material [N/mm^2]

T = propeller thrust [N]

Θ = half-conicity of shaft ends

= C/2

μ_0 = coefficient of static friction

= 0.15 for hydraulic shrink fits

= 0.18 for dry shrink fits

Δ_{min} = minimum shrink interference [mm]

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

$$d_f = 16 \cdot \sqrt{\frac{10^6 \cdot P_W}{n \cdot z \cdot D \cdot R_m}} \quad [\mathrm{mm}]$$

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

2.3.5.4 The minimum thread root diameter d_k of connecting bolts used for clamp-type couplings shall be determined using the following formula:

$$d_k = 12 \cdot \sqrt{\frac{10^6 \cdot P_W}{n \cdot z \cdot D \cdot R_m}} \quad [\mathrm{mm}]$$

2.3.5.5 The shank of necked-down bolts can be designed to a minimum diameter of 0.9 times the thread root diameter. If, besides the torque, the bolted connection is also required to transmit considerable additional forces, the size of the bolts shall be increased accordingly.

2.3.5.6 Where shafts are coupled together without keys by shrink-fitted coupling flanges or coupling sleeves, the dimensions of these shrink fits should be such that the maximum Van 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 shall be based on the “no go” ends of the prescribed tolerance gauges, and the necessary interface pressure p [N/mm^2], in the shrunk joint shall be determined as follows:

$$p = \frac{\sqrt{\Theta^2 \cdot T^2 + f \cdot \left(c_A^2 \cdot Q^2 + T^2\right)} - \Theta \cdot T}{A \cdot f}$$

T shall be introduced as a positive value if the propeller thrust increases the surface pressure at the taper. Change of direction of propeller thrust shall be neglected as far as power and thrust are essentially less.

T shall be introduced as a negative value if the propeller thrust reduces the surface pressure at the taper,

e.g. for tractor propellers.

2.3.6 **Shaft bearings**

2.3.6.1 **Arrangement of shaft bearings**

Shaft bearings both inside and outside the stern tube shall 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 shall 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, so that the reaction forces of line or gear shaft bearings are not appreciably affected should the alignment of one or more bearings be altered by hull deflections or by displacement or wear of the bearings themselves.

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

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

K_1 = coefficient defined as:

= 450 for oil-lubricated white metal bearing

= 280 for grey cast iron, grease-lubricated stern tube bearings

= 280 – 350 for water-lubricated rubber bearings in stern tubes and shaft brackets (upper values for special designs only)

Remark:

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

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

excessive loads due to bending vibrations. In borderline cases a bending stress analysis should be made for the shafting system.

K_2 = coefficient defined as:

= 8400 for oil-lubricated white metal bearings

= 5200 for grease-lubricated, grey cast iron bearings and for rubber bearings inside stern tubes and tail shaft brackets

2.3.6.2 **Stern tube bearings**

The camber shall be sufficient to tolerate without adverse effects an angular deviation of 0.1% between the shaft and the bearing axis. Self-aligning roller bearings may be used to carry the propeller shaft only if provision is made for the axial adjustment of such bearings.

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

Remark:

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

Where the propeller in the stern tube runs in bearings made of rubber or plastic, the length of the after bearing should equal approximately 3 - 4 times the shaft diameter, while the length of the forward bearing should be approximately 1 – 1.5 times the shaft diameter. Where the propeller shaft inside the stern tube runs in oil-lubricated white metal bearings, the lengths of the after and forward stern tube bearings should be approximately 2 and 0.8 times the shaft diameter respectively. 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.

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.

Where the propeller shafts are intended to run in anti-friction bearings within the stern tube, such bearings should be preferably cylindrical roller bearings with cambered rollers or bearing races and with an increased bearing clearance.

2.3.6.3 **Bearing lubrication**

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

Lubricating oil or grease shall be used 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 shall be used to secure a continuous supply of grease.

Where the shaft runs in oil within the stern tube, a header tank shall be fitted at a sufficient height above the vessel’s load line. There shall be provision for checking the level of oil in the tank at any time.

2.3.6.4 **Stern tube connections**

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

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

2.3.6.5 **Cast resin mounting**

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

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

Installation instructions issued by the manufacturer of the cast resin shall be observed.

2.3.7 **Shaft locking device**

To prevent dragging of a shutdown propulsion unit, the shafting shall be fitted with a locking device.

2.3.8 **Pressure tests**

2.3.8.1 **Shaft liners**

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

2.3.8.2 **Stern tubes**

Prior to fitting in the finish-machined condition, cast stern tubes shall be subjected to a hydraulic tightness test at 2 bar pressure. A further tightness test shall 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.

2.4 Gears and couplings

2.4.1 General

2.4.1.1 **Scope**

The following requirements apply to spur, planetary and bevel gears and to all types of couplings for application in the propulsion plant or auxiliary machinery such as:

—electric generator sets

—windlasses

—bow thruster units

—lubricating oil, cooling water, bilge pumps, etc.

Remark:

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 [2.4.7].

2.4.1.2 Documents for approval

Assembly and sectional drawings together with the necessary detail drawings and parts lists shall be submitted to the Society for approval. They shall contain all data necessary to enable the load calculations to be checked.

2.4.2 Materials

2.4.2.1 **Approved materials**

a) Shafts, pinions, wheels and wheel rims of gears in the main propulsion plant shall normally be made of forged steel. For plain, flangeless shafts, rolled steel bar may also be used. Gear wheel shall be of grey cast iron nodular cast iron or welded steel or cast steel hubs.

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

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

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

However, for generator sets use shall only be made of coupling bodies made of nodular cast iron with a mostly ferritic matrix, of steel or of cast steel, to confirm that the couplings 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.

Remark:

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.

2.4.2.2 Testing of materials

All materials of torque transmitting components of gearing and couplings and the plates and steel parts of welded gear casings shall possess the properties specified in Part 2 of Ship Rules. This may be proven by an acceptance test certificate issued by the manufacturer.

With the consent of the Society, the tests prescribed in Part 2 may be reduced if the execution of such tests is rendered impracticable by the small size of certain components or by the manufacturing techniques used. For such parts, proof of quality shall be furnished to the Society by other means.

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

2.4.3.1 General

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

For the design and calculation of the gears, the requirements for the design and construction of gears according to Part 5A Ch 3 of Ship Rules are applicable.

2.4.3.2 Application factor K_A

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

Where a value as described above cannot be supplied, the application factor K_A shall be determined for main and auxiliary systems in accordance with Table 5.

Table 5 Application factor

System type	K_A
Main propulsion	
Diesel engine with fluid coupling or electro-magnetic 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
Remark: *For other types of systems, the factor K_A shall be stipulated separately*	

2.4.4 **Gear shafts**

2.4.4.1 Minimum diameter

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

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

For $d_i/d_a \leq 0.3$:

$$1 - \left(\frac{d_i}{d_a}\right)^4 = 1.0$$

d_i = diameter of shaft bore, if applicable [mm]

d_a = actual shaft diameter [mm]

P_W = driving power of shaft [kW]

N = shaft rotational speed [rev./min]

F = factor for the type of drive

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

= 94 for all other types of drive. 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

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

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

k = coefficient defined as:

= 1.10 for gear shafts

= 1.15 for gear shafts in the area of the pinion or wheel body, if this is keyed to the shaft, and for multi-spline shafts.

Higher values of k may be specified by 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.

2.4.5 Equipment

2.4.5.1 Oil level indicator

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

2.4.5.2 Pressure and temperature control

Temperature and pressure gauges shall 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 shall 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 shall be complied with.

2.4.5.3 Lubricating oil pumps

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

2.4.5.4 Gear casings

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

2.4.5.5 Seating of gears

The seating of gears on steel or cast resin chocks shall conform to Part 5A Ch 3 of Ship Rules

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

2.4.6 Balancing and testing

2.4.6.1 Balancing

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

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

$$U = \frac{9.6 \cdot Q \cdot G}{z \cdot N}$$

G = mass of body to be balanced [kg]

N = operating rotational speed [rev./min] of body to be balanced

z = number of balancing planes

Q = degree of balance

= 6.3, for gear shafts, pinions and coupling members for engine gears

= 2.5, for torsion shafts and gear couplings, pinions and gear wheels belonging to turbine transmissions

2.4.6.2 Testing in the manufacturer’s works

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

Tightness tests shall be performed on those components to which such testing is appropriate. Reductions in scope of tests require the consent of the Society.

2.4.7 Design and construction of couplings

For the design and construction of couplings in main and auxiliary propulsion systems, such as tooth couplings, flexible couplings, etc., the Society's Rules, Part 5A Ch 4 Sec 3 of Ship Rules are applicable.

2.5 Propellers

2.5.1 General

2.5.1.1 Scope

The following requirements applicable to screw propellers and controllable pitch propellers. Where a design is proposed to which the following requirements cannot be applied, special strength calculations shall be submitted to the Society and the necessary tests shall be agreed with the Society.

Documents for approval

Design drawings of propellers shall be submitted to the Society for approval. Drawings shall contain all the details necessary to verify compliance with the following Rules.

2.5.1.2 **Symbols and terms**

A = effective area of shrink fit [mm^2]

B = developed blade width of cylindrical sections at radii 0.25·R, 0.35·R and 0.60·R [mm]

C_A = coefficient for shrunk joints

= 1.0 for gear transmissions, electric motors

= 1.2 for direct diesel drives

C_G = size factor

$$= \sqrt{\frac{f_1 + 0.001 \cdot D}{12.2}}$$

with $1.1 \geq C_G \geq 0.85$

C_W = characteristic value for propeller material as shown in Table 6 (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 [2.5.2])

C = conicity of shaft ends

= difference in taper diameter/length of taper

d = pitch circle diameter of blade or propeller fastening bolts [mm]

d_k = root diameter of blade or propeller fastening bolts [mm]

d_S = nominal diameter of studs or bolts [mm]

Table 6 Characteristics values CW for propeller materials

Material	Description 1)	Cw
Cu 1	Cast manganese brass	440
Cu 2	Cast manganese nickel brass	440
Cu 3	Cast nickel aluminium bronze	590
Cu 4	Cast manganese aluminium bronze	630
Fe 1	Unalloyed cast steel	440
Fe 2	Low-alloy cast steel	440
Fe 3	Martensitic cast chrome steel 13/1-6	600

Fe 4	Martensitic cast chrome steel 17/4	600
Fe 5	Ferritic-austenitic cast steel 24/8	600
Fe 6	Austenitic cast steel 18/8-11	500
1) For the chemical composition of the alloys, see the Part 2 of Ship Rules		

D = diameter of propeller [mm]

D_m = mean taper diameter [mm]

e = blade rake to aft [mm]

= 0.5 · D · tan ε (refer Fig. 4)

f, f_1 = factors defined as:

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

f_1 = 7.2 for solid propellers

= 6.2 for separately cast blades of variable pitch or built-up propellers

H = propeller blade face pitch at radii 0.25·R, 0.35·R and 0.60·R [mm]

H_m= mean effective propeller pitch on blade face for pitch varying with the radius [mm]

$$= \frac{\Sigma(R \cdot B \cdot H)}{\Sigma(R \cdot B)}$$

where R, B and H shall be substituted by values corresponding to the pitch at the various radii

k = coefficient for various profile shapes in accordance with Table 7

ℓ_M = 2/3 of the leading edge component of the blade width at 0.9·R, but at least ¼ of the total blade width at 0.9·R for propellers with heavily skewed blades [mm]

L = pull-up length when mounting propeller on taper [mm]

L_{mech} = pull-up length at t = 35 °C [mm]

L_{temp} = temperature-related portion of pull-up length at t < 35 °C [mm]

n_2 = propeller speed [min^{-1}]

P_W = nominal power of driving engine [kW]

P = specific pressure in shrunk joint between propeller and shaft [N/mm^2]

Q_n = nominal peripheral force at mean taper diameter at maximum continuous rating (MCR) condition [N]

$$= 19.1 \cdot \frac{P_W}{n_2 \cdot d_m} \cdot 10^6$$

Q_{FR} = peripheral force at mean taper diameter at MCR condition including Q_n and $Q_{V\text{-}MCR}$ [N]

$Q_{V\text{-}MCR}$ = peripheral force at mean taper diameter at MCR condition due to torsional vibration [N]

$R_{P0.2}$ = 0.2% proof stress of propeller material [N/mm^2]

R_{eH} = yield strength [N/mm^2]

R_m = tensile strength of the material of fitted or conventional bolts [N/mm^2]

S = margin of safety against propeller slipping on taper

= 2.8

t = maximum blade thickness of developed cylindrical section at radii 0.25·R, 0.35·R and 0.60·R [mm]

T = propeller thrust [N]

T_M = impact moment in accordance with [2.5.4.3] [N·m]

$W_{0.35R}$ = section modulus of cylindrical blade section at radius 0.35 R [mm]

$W_{0.6R}$ = section modulus of cylindrical blade section at radius 0.6 R [mm^3]

Z = total number of bolts used to retain one blade or propeller

z = number of blades

α = pitch angle of profile at radii 0.25·R, 0.35·R and 0.60·R

$$\alpha_{0.25} = \operatorname{atan}\frac{1.27 \cdot H}{D}$$

$$\alpha_{0.35} = \operatorname{atan}\frac{0.91 \cdot H}{D}$$

$$\alpha_{0.60} = \operatorname{atan}\frac{0.53 \cdot H}{D}$$

a_A = tightening factor for retaining bolts and studs, depending on the method of tightening used

guidance values:

= 1.2 for angle control

= 1.3 for bolt elongation control

= 1.6 for torque control

ε = angle included by face generatrix and normal (see Fig. 4) [°]

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

Θ = half-conicity of shaft ends

= C/2

μ_0 = coefficient of static friction

= 0.13 for hydraulic oil shrunk joints

= 0.15 for fitted joints, bronze to steel

= 0.18 for dry shrunk joints, steel to steel

Friction improving agents are not taken into account in the values listed above.

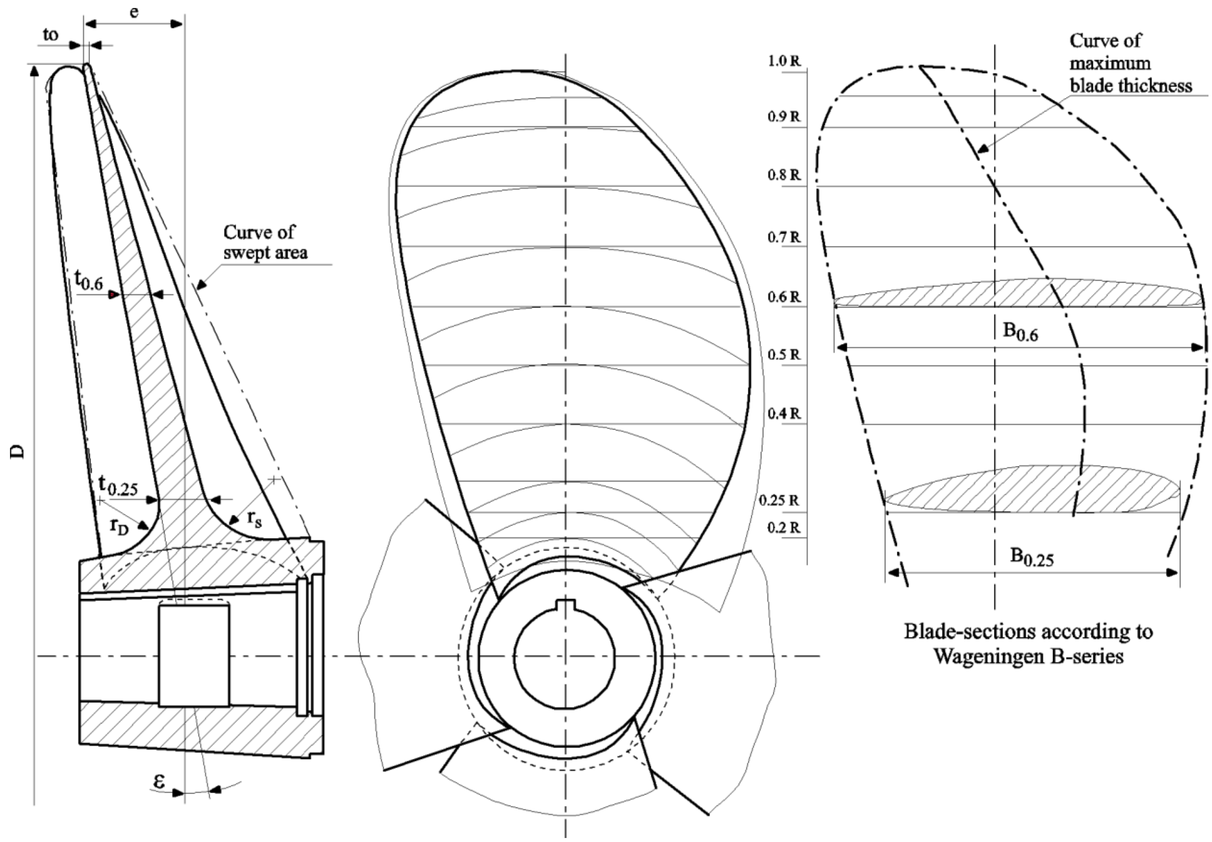


Figure 4 Blade sections

2.5.2 **Materials**

2.5.2.1 **Approved materials**

Propellers shall be made of established cast copper or cast steel alloys with a tensile strength of at least 440 N/mm^2 and of proven sufficient fatigue strength under alternating bending stresses.

The use of grey cast iron, un- and low-alloyed cast steel for propellers may be permitted on a case-by-case basis.

Composite materials may also be used, provided that a sufficient strength has been demonstrated and the propeller is manufactured according to an approved procedure.

For the use shall of propeller materials which performance has not yet been documented, documentation supporting their suitability shall be submitted to the Society.

2.5.2.2 **Testing of materials**

Propeller materials and materials of blade mounting screws/bolts as well as those of important components involved in the adjustment of variable pitch propellers shall possess the properties specified in Pt.2 of Ship Rules. This may be demonstrated by an acceptance test certificate issued by the manufacturer.

2.5.3 Calculation of blade thickness

2.5.3.1 At radii 0.25 · R, and 0.60 · R (refer Fig.4), the blade thickness of solid propellers shall, as a minimum requirement, comply with the following formula:

$t = K_0 \cdot k \cdot K_1 \cdot C_G$

K_0 = coefficient defined as

$$= 1 + \frac{e \cdot \cos\alpha}{H} + \frac{n_2}{15000}$$

K_1 = coefficient defined as

$$\sqrt{\frac{P_W \cdot 10^5 \cdot \left(2 \cdot \frac{D}{H_m} \cdot \cos\alpha + \sin\alpha\right)}{n_2 \cdot B \cdot z \cdot C_W \cdot (\cos\varepsilon)^2}}$$

2.5.3.2 The blade thicknesses of controllable pitch propellers shall be determined at radii 0.35·R and 0.60·R by applying the formula mentioned in [2.5.3.1].

For the controllable pitch propellers of tugs and pushing vessels with similar operating conditions, the diameter/pitch ratio D/H_m for the maximum static bollard pull shall be used in formula given in [2.5.3.1].

For other vessels, the diameter/pitch ratio D/H_m applicable to open-water navigation can be used in formula mentioned [2.5.3.1].

2.5.3.3 The blade thicknesses calculated by applying formula mentioned in [2.5.3.1] are minima for the finish- machined propellers without fillets.

If the propeller is subjected to an essential wear, e.g. abrasion in muddy waters, the thickness determined under [2.5.3.1] shall be increased. If the actual thickness in service is below 50% at the tip and 90% at other radii of the value obtained from formula given in [2.5.3.1] countermeasures shall be taken.

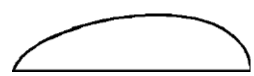
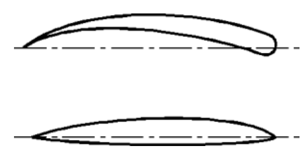
2.5.3.4 The fillet radii at the transition from the face and back of the blades should correspond, in the case of three and four-bladed propellers, to about 3.5 % of the propeller diameter. For propellers with a larger

number of blades, the maximum fillet radii allowed by the propeller design should be aimed at, and the radii shall not in any case be made smaller than $0.4 \cdot t_{0.25R}$.

2.5.3.5 For special designs such as propellers with skew angle ψ ≥ 25°, end plate propellers, tip fin propellers, special profiles, etc., special mechanical strength calculations shall be submitted to the Society.

A blade geometry data file and details on the measured wake shall be submitted to the Society by data carrier 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.

Table 7 Values of k for various profile shapes

Profile shape	*Values of k*		
	0.25 R	*0.35 R*	*0.6 R*
Segmental profiles with circular arced suction side	73	62	44
			
Segmental profiles with parabolic suction side	77	66	47
			
Blade profiles as for Wageningen B Series propellers	80	66	44
			

2.5.4 **Controllable pitch propellers**

2.5.4.1 **Documents for approval**

In the case of controllable pitch propellers, besides the design drawings of the blades and propeller boss, general and sectional drawings of the entire controllable pitch propeller installation shall be submitted to the Society for approval. Diagrams of control systems and piping shall be accompanied by a functional description. For new designs and controllable pitch propellers which shall be installed for the first time on a vessel, a description of the controllable pitch propeller system shall be submitted at the same time.

2.5.4.2 Hydraulic control equipment

Where the pitch control mechanism is operated hydraulically, one set of pumps might be sufficient for the pitch setting. However, one hand pump shall be provided, by which blade adjustment is possible.

2.5.4.3 Pitch control mechanism

For the pitch control mechanism, proof is required that, when subjected to an impact moment T_M as defined by the formula below, the individual components still have a safety factor of 1.5. The calculated stress should not exceed the yield strength value.

$$T_M = \frac{1.5 \cdot R_{P0.2} \cdot W_{0.6R}}{\sqrt{\left(\frac{0.15 \cdot D}{\ell_M}\right)^2 + 0.75}} \cdot 10^{-3}$$

$W_{0.6R}$ = parameter defined in [2.5.1.3]

$= 0.12 \cdot \left(B \cdot t^2\right)_{0.6R}$

2.5.4.4 Blade retaining bolts and studs

The blade retaining bolts shall be designed in such a way as to withstand the forces induced in the event of plastic deformation at the root section at 0.35 · 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.

For a thread core diameter greater than:

$$d_k = 2.6 \cdot \sqrt{\frac{M_{0.35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

where:

$$M_{0.35R} = W_{0.35R} \cdot R_{p0.2}$$

The blade retaining bolts or studs shall be tightened in a controlled manner in such a way that the loading on the bolts or studs is about 60 – 70% of their yield strength.

The shank of the blade retaining bolts may be designed with a minimum diameter equal to 0.9 times the root diameter of the thread. Blade retaining bolts shall be secured against unintentional loosening.

2.5.4.5 Flanges for connection of blades to hubs

The diameter D_F, in mm, of the flange for connecting the blade to the propeller hub shall not be less than that obtained from the following formula:

D_F $= d + 1.8 \cdot d_S$

The thickness of the flange shall not be less than 1/10 of the diameter D_F. This formula is also applicable for built-up propellers.

2.5.4.6 Indicators

Controllable pitch propeller systems shall be provided with an engine room indicator showing the actual pitch setting of the blades. If the controllable pitch propeller is operated from the steering stand of the vessel, the steering stand shall also be equipped with an indicator showing the actual blade pitch setting.

For vessels with automated machinery installations, Refer also Sec.1 [3.8].

2.5.4.7 Failure of control system

Suitable devices shall be fitted to confirm that an alteration of the blade pitch setting cannot overload the propulsion plant or cause it to stall.

Alternate arrangement shall be provided that, in the event of failure of the control system, the setting of the blades:

— does not change or

— reaches a final position slowly enough to allow the emergency control system to be put into operation or to take other suitable countermeasures.

2.5.4.8 Emergency control

If the remote control system fails, then controllable pitch propeller systems shall be equipped with means of emergency control enabling the controllable pitch propeller to remain in operation.

Remark:

It is recommended that a device is fitted which locks the propeller blades in the “ahead” setting.

2.5.5 **Balancing and testing**

2.5.5.1 **Balancing**

The finished propeller and the blades of controllable pitch and built-up propellers are required to undergo static balancing.

2.5.5.2 **Testing**

The finished propeller shall 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.

2.5.6 **Propeller mounting**

2.5.6.1 **Tapered mountings**

Where the tapered joint between the shaft and the propeller is fitted with a key, the propeller shall 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 shall be locked 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 shall also be made for surface smoothening when calculating L.

L_{mech} is determined according to the formulas of elasticity theory applied to shrunk joints for a specific pressure p [N/mm^2] at the mean taper diameter determined by applying the following formula and for a temperature of 35 °C (95°F):

$$p = \frac{\sqrt{\Theta^2 \cdot T^2 + f \cdot \left(c_A{}^2 \cdot Q^2 + T^2\right)} \pm \Theta \cdot T}{A \cdot f}$$

"+" = sign applying to shrunk joints of tractor propeller

"–" = sign applying to shrunk joints of pusher propeller

L_{temp} applies only to propellers made of bronze and austenitic steel.

$$L_{temp} = \frac{d_m}{C} \cdot 6 \cdot 10^{-6} \cdot (35 - t_1)$$

t_1 = temperature [°C] at which the propeller is mounted

The safety factor shall be taken as S = 2.8 for geared plants and $Q = Q_n$.

For direct drives the safety factor shall be taken as S = 1.0 and the circumferential force Q shall be replaced by Q_{FR} according to the following formula:

$Q_{FR} = 2.0 \cdot Q_n + 1.8 \cdot Q_{V\text{-}MCR}$

Q_{FR} replaces Q in the formula of specific pressure p given here above.

$Q_{V\text{-}MCR}$ = maximum value from torsional vibration evaluations, but shall not be taken less than 0.44 times the Q_n

The torsional vibration evaluation shall consider the worst relevant operating conditions, e.g. such as misfiring (one cylinder with no injection) and cylinder unbalance.

The tapers of propellers which are mounted on the propeller shaft with the aid of hydraulic oil technique should not be more than 1:15 or less than 1:20.

The Von Mises equivalent stress based on the maximum specific pressure p and the tangential stress in the bore of the propeller hub may not exceed 75% of the 0.2 % proof stress or yield strength of the propeller material.

The propeller nut shall be locked to the propeller shaft by mechanical means.

2.5.6.2 **Flange connections**

Flanged propellers and the bosses of controllable pitch propellers shall be attached using fitted pins and bolts (necked down bolts for preference).

The diameter of the fitted pins shall be calculated by applying formula mentioned in [2.3.5.2]. The propeller retaining bolts shall be of similar design to those described in [2.5.4.4].

The thread core diameter shall not be less than:

$$d_k = 4.4 \cdot \sqrt{\frac{M_{0.35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

The suitability of the connection shall be demonstrated. Friction coefficients shall be used according to [2.5.1.3].

Remark:

In exceptional cases flange connections may transmit a fraction of the torque by friction. The fraction should not exceed 50% and fraction multiplied by safety factor shall not be below 100% of the maximum engine torque.

2.6 Torsional vibrations

2.6.1 General

2.6.1.1 Application

The following requirements apply to the shafting of the following installations:

—propulsion systems with prime movers developing 300 kW or more

—other systems with internal combustion engines developing 300 kW or more and driving auxiliary machinery intended for essential services.

2.6.1.2 Definition

Torsional vibration stresses are additional loads due to torsional vibrations. They result from the alternating torque which is normally superimposed on the mean torque.

2.6.2 Calculation of torsional vibrations

2.6.2.1 A torsional vibration analysis covering the torsional vibration stresses to be expected in the main engine shafting system including its branches shall be submitted to the Society for examination.

2.6.2.1.1 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

2.6.2.2 The calculations shall be performed both for normal operation and misfiring operation caused by irregularities in ignition. In this respect, the calculations shall assume operation for one cylinder without ignition (misfiring).

2.6.2.3 Where the arrangement of the installation allows various different operation modes, the torsional vibration characteristics shall 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.

2.6.2.4 The calculation of torsional vibrations shall also consider of the stresses resulting from the superimposition of several orders of vibration (synthesized torques/stresses).

2.6.2.5 If modifications are introduced into the system which have a substantial effect on the torsional vibration characteristics, the calculation of the torsional vibrations shall be repeated and submitted for checking.

2.6.3 Permissible torsional vibration stresses

2.6.3.1 General

The calculation of the permissible torsional vibration stresses as well as the determination of the permissible vibratory torques for gearing, couplings and crankshaft shall be performed in accordance with Part 5A Ch 4 Sec 4.3 of Ship Rules.

2.6.4 Torsional vibration measurements

2.6.4.1 After consideration of the results of the calculations according to [2.6.2], the Society may request the performance of torsional vibration measurements during river trials.

2.6.4.2 Torsional vibration measurements may also be required by the Society in the case of conversions affecting the main propulsion plant.

2.6.5 Barred speed range

2.6.5.1 Normal operation

Operating ranges, because of the magnitude of the torsional vibration stresses, may only be passed through shall be marked 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 shall be passed through as quickly as possible. In specifying barred speed ranges, it is important to confirm that the navigating and maneuvering functions are not unreasonably restricted.

The speed range $\lambda \geq 0.8$ shall 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.

2.6.5.2 Deviations from normal operation

This is understood to include firing irregularities or, in an extreme case, the complete interruption of the fuel supply to a cylinder.

The actions necessary to prevent overloading of the propulsion plant in case of deviation from normal operation shall be clearly displayed on tables at all the operating stations from which the plant can be controlled.

Remark:

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 [2.6.5.1].

Even in the event of an abnormal operation due to ignition failure of one cylinder, a continuous operation over extended time periods within certain speed ranges shall remain possible, thus maintaining the maneuverability for safe operation of the vessel.

2.6.6 **Auxiliary machinery**

2.6.6.1 Important auxiliary machinery such as diesel generators and lateral thrust units shall 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 shall be submitted to the Society.

2.6.6.2 Essential auxiliary machinery shall be designed such that, operation under misfiring condition is possible, so far, no adequate redundancy is provided.

2.6.6.3 In the case of diesel generators with rigidly coupled generators, the torsional vibration torque in continuous operation shall not exceed 2.5 times the generator's normal torque.

2.7 Windlasses

2.7.1 **General**

2.7.2 **Scope**

2.7.2.1 This sub-section applies to bow anchor windlasses, stern anchor windlasses and wire rope windlasses. For anchors, chains and ropes, refer Pt.3 Ch.6 Sec.4.

2.7.2.2 **Documents for approval**

For each type of anchor windlass, general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the main shaft, cable lifter and brake shall be submitted to the Society for approval.

One copy of a description of the anchor windlass including the proposed overload protection and other safety devices is likewise to be submitted.

Where an anchor windlass shall be approved for several strengths and types of chain cable, the calculation relating to the maximum braking torque shall be submitted and proof furnished of the power and hauling-in speed in accordance with [2.7.4.1] corresponding to all the relevant types of anchor and chain cable.

2.7.3 **Materials**

2.7.3.1 **Approved materials**

The provisions contained in Pt.2 of Ship Rules shall be applied as appropriate to the choice of materials.

2.7.3.2 **Testing of materials**

The material of components which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, brake bands, brake spindles, brake bolts, tension strap) shall possess mechanical characteristics in conformity with Pt.2. Evidence of this may take the form of a certificate issued by the steel manufacturer which contains material composition and the test results prescribed in Pt.2.

In the case of hydraulic systems, the material used for pipes and pressure vessels shall also be tested.

2.7.4 Design and equipment

2.7.4.1 Type of drive

Windlasses are normally 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.

Remark:

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

Hand-operated winches shall be fitted with devices to prevent kick-back of the crank. Winches that are both power- and manually driven shall be designed in such a way that the motive-power control cannot actuate the manual control.

2.7.4.2 Overload protection

For protection of the mechanical parts in the case of the windlass jamming, an overload protection (e.g. slip coupling, relief valve) shall be fitted to limit the maximum torque of the drive engine (refer [2.7.4.1]). The setting of the overload protection shall be specified (e.g. in the operating instructions manual)

2.7.4.3 Clutches

Windlasses shall be fitted with dis-engageable clutches between the cable lifter and the drive shaft. In an emergency case, hydraulic or electrically operated clutches shall be capable of being disengaged by hand.

2.7.4.4 Braking equipment

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

2.7.4.5 Pipes

For the design and dimensions of pipes, valves, fittings and hydraulic piping systems, etc. refer Sec.2.

2.7.4.6 Cable lifters

Cable lifters shall have at least five snugs.

Remark:

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

2.7.4.7 Windlass as warping winch

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

2.7.4.8 Electrical equipment

The electrical equipment shall comply with Ch.4.

2.7.4.9 Hydraulic equipment

Tanks forming part of the hydraulic system shall be fitted with oil level indicators. The lowest permissible oil level shall be monitored.

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

2.7.4.10 Wire rope windlass

The rope drum diameter shall be at least 14 times the required rope diameter. The drive of the windlass shall be capable of being uncoupled to the rope drum.

The rope end fastening of the windlass shall brake if the wire rope shall 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.

2.7.4.11 Chain stoppers

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

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

2.7.4.12 Connection with deck

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

2.7.5 Power and design

2.7.5.1 Driving power

a) Depending on the grade of the chain cable, windlasses shall be capable of exerting the following nominal pulls at a speed of at least 0.15 m/s:

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

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

Z_i = pull [N]

d = diameter of anchor chain [mm]

b) The nominal output of the power units shall be such that the conditions specified above can be met for 30 minutes without interruption. In addition, the power units shall be capable of developing a maximum torque equal to 1.5 times the rated torque for at least two minutes at a correspondingly reduced lifting speed.

c) At the maximum torque specified in b), a short-time overload of up to 20% is allowed in the case of internal combustion engines.

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

e) With manually operated windlasses, steps shall be taken to confirm that the anchor can be hoisted at a mean speed of 0.033 m/s with the pull specified in a). This shall be achieved without exceeding a manual force of 150 N applied to a crank radius of about 350 mm (13.7795”) with the hand crank turned at about 30 rev./min.

2.7.5.2 Design of transmission elements

The basis for the design of the load-transmitting components of windlasses is given by the anchors and chain cables specified in the Society's rules Part 4 Ch 3 of Ship Rules

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

The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft and braking equipment, bedframe and deck fastening) shall be based on a theoretical pull equal to 80% of the nominal breaking load specified in the Society's Rules Part 2 for the chain in question.

The design of the main shaft shall take account of the braking forces, and the cable lifter brake shall not slip when subjected to this load.

The design of all other windlass components shall be based upon a force acting on the cable lifter pitch circle and equal to 1.5 times the nominal pull specified in a) of [2.7.4.1].

At the theoretical pull, the force exerted on the brake hand wheel shall not exceed 500 N.

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

The foundations and pedestals of windlasses and chain stoppers shall be adequately designed to withstand the forces and loads as specified in [2.7.3.11] and in paragraphs here above.

2.7.6 Testing in the manufacturer’s works

2.7.6.1 Testing of driving engines

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

For electric motors, refer Ch.4 Sec.3.

Hydraulic pumps shall be subjected to pressure and operational tests.

2.7.6.2 Pressure and tightness tests

Pressure components shall undergo a pressure test at pressure:
$p_{ST} = 1.5 \cdot p$
p_{ST} = test pressure [bar]
p = maximum allowable working pressure or pressure at which the relief valves open [bar]
For working pressures above 200 bar, the test pressure need not exceed p + 100.
For pressure testing of pipes, their valves, and fittings, and also of hose assemblies, refer Sec. 2. Tightness tests shall be performed on components as appropriate.

2.7.6.3 Final inspection and operational testing

After completion of manufacturing, windlasses are subjected to final inspection and operational testing at twice the nominal pull in the presence of a Surveyor from the Society. The hauling-in speed shall be verified with continuous application of the nominal pull. During the tests, particularly pay attention to the testing and 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 shall be performed under no-load conditions.

2.8 Hydraulic system

2.8.1 General

2.8.1.1 Scope

This sub-section applies to hydraulic systems used, for example, to operate closing appliances in the vessel's shell, landing ramps and hoists. The requirements shall be applied in analogous manner to vessel's other hydraulic systems.

2.8.1.2 Documents for approval

The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used, etc., shall be submitted to the Society for approval.

2.8.1.3 Dimensional design

For the design of pressure vessels,-refer Ch.3 Sec.1 [1], for the dimensions of pipes, refer Ch.2.

2.8.2 Materials

2.8.2.1 Approved materials

Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with the Part 2 of Ship Rules. 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 shall 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.2.

2.8.2.2 Testing of materials

The materials of pressure casings and pressure oil lines shall have mechanical characteristics according to Pt.2. 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 Part 2 of Ship Rules.

2.8.3 Design and equipment

2.8.3.1 Control

Hydraulic systems shall be supplied either from a common power station or from several power stations, each serving a particular system.

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

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

Local controls, inaccessible to unauthorized persons, shall 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 shall be fitted. In addition, the operating stations are then to be equipped with indicators for monitoring the movement of the hoist.

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

2.8.3.2 Pipes

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

Pipes shall 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 shall be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

Pipes shall be so installed such that they are free from stress and vibration.

The piping system shall be fitted with filters for cleaning the hydraulic fluid. Equipment shall be provided to enable the hydraulic system to be vented.

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

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

2.8.3.3 Oil level indicators

Tanks within the hydraulic system shall be equipped with oil level indicators.

An alarm located in the wheelhouse shall be fitted for the lowest permissible oil level.

2.8.3.4 Hose lines

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

High-pressure hose assemblies shall be used if necessary, for flexible connections. These hose assemblies shall meet the requirements of Ch.2 or an equivalent standard. The hose assemblies shall be properly installed and suitable for the relevant operating media, pressures, temperatures, and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose assemblies shall be flame-resistant or to be protected correspondingly.

2.8.4 Testing in the manufacturer's works

2.8.4.1 Testing of power units

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

For electric motors, refer Ch.4 Sec.3.

Hydraulic pumps shall be subjected to pressure and operational tests.

2.8.4.2 Pressure and tightness tests

Pressure components shall undergo a pressure test at pressure

p_{ST} = 1.5 · p

p_{ST} = test pressure [bar]

p = maximum allowable working pressure or pressure at which the relief valves open [bar]

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

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, refer Ch.2. Tightness tests shall be performed on components as appropriate.

SECTION 3 LATERAL THRUST UNITS

Contents

3.1 General

3.1.1 Scope

The following requirements apply to the lateral thrust unit, the control station and all the transmission elements from the control station to the lateral thrust unit.

3.1.2 Documents for approval

Assembly and sectional drawings together with detail drawings of the gear mechanism and propellers containing all the necessary data and calculations shall be submitted to the Society for approval.

3.2 Materials

Materials are subject, as appropriate, to the provisions of Sec.2 [2.2] and Sec.2 [3.2].

3.3 Thruster tunnel

3.3.1 Scantlings and arrangements

The scantlings and arrangements of the thruster tunnel shall be in compliance with Pt.3 Ch.5 Sec.1 [8].

3.4 Machinery and systems

3.4.1 **Dimensions and design**

3.4.4.1 The dimensional design of the driving mechanisms of lateral thrust units shall be in compliance with Sec.2 [3] and Sec.2 [4].

The dimensional design of the propellers shall comply with Sec.2 [5].

The free end of the driving shaft from the non-drive end bearing to the propeller shall be dimensionally designed as a propeller shaft in accordance with Sec.2 [3].

3.4.4.2 The pipes for drive systems of lateral thrust units shall 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 shall be provided with protective shielding and shall 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 shall be used if necessary, for flexible connections. These hose lines shall meet the requirements of Ch.2 or an equivalent standard. The hose lines shall be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel, and in spaces subjected to a fire hazard, the hose lines shall be flame resistant or to be protected accordingly.

3.4.4.3 Lateral thrust units shall be capable of being operated independently of other connected systems.

3.4.2 Steering thruster control

Controls for steering thrusters shall be provided from the wheelhouse, machinery control station and locally. Means shall be provided to stop any running thruster at each of the control stations.

A thruster angle indicator shall be provided at each steering control station. The angle indicator shall be independent of the control system.

3.5 Electrical installations

3.5.1 General

Electrical installations of lateral thrust units shall comply with Ch.4 Sec.8 [2].

3.5.2 Cables

The cables shall be intended to supply a short-time load for up to one hour service.

3.5.3 Auxiliary machinery

3.5.3.1 Thruster auxiliary plants

The thruster auxiliary plants shall 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.

3.6 Test in the manufacturer’s works

3.6.1 Testing of power units

The power units are required to undergo a test on a test stand. The relevant manufacturers test certificates shall be presented at the time of the final inspection of unit.

For electrical motors, refer Ch.4.

Hydraulic pumps shall be subjected to pressure and operational tests.

3.6.2 Pressure and tightness tests

Pressure components shall subjected to a pressure test, using the following testing pressure:

$p_{ST} = 1.5 \cdot p$

p_{ST} = testing pressure [bar]

p = maximum allowable working pressure or pressure at which the relief valve is open

however, for working pressures above 200 bar, the testing pressure need not exceed p + 100 bar

For pressure testing of pipes, their valves and fittings and also for hose assemblies, refer Sec.2. Tightness tests shall be performed on components to which this is appropriate.

3.6.3 Final inspection and operational test

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of the Society's surveyor. The overload protection shall be adjusted at this time.

SECTION 4 DOMESTIC GAS INSTALLATIONS

Contents

4.1 General

4.1.1 Application

4.1.1.1 The following requirements apply to permanently installed domestic liquefied gas installations on vessels.

4.1.1.2 A liquefied gas installation shall only be used for domestic purposes in the accommodation and the wheelhouse, and for corresponding purposes on passenger vessels.

4.1.1.3 Deviations from these requirements are permissible, required they are permitted by the statutory regulations in force in the area of service.

4.1.2 General provisions

4.1.2.1 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.

4.1.2.2 Such installations may be operated only with commercial propane.

4.1.1.1 Documents to be submitted

Diagrammatic drawings including following information, shall be submitted to 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

4.2 Gas installations

4.2.1 General

4.2.1.1 Liquefied gas installations shall be suitable throughout for use with propane and shall be built and installed in accordance with the rules.

4.2.1.2 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.

4.2.1.3 No part of a liquefied gas installation shall be located in the engine room.

4.2.2 Gas receptacles

4.2.2.1 Only receptacles with an approved content of between 5 and 35 kg are permitted.

Remark:

For passenger vessels, the use of receptacles with a larger content shall be approved on a case-by-case basis.

4.2.2.2 The gas receptacles shall be permanently marked with the test pressure.

4.2.3 Supply unit

4.2.3.1 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.

4.2.3.2 No more receptacles may be in operation simultaneously than are necessary for the functioning of the installation. Several receptacles may be in operation provided 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.

4.2.3.3 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.

4.2.3.4 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.

4.2.3.5 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.

4.2.3.6 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.

4.2.3.7 Cupboards shall be so built and placed that the temperature of the receptacles cannot exceed 50 °C. (122°F)

4.2.4 Pressure reducers

4.2.4.1 Gas-consuming appliances shall 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 shall be reduced in one or two stages. All reducing valves shall be set permanently at a pressure determined in accordance with [4.2.5].

4.2.4.2 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 confirmed 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.

4.2.4.3 The protection devices and vents shall be protected against the entry of water.

4.2.5 Pressure

4.2.5.1 Where two-stage reducing systems are used, the mean pressure shall be not more than 2.5 bar (36.25 psi) above atmospheric pressure.

4.2.5.2 The pressure at the outlet from the last pressure reducer shall be not more than 0.05 bar(0.72 psi) above atmospheric pressure, with a tolerance of 10%.

4.2.6 **Piping and flexible tubes**

4.2.6.1 Pipes shall consist of fixed steel or copper tubing, in compliance with requirements of Ch.2.

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 (3.28 Foot) long.

4.2.6.2 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.

4.2.6.3 Pipes shall have as minimum joints as possible. Both pipes and joints shall remain gastight immaterial of any vibration or expansion to which they shall be subjected.

4.2.6.4 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.

4.2.6.5 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.

4.2.7 **Distribution system**

4.2.7.1 There shall be a provision to shut off the entire distribution system by means of a valve which is at all times easily and rapidly accessible.

4.2.7.2 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.

4.2.7.3 Valves shall be fitted at points where they are protected from the weather and from impact.

4.2.7.4 An inspection joint shall be fitted after each pressure reducer. It shall be confirmed using a closing device that in pressure tests the pressure reducer is not exposed to the test pressure.

4.2.8 **Gas-consuming appliances**

4.2.8.1 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.

4.2.8.2 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.

4.2.8.3 Heating and water-heating appliances and refrigerators shall be connected to a duct for evacuating combustion gases into the open air.

4.2.8.4 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.

4.2.8.5 Gas-consuming appliances may be installed in sleeping quarters only if combustion takes place independently of the air in the quarters.

4.2.8.6 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.

4.3 Ventilation system

4.3.1 General

4.3.1.1 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.

4.3.1.2 Ventilation apertures shall not have any closing device and shall not lead to sleeping quarters.

4.3.1.3 Evacuation devices shall be so designed as to confirm 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.

4.4 Tests and trials

4.4.1 Definition

A piping shall be considered gastight provided, after sufficient time has elapsed for thermal balancing, no pressure drops in the test pressure the following 10 minutes.

4.4.2 Testing conditions

4.4.2.1 The completed installation shall be subjected to tests defined in [4.2.2] to [4.2.8].

4.4.2.2 Medium-pressure pipes between the closing device, referred to in [4.2.8.4], of the first reducing device and the valves fitted before the final pressure reducer:

a) pressure test, carried out using air, an inert gas or a liquid at a pressure 20 bar (290.07 psi) above atmospheric pressure

b) gas tightness test, carried out with air or an inert gas at a pressure 3.5 bar (50.76 psi) above atmospheric pressure

4.4.2.3 Pipes at the utilization pressure between the closing device, referred to in [4.2.7.4], 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

4.4.2.4 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 (2.17 psi) above atmospheric pressure

4.4.2.5 In the tests referred to in [4.2.2] (b), [4.2.3] and [4.2.4], the pipes are deemed gastight if, after sufficient time to allow for normal balancing, no drop in the test pressure is observed during the following 10 minutes.

4.4.2.6 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

4.4.2.7 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 confirm that they operate satisfactorily.

4.4.2.8 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 5 TESTS ON BOARD

Contents

5.1 General

5.1.1 Application

The following covers onboard tests, both at the moorings and during river trials. Such tests are additional to the workshop tests required in the other sections.

5.1.2 Purpose of onboard tests

Shipboard tests are necessary to demonstrate 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 surveyor of the Society.

5.1.3 Documentation to be submitted

A comprehensive list of the shipboard tests intended to be carried out by the shipyard shall be submitted to the Society. For each test, the following information shall be provided:

- scope of the test
- parameters to be recorded

5.2 General requirements for shipboard tests

5.2.1 Trials at the moorings

Trials at the moorings are to demonstrate the following:

a) satisfactory operation of the machinery in relation to the service for which it is intended

b) quick and easy response to operational commands

c) safety of the various installations, as regards:

- the protection of mechanical parts
- the safeguards for personnel

d) accessibility for cleaning, inspection, and maintenance

Where the above features are not deemed satisfactory and require repairs or alterations, 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.

5.2.2 River trials

5.2.2.1 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 fails

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

5.2.2.2 **Exemptions**

Exemption from some of the river trials may be considered by the Society in the case of vessels having a sister ship for which the satisfactory behavior in service has been demonstrated.

An exemption shall in any case be subject to trials at the moorings to verify the safe and efficient operation of the propulsion system.

5.3 Shipboard tests for machinery

5.3.1 Conditions of river trials

5.3.1.1 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).

5.3.1.2 Power of the machinery

a) The power developed by the propulsion machinery during the river trials shall be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials shall be suitably modified so as to confine the stresses within the design limits.

5.3.1.3 Determination of the power and rotational speed

a) The shaft revolutions shall be recorded in the course of the river trials, preferably by means of a continuous counter.

b) In general, the power shall 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.

The methods of determining the power may be considered by the Society on a case-by-case basis.

5.3.2 Navigation and maneuvering tests

5.3.2.1 Speed trials

a) Where required, the speed of the vessel shall be determined using procedures deemed suitable by the Society.

b) The vessel speed shall be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

5.3.2.2 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 maneuver 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 maneuvering or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b).

5.3.3 **Tests of diesel engines**

5.3.3.1 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 shall be demonstrated.

5.3.3.2 Main propulsion engines driving fixed propellers

River trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 2 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 1 hour

c) operation at engine speed $n = 1.032 \cdot n_0$ for 30 minutes

d) operation at minimum load speed

e) starting and reversing maneuvers

f) operation in reverse direction of propeller rotation at a minimum engine speed of $n = 0.7 \cdot n_0$ 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

Remark:

– *The test in c) shall be performed only where permitted by the engine adjustment.*

– *The test in f) may be performed during the dock or river trials.*

5.3.3.3 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 [5.3.3.1].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

5.3.3.4 Engines driving generators for propulsion

River trials of engines driving generators for propulsion are to include the following tests:

a) operation at 100% power (rated power) for at least 2 hours

b) operation at normal continuous cruise power for at least 1 hour

c) operation at 110% power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

e) starting maneuvers

f) tests of the monitoring, alarm and safety systems

Remark:

–*The test in d) may be performed during the dock or river trials.*

–*The above tests a) to f) are to be performed at rated speed (with a constant governor setting). The powers refer to the rated electrical powers of the driven generators.*

5.3.3.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 2 hours. During the test, the set concerned is required to operate at its rated power for at least 1 hour.

b) It shall be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account shall be taken of the times needed to actuate the generator's overload protection system.

5.3.4 **Tests of gears**

5.3.4.1 Tests during river trials

During the river trials, the performance of reverse and/or reduction gearing shall 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

5.3.4.2 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 colored with suitable dye penetrant 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 shall 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 shall be based on the guide values for the proportional area of contact in the axial and radial directions of the teeth given in Table 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%

5.3.5 Tests of main propulsion shafting and propellers

5.3.5.1 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by Sec.2 [5]. The type of the measuring equipment and the location of the measurement points are to be specified.

5.3.5.2 Bearings

The temperature of the bearings shall be checked under the machinery power conditions specified in [5.3.1.2]

5.3.5.3 Stern tube sealing gland

The stern tube oil system shall be checked for oil leakage if any at the stern tube seal.

5.3.5.4 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position shall be demonstrated. It shall also be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations shall be tested during the river trials.

5.3.6 Tests of piping systems

5.3.6.1 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.

5.3.6.2 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

5.3.7 Tests of steering gear

5.3.7.1 General

a) The steering gear shall be tested during the river trials under the conditions stated in [5.3.1] in order to demonstrate, to the surveyor’s satisfaction, that the applicable requirements of Ch.6 are fulfilled.

b) For controllable pitch propellers, the propeller pitch shall 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 shall 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.

5.3.7.2 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.6 Sec.1[4.2] and Ch.6 Sec.1[4.3]

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.6 Sec.1 [4.4]

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) Where the steering gear design is required to consider the risk of hydraulic locking, a test shall be performed to demonstrate the efficiency of the devices intended to detect this.

Remark:

– *tests d) to i) may be carried out either during the mooring trials or during the river trials*

– *for vessels of less than 500 tons gross tonnage, the Society may accept departures from the above list, in particular to consider the actual design features of their steering gear*

– *Azimuth thrusters are to be subjected to the above tests, as far as applicable.*

5.3.8 **Tests of windlasses**

5.3.8.1 The working test of the windlass shall be carried out in the presence of a surveyor.

5.3.8.2 The anchor equipment shall be tested during river trials. As a minimum requirement, this test is required to demonstrate that the conditions specified in Sec.2 [7.4] can be fulfilled.

5.4 Inspection of machinery after river trials

5.4.1 **General**

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the river trials, or malfunctions, 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 shall be submitted to the Society for information.

5.4.2 **Diesel engines**

a) In general, for all diesel engines, the following items are to be verified:

— the deflection of the crankshafts, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine

— the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the river trials.

CHAPTER 2 PIPES, VALVES, FITTINGS AND PUMPS

CONTENTS

SECTION 1 PIPING SYSTEMS

Contents

1.1 General

1.1.1. Scope

These rules apply to piping systems, including valves, fittings and pumps, which are essential for the operation of the main propulsion plant together with its auxiliaries and equipment. They also apply to piping systems used in the operation of the vessel whose failure could directly or indirectly impair the safety of vessel or cargo, and to piping systems which are dealt with in other parts of the rules.

1.1.2. Documents for approval

Diagrammatic plans of the following piping systems shall be submitted to the Society, at least in triplicate, and shall contain all the details necessary for assessment:

- steam systems
- boiler feed and condensate systems
- fuel systems (bunkering, transfer and supply systems)
- lubricating oil systems
- cooling water systems
- compressed air systems
- Exhaust gas system
- Bilge, ballast and Fire main systems
- thermal oil systems
- air, sounding and overflow systems
- drinking water and sewage systems
- systems for remotely controlled valves
- hose assemblies and compensators

Hoses and expansion joints made of non-metallic materials shall be clearly indicated.

1.1.3. Classes of pipes

Pipes are subdivided into two classes as indicated in Table 1.

Table 1 Classification of pipes into "pipe classes"

Medium conveyed by the piping system	*Design pressure PR [bar]* *Design temperature t [°C]*	
Pipe class	II	III
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

Medium conveyed by the piping system	*Design pressure PR [bar]* *Design temperature t [°C]*	
steam, thermal oil	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t ≤ 170
Air, gas Lubricating oil, hydraulic oil Boiler feedwater, condensate Seawater and fresh water for Cooling	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
Liquid fuels	PR ≤ 16 and t ≤ 150	PR ≤ 7 and t ≤ 60
Cargo pipelines for tankers	not applicable	all
Open-ended pipelines (without shut-off), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	not applicable	all

1.2 Materials, quality assurance, pressure tests

1.2.1. General

Materials shall be suitable for the proposed application and shall comply with Pt.2 of Ship Rules. In the case of especially corrosive media, the Society may impose special requirements on the materials used. For welds, see Pt.2. For the materials used for pipes and valves for steam boilers, see Ch.3 Sec.1 [1.2].

1.2.2. Materials

1.2.2.1. Pipes, valves and fittings of steel

Pipes belonging to class II shall be either seamless drawn or produced by a welding procedure approved by the Society.

1.2.2.2. Pipes, valves and fittings of copper and copper alloys

Pipes of copper and copper alloys shall be of seamless drawn material or produced by a method approved by the Society. Class II copper pipes shall be seamless.

In general, copper and copper alloys pipelines shall not be used for media having temperatures above the limits given in Table 2.

Table 2 Medium limit temperature

Material	*Medium limit temperature*
Copper and aluminium brass	200°C(392°F)
Copper nickel alloys	300°C(572°F)
High-temperature bronze	230°C(446°F)

1.2.2.3. Pipes, valves and fittings of cast iron with spheroidal or nodular graphite (GGG)

Pipes, valves and fittings of nodular ferritic cast iron according to Pt.2 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.(662°F)

1.2.2.4. Pipes, valves and fittings of cast iron with lamellar graphite (grey cast iron) (GG)

Pipes, valves and fittings of grey cast iron shall 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 (140°F) Tough materials shall be used for cargo hose connections and distributor headers.

Grey cast iron is not allowed for pipes, valves and fittings for media having temperatures above 220°C (428°F) 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.

Grey cast iron used for valves on fuel tanks subject to static head with sufficient protection against damage.

The use of grey cast iron for other services will be subject to special consideration by the Society.

1.2.2.5. Plastic pipes

Plastic pipes may be used after special approval by the Society.

Pipes, connecting pieces, valves and fittings made of plastic materials shall 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 shall be approved by the Society. Plastic pipes shall be continuously and permanently marked with the following particulars:

—manufacturer’s marking

—standard specification number

—outside diameter and wall thickness of pipe

—year of manufacture

Valves and connecting pieces made of plastic shall, as a minimum requirement, be marked with the manufacturer’s marking and the outside diameter of the pipe.

1.2.2.6. Aluminum and aluminum alloys

Aluminum and aluminum alloys shall comply with Pt.2 and may in individual cases, with the agreement of the Society, be used for temperatures up to 200 °C (392°F) .They are not acceptable for use in fire-extinguishing lines.

1.2.2.7. Application of materials

For the pipe classes materials shall be applied according to Table 3.

Table 3 Approved materials

<table>
<tr><th colspan="2" rowspan="2">Material or application</th><th colspan="2">Pipe classes</th></tr>
<tr><th>II</th><th>III</th></tr>
<tr><td rowspan="3">Steel</td><td>Pipes</td><td>Pipes for general applications, below
−10°C pipes made of steels with high low- temperatures toughness, stainless steel pipes for chemicals</td><td>Steel not subject to any special quality specification, weldability in accordance with Pt.2</td></tr>
<tr><td>Forgings, plates, flanges</td><td colspan="2">Steels suitable for the corresponding loading and processing conditions, for temperatures below −10°C steels with high low-temperature toughness</td></tr>
<tr><td>Bolts, nuts</td><td>Bolts for general machine construction, below
−10 °C steels with high low-temperature toughness</td><td>Bolts for general machine construction</td></tr>
<tr><td rowspan="3">Castings valves, fittings, pipes)</td><td>Cast steel</td><td>Cast steel for general applications, below
−10°C cast steel with high low-temperature toughness, for aggressive media stainless castings</td><td>Cast steel for general applications</td></tr>
<tr><td>Spheroidal/Nodular cast iron (GGG)</td><td colspan="2">Only ferritic grades, elongation A5 at least 12 %</td></tr>
<tr><td>Cast iron with lamellar graphite (grey cast iron) (GG)</td><td>Not applicable</td><td>At least GG-20 for Pipe Class III up to 220°C not permitted in:
– ballast lines of ballast tanks outside cargo are through cargo tanks
– valves on vessel's side, collision bulk-head and fuel tanks</td></tr>
</table>

Non-ferrous metals (valves, fittings, pipes)	Copper, copper alloys	In cargo lines on tank ships carrying chemicals only with special approval low- temperature copper nickel alloys by special agreement	For seawater 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]

1.2.3. **Quality assurance**

1.2.3.1. The proof of the quality of materials for pipe class II shall be in the form of an inspection certificate 3.1 according to EN 10.204 or equivalent. For this purpose, the manufacturer of the material shall have been accepted by the Society.

1.2.3.2. For components in pipe class III a works certificate issued by the manufacturer of the material is sufficient.

1.2.3.3. Welded joints in pipelines of class II shall be tested in accordance with Pt.2.

1.2.4. **Hydraulic tests on pipes**

1.2.4.1. Definitions

a) Maximum allowable working pressure, PB [bar] formula symbol: $p_{e,perm}$

This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design requirements, the working temperature and undisturbed operation.

b) Nominal pressure, PN [bar]

This is the term applied to a selected pressure temperature relation used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20°C (68°F)

c) Test pressure, PP [bar] formula symbol: p_p

This is the pressure to which components or piping systems are subjected for testing purposes.

d) Design pressure, PR [bar] formula symbol: p_c

This is the maximum allowable working pressure PB for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

1.2.4.2. Pressure tests of piping before assembly on board

All class II pipes as well as steam lines, feed water pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3.5 bar (50.76 psi) 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:

$P = 1.5 \cdot p_c$

p_c = design pressure defined in [1.2.4.1]

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 shall 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 [4.3].

Pressure testing of pipes with a nominal diameter less than 15 mm (0.59 Inch) shall be omitted at the Society discretion depending on the application

1.2.4.3. Pressure tests of piping after assembly on board

In general, all pipe systems shall be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests shall be applied.

In particular, the following applies:

— Heating coils in tanks and fuel lines shall be tested to not less than 1.5 PB but in no case less than 4 bar (58 psi)

— Liquefied gas process piping systems shall be leak tested (by air, halides, etc.) to a pressure depending on the leak detection method applied.

1.2.5. Hydrostatic tests of valves

The following valves shall be subjected in the manufacturer's works to a hydraulic pressure test in the presence of a surveyor:

a) Valves of Pipe class II to 1.5 PR

b) Valves mounted on the vessel's side not less than 5 bars (72.51psi)

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, refer Ch.3 Sec.5 [2].

1.3 Pipe wall thicknesses

1.3.1. Minimum wall thickness

1.3.1.1. The pipe thicknesses given in Table 4 and Table 5 are the assigned minimum thicknesses

d_a = outside diameter of pipe [mm]

s = minimum wall thickness [mm]

Table 4 Steel pipes

up to 10.2	1.6	from 114.3	3.2
from 13.5	1.8	from133.0	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

Table 5 Copper and copper alloy pipes

Copper	pipes	Copper alloy pipes	
d_a	s	d_a	s
up to 12.2	1.0	up to 22.0	1.0
from 14.0	1.5	from 25.0	1.5
from 44.5	2.0	from 76.0	2.0
from 60.0	2.5	from 108.0	2.5
from 108.0	3.0	from 219.0	3.0
from 159.0	3.5		

1.3.1.2. Air pipes, sounding pipes, overflow pipes and pipes carrying media which is different to that in the tanks may not be routed through tanks for drinking water, feed water or lubricating oil. If this cannot be avoided, the arrangement of the pipes in the tanks shall be agreed with the Society.

1.4 Principles for the construction of pipes, valves, fittings, and pumps

1.4.1. General principles

1.4.1.1. Piping systems shall be constructed and manufactured based on standards generally used in vessel building.

1.4.1.2. Welded connections instead of detachable connections shall be used for pipelines carrying toxic media and inflammable liquefied gases.

1.4.1.3. Expansion in piping systems due to heating and shifting of their suspensions caused by deformation of the vessel shall be compensated by bends, compensators, and flexible pipe connections. The arrangement of suitable fixed points shall be taken into consideration

1.4.2. Pipe connections

1.4.2.1. Dimensions and calculation

The dimensions of flanges and bolting are to comply with recognized standards.

1.4.2.2. Pipes connections

The following pipe connections shall 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, refer Table 6.

Table 6 Pipe connections

Types of connections	*Pipe class*	*Nominal diameter*
Welded butt-joints with special provisions for root side	II, III	all
Welded butt-joints without all special provisions for root side	II, III	
Welded sockets	III	
Screwed sockets	for subordinate systems see [4.2.2]	< 50

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 considering the allowed pressures and temperatures as stated in the corresponding standards.

Flanges made of non-ferrous metals shall 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(392°F) or 300°C (572°F) 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 (248°F)

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 drainpipes
- drinking water pipes.

These couplings shall only be used inside machinery spaces, provided 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.

1.4.3. **Layout, marking and installation**

1.4.3.1. Piping systems shall be adequately identified according to their purpose. Valves shall be permanently and clearly marked.

1.4.3.2. Pipes leading through bulkheads and tank walls shall be water and oil tight. Bolts through bulkheads are not permitted. Holes for set screws shall not be drilled in the tank walls.

1.4.3.3. Piping systems close to electrical switchboards shall be so installed or protected such that possible leakage cannot damage the electrical installation.

1.4.3.4. Piping systems shall be so installed that they can be completely emptied, drained and vented as required. The accumulation of liquids in piping during operation could cause damage shall be provided with special drain arrangements.

1.4.4. **Shut-off devices**

1.4.4.1. Shut-off devices shall comply with a recognized standard. Valves with screwed-on covers shall be secured to prevent unintentional loosening of the cover.

1.4.4.2. Hand-operated shut-off devices shall be closed by turning in the clockwise direction.

1.4.4.3. Indicators shall be provided showing the open/closed position of valves unless their position is shown by other means.

1.4.4.4. Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service shall not be used.

1.4.5. **Outboard connections**

1.4.5.1. Valves shall only be mounted on the vessel’s side by means of reinforcing flanges or thick-walled connecting pipes.

1.4.5.2. Vessel’s side valves shall be easily accessible. Water inlet and outlet valves shall be capable of being operated from above the floor plates. Cocks on the vessel's side shall be so arranged that the handle can only be removed when the cock is closed

1.4.5.3. Where discharge pipes without shutoff devices may be connected to the vessel’s hull below the freeboard deck, the wall thickness of the pipes to the nearest shut-off device shall be equal to that of the shell plating at the ends of the vessel, but need not to exceed 8 mm (0.31 Inch)

1.4.5.4. Outboard connections shall be fitted with shut-off valves.

Cooling water discharge lines shall be provided with loops led at a minimum height of 0.3 m (0.98 Foot) above the maximum draft.

1.4.6. Remote controlled valves

1.4.6.1. Scope

These requirements are applicable to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

1.4.6.2. Construction

Remote controlled bilge valves and valves important to the safety of the vessel shall be equipped with an emergency operating procedure.

1.4.6.3. Arrangement of valves

The accessibility of the valves for maintenance and repairing shall be taken into consideration. Valves in bilge lines and sanitary pipes shall always be accessible.

Bilge lines valves and control lines shall be located as far as possible from the bottom and sides of the vessel. The requirements stated here above also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

Remote-controlled valves mounted on high and wing fuel tanks shall be capable of being closed from outside the compartment in which they are installed.

Where remote controlled valves are arranged inside cargo tanks, valves should always be fitted in the tank adjoining that to which they relate. A direct arrangement of the remote controlled valves in the tanks

concerned is allowed only if each tank is fitted with two suction lines each of which is provided with a remote controlled valve.

1.4.6.4. Control stands

The control devices of remote controlled valves shall be arranged together in one control stand. The control devices shall be clearly and permanently identified and marked.

It shall be identified 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 shall 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 shall be located outside the machinery spaces and above the bulkhead deck.

1.4.6.5. Power units

Power units shall be provided 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 shall 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 shall be provided. This shall be of adequate capacity and shall 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 shall be arranged in the filling connection of the pressure accumulator.

The accumulator shall 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 shall be located outside the engine room.

1.4.6.6. After installation on board, the entire system shall be subjected to an operational test.

1.4.7. Pumps

1.4.7.1. Displacement pumps shall be equipped with sufficiently dimensioned relief valves without shut-off to prevent any excessive overpressure in the pump housing.

1.4.7.2. Rotary pumps shall be capable of being operated without damage even when the delivery line is closed.

1.4.7.3. Pumps mounted in parallel shall be protected against overloading by means of non-return valves fitted at the outlet side.

1.4.8. Protection of piping systems against overpressure

The following piping systems shall be fitted with safety valves to avoid over pressure:

— piping systems and valves in which liquids can be enclosed and heated

— piping systems which may be exposed in service to pressures in excess of the design pressure

Safety valves shall be set at10 % above maximum pressure. Safety valves shall be fitted on the low-pressure side of reducing valves.

1.5 Steam systems

1.5.1. Laying out of steam systems

1.5.1.1. Steam systems shall 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.

1.5.1.2. Steam lines shall be so installed that water pockets will be avoided.

1.5.1.3. Means shall be provided for the complete drainage of the piping system.

1.5.1.4. Pipe penetrations through bulkheads and decks shall be insulated to prevent heat conduction.

1.5.1.5. Steam lines shall 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 against unintended contact shall be provided. The surface temperature of steam systems in the pump rooms of tankers may nowhere exceed 220°C(428°F). The steam lines shall be fitted with sufficient provisions for expansion

Where a system can be entered from a system with higher pressure, the former shall 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 Pt.2.

1.5.2. Steam strainers

Wherever necessary, machines and apparatus in steam systems shall be protected against foreign matter by steam strainers.

1.5.3. Steam connections

Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam out arrangements, shall be so secured that fuel and oil cannot penetrate into the steam systems.

1.6 Boiler feed water and circulating arrangement, condensate recirculation

1.6.1. Feed water pumps

1.6.1.1. At least two feed water pumps shall be provided for each boiler installation.

1.6.1.2. Feed water pumps shall be provided with no backflow of water can occur when the pumps are at a standstill.

1.6.1.3. Feed water pumps shall be used only for feeding boilers.

1.6.2. Capacity of feed water pumps

1.6.2.1. Where two feed water pumps are provided, the capacity of each shall be equivalent to at least 1.25 times the maximum permitted output of all the connected steam producers.

1.6.2.2. Where more than two feed water pumps are installed, the capacity of all other feed water pumps in the event of the failure of the pump with the largest capacity is to comply with the requirements of [1.6.2.1].

1.6.2.3. For continuous flow boilers the capacity of the feed water pumps shall be at least 1.0 times the maximum steam output.

1.6.3. Delivery pressure of feed water pumps

Feed water pumps shall be installed such that the delivery pressure can satisfy the following requirements:

— the required capacity according to [1.6.2] shall be achieved against the maximum allowable working pressure of the steam producer

— the safety valves shall have a capacity equal 1.0 times the approved steam output at 1.1 times the allowable working pressure.

The resistances to flow in the piping between the feed water pump and the boiler shall be taken into consideration. In the case of continuous flow boilers, the total resistance of the boiler shall be considered

1.6.4. **Power supply to feed water pumps**

For electric drives, a separate lead from the common bus-bar to each pump motor is sufficient.

1.6.5. **Feedwater systems**

1.6.5.1. General

Feedwater systems shall not pass through tanks which do not contain feed water.

1.6.5.2. Feed water systems for boilers

a) Each boiler shall be provided with a main and an auxiliary feed water system.

b) Each feed water system shall be fitted with a shut-off valve and a check valve at the boiler inlet. Where the shut-off valve and the check valve are not directly connected in series, the intermediate pipe shall be fitted with a drain.

c) Each feed water pump shall be fitted with a shut-off valve on the suction side and a screw-down non- return valve on the delivery side. The pipes shall be so arranged that each pump can supply each feed water 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 feed water supply fail and that the feed water pump supplies only one boiler.

1.6.6. **Boiler water circulating systems**

1.6.6.1. Each forced-circulation boiler shall be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation shall be signaled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.

1.6.6.2. 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.

1.6.7. **Condensate recirculation**

The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil, etc.) shall be led to condensate observation tanks. These tanks shall be fitted with air vents and sight level glasses

1.7 Fuel oil systems

1.7.1. Storage of liquid fuels

1.7.1.1. General safety precautions for liquid fuel

Tanks and fuel pipes shall 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 shall be fitted with air and overflow pipes to prevent excessive pressure (Refer Sec [13]).

1.7.1.2. Distribution and location of fuel tanks

The fuel supply shall 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).

1.7.2. Fuel tank fittings and mountings

For fuel filling and suction systems Refer [7.6]; for air, overflow and sounding pipes, Refer Sec [13].

1.7.2.1. Service tanks shall be so arranged that water and residues can settle out despite the movement of the vessel.

1.7.2.2. Free discharge and drainage lines shall be fitted with self-closing shut-off valves.

1.7.2.3. Tank gauges

The following tank gauges are permitted:

— sounding pipes

— oil level indicating devices

— oil gauges with flat glasses and self-closing shut-off valves at the connections to the tank and protected against external damage

For fuel storage tanks, the provision of sounding pipes is sufficient. Such sounding pipes need not be fitted to tanks equipped with oil level indicating devices which have been type-tested by the Society.

Fuel service tank supplying the main propulsion unit, important auxiliaries and the driving engines for bow thrusters shall be fitted with low level alarm which has been type-approved by the Society.

The low level alarm shall be fitted at a height which enables the vessel to reach a safe location in accordance with the class notation without refilling the service tank.

Sight glasses and oil gauges fitted directly on the side of the tank and round glass oil gauges are not permitted.

Sounding pipes of fuel tanks may not terminate in accommodation or passenger spaces, nor shall they terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise

1.7.3. Attachment of mountings and fittings to fuel tanks

1.7.3.1. Only appliances, mountings and fittings forming part of the fuel tank equipment shall generally be fitted to tank surfaces.

1.7.3.2. Valves and pipe connections shall be attached to strengthening flanges welded to the tank surfaces. Holes for attachment bolts shall not be drilled in the tank surfaces. Instead of strengthening flanges, short, thick pipe flange connections may be welded into the tank surfaces.

1.7.4. **Hydraulic pressure test**

Refer Sec [2.4]

1.7.5. **Filling and delivery system**

The filling of fuels shall be provided from the open deck through permanently installed lines.

1.7.6. **Tank filling and suction systems**

1.7.6.1. Filling and suction lines terminating below the oil level in tanks shall be fitted with remote-controlled shut-off valves. The shut-off valves shall be directly at the tanks.

1.7.6.2. The remote-controlled shut-off valves shall be capable of being operated from a permanently accessible open deck.

1.7.6.3. Air and sounding pipes shall not be used to fill fuel tanks.

1.7.6.4. The inlet openings of suction pipes shall be located above the drainpipes.

1.7.6.5. Service tanks of up to 50 liters capacity mounted directly on diesel engines need not be fitted with remote controlled shut-off valves.

1.7.7. **Pipe layout**

1.7.7.1. Fuel lines may not pass through tanks containing feed water, drinking water or lubricating oil.

1.7.7.2. Fuel lines may not be installed in the vicinity of hot engine components, boilers or electrical equipment. The number of detachable pipe connections shall be limited. Shut-off valves in fuel lines shall be operable from above the floor plates in machinery spaces.

Glass and plastic components are not permitted in fuel systems.

1.7.7.3. Shut-off valves in fuel spill lines to service tanks are not permitted

1.7.8. **Filters**

Fuel supply lines to continuously operating engines shall be fitted with duplex filters with a changeover cock or with self-cleaning filters. By-pass arrangements are not permitted.

1.8 Lubricating oil systems

1.8.1. **Storage of lubricating oil**

1.8.1.1. Tank arrangement

For the arrangement of the tanks, requirements of Pt.3 Ch.4 Sec.5 [8] shall be applicable.

1.8.2. **Tank fittings and mountings**

1.8.2.1. Oil level glasses shall be connected to the tanks by means of self-closing shut-off valves.

1.8.2.2. The requirements set out under [1.2.4] apply likewise to the mounting of appliances and fittings on these tanks.

1.8.3. Capacity and construction of tanks

1.8.3.1. Lubricating oil circulating tanks should be sufficiently large to ensure that the dwelling time of the oil is long enough for the expulsion of air bubbles, the settling out of residues, etc. The tanks shall be large enough to hold at least the lubricating oil contained in the entire circulation system.

1.8.3.2. Measures, such as the provision of baffles or limber holes shall 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 drainpipes from engines shall be submerged closed to the tank bottom at their outlet ends. Suction pipe connections should be placed as far as is practicable from oil drainpipes so that neither air nor sludge can be sucked up irrespective of the inclination of the vessel.

1.8.3.3. Lubricating oil drain tanks shall be equipped with sufficient vent pipes.

1.8.4. Hydraulic pressure test

Refer [2.4]

1.8.5. Lubricating oil piping

1.8.5.1. Lubricating oil systems shall be constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines and to confirm adequate heat transfer.

1.8.5.2. Priming pumps

Where necessary, priming pumps shall be provided for supplying lubricating oil to the engines.

1.8.6. Lubricating oil pumps

The suction connections of lubricating oil pumps shall be located as far as possible from drainpipes.

1.8.7. Filters

Change-over duplex filters or automatic back-flushing filters shall be mounted in lubricating oil lines on the delivery side of the pumps.

1.9 Cooling water systems

1.9.1. Cooling water intakes, river chest

1.9.1.1. Each river chest shall be provided with an air pipe which can be shut-off and which shall extend above the bulkhead deck. The inside diameter of the air pipe shall be compatible with the size of the river chests and shall not be less than 30 mm (1.18 Inch)

1.9.1.2. Where compressed air shall be used to blow through river chests, the pressure shall not exceed 2 bar.

1.9.2. Cooling water intake valves

Two valves shall be provided for main propulsion plants. The cooling water pumps of important auxiliaries should be connected to the river chests over separate valves.

1.9.3. **Filters**

The suction lines of cooling water pumps for main engines shall be fitted with filters which can be cleaned in service.

1.9.4. **Expansion tanks of freshwater cooling**

The freshwater cooling system shall be provided with expansion tanks located at a sufficient height. The tanks shall 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 shall be fitted with overpressure/under pressure valves.

1.9.5. **Fresh water coolers**

For freshwater coolers forming part of the vessel's shell plating and for special outboard coolers, provision shall be made for satisfactory deaeration of the cooling water. Drawings of the cooler and the cooler arrangement shall be submitted for approval.

1.10 Compressed air systems

1.9.6. General

1.9.6.1. Pressure lines connected to air compressors shall be fitted with non-return valves at the compressor outlet.

1.9.6.2. Efficient oil and water traps shall be provided in the filling lines of compressed air receivers.

The air discharge from relief valves in the compressed air receivers installed in the engine rooms shall lead to the open air.

1.9.6.3. Starting air lines may not be used as filling lines for air receivers.

1.9.6.4. The starting air line to each engine shall be fitted with a non-return valve and a drain.

1.9.6.5. Typhons shall be connected to at least two compressed-air receivers.

1.9.6.6. A safety relief valve shall be fitted downstream of each pressure-reducing valve.

1.9.6.7. Pressure water tanks and other tanks connected to the compressed air system shall be considered as pressure vessels and shall comply with the requirements in Ch.3 Sec.1 [1].

1.9.7. **Compressed air connections for blowing**

For compressed air connections for blowing through river chests refer to [9.1.2].

1.9.8. **Compressed air supply to pneumatically**

For the compressed air supply to pneumatically operated valves refer to [4.6].

1.11 Bilge systems

1.11.1. **General**

The equipment of vessels with oil-separating facilities is to conform to national and international Regulations.

1.11.2. **Bilge lines**

1.11.2.1. **Layout of bilge lines**

Bilge lines and bilge suctions shall be installed so that the bilges can be completely pumped out 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 shall be drained by other suitable means of adequate capacity.

The collision bulkhead may be pierced by a pipe for filling and draining of the fore peak, provided that a screw-down valve capable of being remotely operated from above the open deck is fitted at the collision bulkhead within the fore peak. Where the fore peak is directly adjacent to a permanently accessible room which is separated from the cargo space, this shut-off valve may be fitted directly at the collision bulkhead inside this room without provision for remote control.

1.11.2.2. **Pipes led through tanks**

Bilge pipes may not be led through tanks for lubricating oil, thermal oil, drinking water or feed water.

1.11.2.3. **Bilge suctions and strums**

Bilge suctions shall be installed so as not to impede the cleaning of bilges and bilge wells. They shall be fitted with easily detachable, corrosion-resistant strums.

1.11.2.4. **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, shall 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 shall be fitted with shut-off valves at the vessel’s side.

Bilge valves shall be installed so as to be always accessible irrespective of the ballast and loading condition of the vessel.

1.11.2.5. **Pipe connections**

To prevent water penetration, each of the branch bilge pipes from the individual compartments shall 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 shall also be used for pumping water over the vessel’s side and from ballast water tanks, the main bilge pipe shall be connected to the suction line of the pump by a non-return device to prevent raw or ballast water from penetrating the bilge system.

Such non-return devices include three-way cocks with L plugs, three-way angle cocks and changeover gate valves. Instead of these changeover devices, a screw-down non-return valve may also be fitted between the pump and the main bilge pipe, so that two non-return valves will then be connected in series.

A direct suction from the engine room shall be connected to the largest of the specified bilge pumps. Its diameter shall not be less than that of the main bilge pipe.

However, the direct suction in the engine room need be fitted with only one screw-down non-return valve.

Where the direct suction is connected to a centrifugal pump which can also be used for cooling water, ballast water or fire-extinguishing, a screw-down non-return valve shall be fitted in the discharge pipe of the pump.

1.11.3.**Calculation of pipe diameters**

1.11.3.1. Tankers

The inside diameter of the main bilge pipe in the main engine rooms of tankers is calculated by applying the formula:

$$d_H = 3.0 \cdot \sqrt{(B + D) \cdot \ell_1} + 25$$

ℓ_1 = total length [m] of spaces between cofferdam or cargo bulkhead and stern tube bulkhead. Other terms as stated under [11.3.2].

Branch bilge pipes shall be dimensioned in accordance with [1.11.3.2].

1.11.3.2. Other vessels

a) Main bilge pipes

$$d_H = 1.5 \cdot \sqrt{(B + D) \cdot L} + 25$$

b) Branch bilge pipes

$$d_Z = 2.0 \cdot \sqrt{(B + D) \cdot \ell} + 25$$

d_H	= inside diameter of main bilge pipe [mm]
d_Z	= inside diameter of branch bilge pipe [mm]
L	= Rule length [m] defined in Pt.3 Ch.1 Sec.1
B	= breadth [m] defined in Pt.3 Ch.1 Sec.1
D	= depth [m] defined in Pt.3 Ch.1 Sec.1
ℓ	= length of the watertight compartment [m]

1.11.4.Bilge pumps

1.11.4.1. Capacity of independent pumps

Each bilge pump shall be capable of delivering:

$Q = 5.75 \cdot 10^{-3} \cdot d^{2}$

Q = minimum capacity [m^3/h]

d_H = calculated inside diameter of main bilge pipe [mm]

1.11.4.2. Where centrifugal pumps are used for bilge pumping, they shall be self-priming or connected to an air extracting device.

1.11.4.3. Capacity of attached bilge pumps

Bilge pumps having a smaller capacity than that specified in [1.11.4.1] are acceptable provided that the independent pumps are designed for a correspondingly larger capacity.

1.11.4.4. Use of other pumps for bilge pumping

Ballast pumps, general service pumps and similar units may also be considered as independent bilge pumps provided, they are of the required capacity according to [1.11.4.1].

Oil pumps may not be connected to the bilge system.

1.11.4.5. Number of bilge pumps

Vessels with a propulsion power of up to 225 kW shall have one bilge pump, which may be driven from the main engine. Where the propulsion power is greater than 225 kW, a second bilge pump driven independently of the main propulsion plant shall be provided.

On passenger vessels further bilge pumps may be required according to size and propulsion power.

1.11.5. Bilge pumping for various spaces

1.11.5.1. Machinery spaces

The bilges of every main machinery space shall be pumped out 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.

1.11.5.2. Fore and after peaks

Connection of the fore and after peaks to the general bilge system is not permitted. Where the peak tanks are not connected to the ballast system, separate means of pumping shall be provided. Where the after peak terminates at the engine room, it may be drained to the engine room bilge through a pipe fitted with a shut- off valve. Similar emptying of the fore peak into an adjoining space is not permitted.

1.11.5.3. Spaces above peak tanks

These spaces may either be connected to the bilge system or be pumped by means of hand-operated bilge pumps. Spaces above the after peak may be drained to the machinery space, provided that the drain line is fitted with a self-closing shut-off valve at a clearly visible and easily accessible position. The drain pipes shall have an inside diameter of at least 40 mm(1.5748 Inch)

1.11.5.4. Cofferdams and void spaces

Bilge pumping arrangements shall be provided for cofferdams and void spaces.

1.11.5.5. Chain lockers

Chain lockers may be connected to the main bilge system or drained by a hand pump. Draining to the forepeak tank is not permitted.

1.12 Thermal oil systems

1.12.1. General

Thermal oil systems shall be installed in accordance with Ch.3 Sec.1 [3].

1.12.2. Pumps

1.12.2.1. Circulating pumps

One circulating pump shall be provided; as the second circulating pump, a complete spare pump stored on board can be accepted.

With the owner’s confirmation, the spare pump on board may be omitted.

1.12.2.2. Transfer pumps

A transfer pump shall be installed for filling the expansion tank.

1.12.2.3. The pumps shall be so mounted that any oil leakage can be safely disposed of.

1.12.2.4. For emergency stopping, Refer Sec.8 [2.3].

1.12.3. Valves

1.12.3.1. Only valves made of ductile materials may be used.

1.12.3.2. Valves shall be designed for a nominal pressure of PN 16.

1.12.3.3. Valves shall be mounted in accessible positions.

1.12.3.4. Non-return valves shall be fitted in the pressure lines of the pumps.

1.12.3.5. Valves in return pipes shall be secured in the open position.

1.12.4. Piping

1.12.4.1. The material of the sealing joints shall be suitable for permanent operation at the design temperature and resistant to the thermal oil.

1.12.4.2. Provision shall be made for thermal expansion by an appropriate pipe layout and the use of suitable compensators.

1.12.4.3. The pipe lines shall be preferably connected by means of welding. The number of detachable pipe connections shall be minimized.

1.12.4.4. The installation of pipes through accommodation, public or service spaces is not permitted.

1.12.4.5. Pipelines passing through cargo holds shall be installed in such a way that no damage can be caused.

1.12.4.6. Pipe penetrations through bulkheads and decks shall be insulated against conduction of heat.

1.12.4.7. The venting shall be so arranged that air/oil mixtures can be carried away without danger.

1.12.5. Tightness and operational testing

1.12.5.1. Location and equipment of thermal tanks

After installation, the entire arrangement shall be subjected to tightness and operational testing under the supervision of the Society.

1.12.6. Location and equipment of thermal oil tanks

For the location and equipment of thermal oil tanks, Refer Ch.3 Sec.1 [3].

1.12.7. Design pressure and test pressure

For design pressure and test pressure, see Ch.3 Sec.1 [3].

1.13 Air, sounding and overflow pipes

1.13.1. Air / overflow pipes

1.13.1.1. Tank equipment in general

All tanks, void spaces, etc. shall be fitted at their highest point with air pipes which shall normally terminate above the open deck.

The height of air and overflow pipes above deck shall be at least 0.45 m (1.47 Foot), for fuel oil tanks of tankers 0.5 m (1.64 Foot)

Air and overflow pipes shall be installed vertically. Air and overflow pipes passing through cargo holds shall be protected against damage.

Where tanks are filled by pumping through permanently installed pipelines, the inside cross-section of the air pipes shall equal at least 125 % that of the corresponding filling pipe.

Air pipes of lubricating oil storage tanks may terminate in the engine room. Air pipes of the lubricating oil storage tanks which form part of the vessel's shell are to terminate in the engine room casing above the freeboard deck.

It is essential to ensure that no leaking oil can spread on to heated surfaces where it may ignite.

The air pipes of lubricating oil tanks, gear and engine crankshaft casings shall not be led to a common line.

Cofferdams and void spaces with bilge connections shall be provided with air pipes terminating above the open deck.

1.13.2. Sounding pipes

1.13.2.1. General arrangement

Sounding pipes shall be provided for tanks, void spaces, cofferdams and bilges (bilge wells) in spaces which are not accessible at all times. As far as possible, sounding pipes shall be installed straight and are to extend as close as possible to the bottom of the tank.

Sounding pipes which terminate below the deepest load waterline shall 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 shall be extended to the open deck. The sounding pipe openings shall always be accessible and fitted with watertight closures.

Sounding pipes of tanks shall be provided close to the top of the tank with holes for equalizing the pressure.

A striking pad shall 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 shall be adequately reinforced.

1.13.2.2. Sounding pipes for fuel and lubricating oil

Where sounding pipes cannot be extended above the open deck, they shall be provided with self-closing shut-off devices as well as with self-closing test valves.

The openings of sounding pipes shall be located at a sufficient distance from boilers, electrical equipment and hot components.

Sounding pipes shall not terminate in accommodation or service spaces. They shall not be used as filling pipes.

1.13.3. **Overflow pipes**

1.13.3.1. **Liquid fuel tanks**

Where an overflow pipe is provided for liquid fuel tanks, the discharge shall generally led to an overflow tank of appropriate capacity.

Overflows from service tanks shall generally led back either to the fuel bunker tanks, 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.

1.13.3.2. **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 shall be made to prevent any risk of intercommunication between the various tanks in the course of movements of liquid when emptying or filling.

1.13.3.3. **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 shall not be less than required in [13.1.1].

1.14 Hose assemblies and compensators

1.14.1. **Scope**

1.14.1.1. The following requirements are applicable for hose assemblies and compensators made of non- metallic and metallic materials.

1.14.1.2. Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in systems for fuel, lubricating oil, hydraulic oil, bilge, ballast, fresh water cooling, river water cooling, compressed air, auxiliary steam, exhaust gas and thermal oil, as well as in secondary piping systems.

1.14.1.3. Compensators made of non-metallic materials are not approved for the use in cargo lines of tankers.

1.14.2. Definitions

1.14.2.1. 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 shall 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 damaged

1.14.2.2. High-pressure hose assemblies made of non-metallic materials

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

1.14.2.3. Low-pressure hose assemblies and compensators

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

1.14.2.4. Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of non-metallic materials

The maximum allowable working pressure of high- pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

The maximum allowable working pressure respectively nominal pressure for low-pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the components.

1.14.2.5. 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.

1.14.2.6. Burst pressure

For non-metallic as well as metallic hose assemblies and compensators the burst pressure shall 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(290psi). For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure. For hose assemblies and compensators in process and cargo piping for gas and chemical tankers the burst pressure is required to be at least 5 times the maximum allowable working pressure.

1.14.3. Requirements

1.14.3.1. Hoses and compensators used in the systems mentioned in [14.1.2] shall be type approved.

1.14.3.2. Manufacturers of hose assemblies and compensators shall be approved by the Society.

1.14.3.3. Hose assemblies and compensators including their couplings shall be suitable for media, pressures and temperatures they are designed for.

1.14.3.4. The selection of hose assemblies and compensators shall be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar shall be considered as the minimum working pressure.

1.14.3.5. Hose assemblies and compensators for the use in systems for fuel, lubricating oil, hydraulic oil, bilge and river water shall be flame-resistant

1.14.4. Installations

1.14.4.1. 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.

1.14.4.2. The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

1.14.4.3. Non-metallic hose assemblies and compensators shall be located at visible and accessible positions.

1.14.4.4. In fresh water systems with a working pressure of ≤ 5 bar(72.51psi) and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

1.14.4.5. Where hose assemblies and compensators are installed in the vicinity of hot components they shall be provided with approved heat-resistant sleeves.

1.14.5. **Tests**

Hose assemblies and compensators shall be subjected in the manufacturer’s works to a pressure test in accordance with [2.4] under the supervision of the Society.

1.14.6. **Vessel cargo hoses**

1.14.6.1. Vessel cargo hoses for cargo-handling on chemical tankers and gas tankers shall be type-approved. Mounting of end fittings shall be carried out only by approved manufacturers.

1.14.6.2. Vessel cargo hoses shall be subjected to final inspection at the manufacturer under supervision of a 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(145.03 psi)

—measuring of the electrical resistance between the end fittings. The resistance shall not exceed 1 kΩ

1.14.7. **Marking**

Hose assemblies and compensators shall be permanently marked with the following particulars:

— manufacturer’s mark or symbol
— date of manufacturing
— type
— nominal diameter
— maximum allowable working pressure respectively nominal pressure
— test certificate number and sign of the Society.

CHAPTER 3 PRESSURE VESSELS

CONTENTS

SECTION 1 PRESSURE VESSELS AND HEAT EXCHANGERS, BOILERS AND THERMAL OIL HEATERS

Contents

1.1 Pressure vessels and heat exchangers

1.1.1. General

1.1.1.1. Scope

The following are applicable to pressure vessels for the operation of the main propulsion plant and its auxiliary machinery. They are also applicable 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.

These requirements do not apply to pressure vessels with permitted working pressures of up to 1.0 bar and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 liters, nor

to pressure vessels with working pressures of > 1 bar (14.5 psi) where the product of pressure [bar] times capacity [liters] is ≤ 200.

Manufacture and inspection of these pressure vessels are subject to the 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.

1.1.1.2. Division into classes

Pressure vessels shall be assigned to classes in accordance with the operating conditions indicated in Table 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, shall be classified as pressure vessels containing air or gas.

Table 1 Pressure vessel classes

Operating medium	Design pressure pc [bar] Design temperature t [°C]		
Liquefied gases (propane, butane, etc.), toxic and corrosive media	all	NA	NA
Steam, compressed air, gases, thermal oil	pc > 16 or t > 300	pc ≤ 16 and t ≤ 300	pc ≤ 7 and t ≤ 170
Liquid fuels, lubricating oils, flammable hydraulic fluids	pc > 16 or t > 150	pc ≤ 16 and t ≤ 150	pc ≤ 7 and t ≤ 60
Water, non-flammable hydraulic fluids	pc > 40 or t > 300	pc ≤ 40 and t ≤ 300	pc ≤ 16 and t ≤ 200
Pressure vessel class	I	II	III
NA = not applicable			

1.1.1.3. **Documents for approval**

Drawings of pressure vessels, heat exchangers and pressurized equipment containing all the data necessary for their safety assessment shall be submitted to the Society. The following details, in particular, shall be specified:

- intended use, substances to be contained in the vessel
- maximum allowable working pressure and temperatures; if necessary, secondary loads and the volume of the individual pressure spaces
- design details of the pressurized parts
- substance to be contained in the pressure vessel, working pressures and temperatures
- materials to be used, welding details, heat treatment.

1.1.2. **Materials**

1.1.2.1. **General requirements**

The materials for pressure vessels shall be suitable for the intended use and shall comply with Pt.2.

Parts such as gussets, girders, lugs, brackets etc. welded directly to pressure vessel walls shall be made of a material compatible with that of the wall and of guaranteed weldability.

Welded structures are also subject to Pt.2.

1.1.2.2. **Testing of materials**

Tests in accordance with Pt.2 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 (572°F) and for service temperatures ≤ 300°C (572°F) if the product of the maximum allowable working pressure, PB [bar] by the nominal diameter, DN [mm] is < 2500 or the nominal diameter DN is > 250

c) Bolts and nuts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm^2, or more than 600 N/mm^2 in the case of nuts, and alloy or heat- treated steel bolts above M 16.

1.1.2.3. 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 Pt.2.

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(9.84 Inch) for service temperatures of < 300°C. (572°F)

1.1.2.4. 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.

1.1.3. Manufacturing principles

1.1.3.1. Manufacturing processes applied to materials

Manufacturing processes shall be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold working are to undergo heat treatment in accordance with Pt.2.

1.1.3.2. Welding

The execution of welding work, the approval of welding shops and the qualification testing of welders shall be in accordance with Pt.2.

1.1.3.3. Reinforcement of openings

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

1.1.3.4. 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 shall be safeguarded against slipping off.

1.1.3.5. Branch pipes

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

Pipe connections in accordance with Ch.2 Sec.2 shall be provided for the attachment of piping.

1.1.3.6. Tube plates

Tube holes shall be carefully drilled and deburred. Bearing in mind the tube-expansion procedure and the combination of materials involved, the ligament width shall be such as to ensure the proper execution of the expansion process and the sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.(0.47 Inch)

1.1.3.7. Compensation for expansion

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

1.1.3.8. Corrosion protection

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

1.1.3.9. Cleaning and inspection

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

Pressure vessels over 2.0 m (6.56 Foot) long shall have inspection openings at each end at least. Where the pressure vessel can be entered, one access opening is sufficient.

Pressure vessels with an inside diameter of more than 800 mm (31.5 Inch) shall be capable of being entered.

In order to provide access with auxiliary or protective gear, a manhole diameter of at least 600 mm (23.62 Inch)is generally required. The diameter may be reduced to 500 mm (19.7 Inch) where the pipe socket height to be traversed does not exceed 250 mm.(9.84 Inch)

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.

1.1.3.10. **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.

1.1.3.11. **Identification and marking**

Each pressure vessel shall 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.

1.1.4. **Design**

Design calculations shall be performed according to the Society's rules or to international standards accepted by the Society, taking into consideration the special requirements for pressure vessels installed on inland waterway vessels.

Additionally applicable statutory requirements of the flag state authority are to be observed .

1.1.5. **Equipment and installation**

1.1.5.1. Shut-off devices

Shut-off devices shall be fitted in pressure lines as close as possible to the pressure vessel. In case of several pressure vessels are grouped together, it is not necessary that each pressure vessel shut-off individually and means need only be provided for shutting off the group. In general, not more than three pressure vessels should be grouped together. Starting air receivers and other pressure vessels which are opened in service shall be capable of being shut off individually. Devices incorporated in piping,

e.g. water and oil separators, do not require shut-off devices.

1.1.5.2. Pressure gauges

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

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

1.1.5.3. **Safety equipment**

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

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

1.1.5.3.2. Safety valves shall be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10%. Means shall be provided to prevent the unauthorized alteration of the safety valve setting. Valves cones shall be capable of being lifted at all times.

1.1.5.3.3. Means of drainage which cannot be shut-off shall be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities shall be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out shall be drained off via an open funnel.

1.1.5.3.4. Steam-filled spaces shall be fitted with a safety valve if the steam pressure inside them is liable to exceed the maximum allowable working pressure. If vacuum will occur, e.g. by condensate, an appropriate safety device is necessary.

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

1.1.5.3.6. Pressure water tanks shall be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with if the air pressure supplied to the tank cannot exceed its maximum allowable working pressure.

1.1.5.3.7. Calorifiers shall be fitted with a safety valve at the cold water inlet.

1.1.5.3.8. Bursting disks are permitted only with the consent of the Society in application where their use is specially justified. They must be designed that the maximum allowable working pressure PB cannot be exceeded by more than 10%.

Rupture bursting disks shall be provided with a guard to catch the fragments of the rupture element and shall be protected against damage from outside. The fragments of the rupture element shall not be capable of reducing the necessary section of the discharge aperture.

1.1.5.3.9. Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the pressure-volume product is PB [bar] x capacity [liters] $\leq$ 200.

1.1.5.3.10. Electrically heated equipment shall be equipped with a temperature limiter besides of a temperature controller.

1.1.5.3.11. Oil-fired warm water generators are to be equipped with limiters for temperature and pressure above a specified threshold. Additionally, a low water level limiter, a limiter for minimum pressure or a low flow limiter shall be provided. The actuation of the limiters shall shut-down and interlock the oil burner.

Warm water generators heated by exhaust gases shall be equipped with the corresponding alarms.

1.1.5.3.12. The equipment on pressure vessels shall be suitable for the use on inland navigation vessels.

The limiters for e.g. pressure, temperature and flow are safety devices and have to be type-approved and have to be provided with appropriate type approval certificates. For type approval of safety valves, the test requirements outlined in ISO/ EN 4196 shall be observed.

1.1.5.4. **Liquid level indicators and feed equipment for heated pressure vessels**

1.1.5.4.1. Heated pressure vessels in which a fall of the liquid level can result in unacceptably high temperatures in the vessel walls shall be fitted with a device for indicating the level of the liquid.

1.1.5.4.2. Pressure vessels with a fixed minimum liquid level shall be fitted with feed equipment of adequate size.

1.1.5.4.3. Warm water generating plants shall be designed as closed systems with external pressure generation and membrane expansion vessel. Water shall be circulated by forced circulation.

1.1.5.5. **Sight glasses**

Sight glasses in surfaces subject to pressure are allowed only if they are necessary for the operation of the plant and other means of observation cannot be provided. They shall not be larger than necessary and shall preferably be round. Sight glasses shall be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses shall be fitted with closable covers.

1.1.5.6. **Draining and venting**

Pressure vessels and equipment shall be able to depressurize and completely emptied or drained. Compressed air pressure vessels draining facility shall be provided

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

1.1.5.7. **Installation**

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

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 shall 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.

1.1.6. Tests

1.1.6.1. Constructional test and pressure tests

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

During the hydrostatic test, the loads specified in Table 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) shall be tested on the water side at 1.5 times the permitted working pressure subject to a minimum of 4 bar.(58 psi)

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

Table 2 Loads during hydrostatic tests

For materials with a definite yield point	*For materials without a definite yield point*
$R_{eH,\,20}$ / 1.1	$R_{m,\,20}$ / 2.0
$R_{eH,\,20}$ = guaranteed yield strength or minimum value of the 0.2% proof stress at room temperature	
$R_{m,\,20}$ = guaranteed minimum tensile strength [N/mm^2] at room temperature	

1.1.6.2. 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 gas tightness.

1.1.6.3. Certification of tests

The constructional test and the pressure test shall 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

1.1.6.4. 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 shall be inspected and, wherever necessary, subjected to a functional test.

1.2 Steam boilers

1.2.1. General

1.2.1.1. Scope

For the purpose of these rules the term “steam boiler” includes all closed pressure vessels and piping systems used for:

a) generating steam with a pressure above atmospheric pressure (steam generators) – the generated steam shall be used in a system outside of the steam generators or

b) raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators) – the generated hot water shall be used in a system outside of the hot water generators.

The term “steam boiler” also includes any equipment directly connected to the aforementioned pressure vessels or piping systems in which the steam is, for example, superheated or cooled, as well as external drums, and the circulating lines and the casings of circulating pumps serving forced-circulation boilers.

For warm water generators having a maximum allowable discharge temperature of not more than 120°C and steam or for hot water generators which are heated solely by steam or hot liquids 1 applies.

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.

1.2.1.3. Definitions

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

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

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

a) the area [m^2] measured on the side exposed to fire or exhaust gas, or

b) in the case of electrical heating, the equivalent heating surface [m^2]:

$$H = \frac{860 \cdot P}{18000} \, [m^2]$$

P = electrical power [kW]

The allowable steam output is the maximum hourly steam quantity which can be produced continuously by the steam generator operating under the design steam conditions.

The “dropping time” is the time taken by the water level under conditions of interrupted feed and allowable steam production, to drop from the lowest water level (LWL) to the level of the highest flue (HF).

$$T = \frac{V}{D \cdot v'} \text{ [min]}$$

T = dropping time [min]

V = volume [m^3] of water between the lowest water level and the highest flue

D = allowable steam output [kg/min]

v' = specific volume of water at saturation temperature [m^3/kg]

The lowest water level shall be set so that the dropping time is not less than 5 minutes.

1.2.1.4. Manual operation

For steam boilers which are operated automatically means for operation and supervision shall be provided which allow manual operation with the following minimum requirements by using an additional control level:

At boilers with a defined highest flue at their heating surface (e.g. oil-fired steam boilers and exhaust gas boilers with temperature of the exhaust gas > 400°C (752°F) at least the water level limiters, and at hot water generators the temperature limiters, have to remain active.

The monitoring of the oil content of the condensate or of the ingress of foreign matters into the feeding water may not lead to a shut-down of the feeding pumps during manual operation.

The safety equipment not required for manual operation may only be deactivated by means of a key- operated switch. The actuation of the key-operated switch is to be indicated.

For detailed requirements in respect of manual operation of the oil firing system, Refer [4]. For manual operation constant and direct supervision of the steam boiler plant required.

1.2.1.5. Documents for approval

The following documents shall be submitted for approval.

- drawings of all steam boiler parts subject to pressure, such as shells, drums, headers, tube arrangements, manholes and inspection covers, etc.,
- drawings of the expansion vessel and other pressure vessels for hot water generating plants
- equipment and functional diagrams with description of the steam boiler plant
- circuit diagrams of the electrical control system and, as applicable, monitoring and safety devices with limiting values.

These drawings shall contain all the data necessary for strength calculations and design assessment, such as maximum allowable working pressure, heating surfaces, lowest water level, allowable steam production, steam conditions, superheated steam temperatures, as well as materials to be used and full details of welds.

Further the documents shall contain information concerning the equipment of the steam boiler as well as a description of the boiler plant with the essential boiler data, information about the installation location in relation to the longitudinal axis of the ship and data about feeding and oil firing equipment.

1.2.2. **Materials**

1.2.2.1. General requirements

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

1.2.2.2. Approved materials

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

Materials not specified in Pt.2 may be used provided that proof is supplied of their suitability and mechanical properties.

1.2.2.3. Material testing

The materials of boiler parts subject to pressure shall be tested under supervision of the Society in accordance with the Pt.2 (Refer Table 3). For these materials, an A-Type certificate shall be issued.

Table 3 Approved materials

Material and product form	*Limits of application*	*Material grade in accordance with Part 2*
Steel plates and strips	NA	Steel plates for steam boilers and pressure vessels
Steel tubes	NA	Steel pipes for high temperatures service
Steel forgings and formed parts	NA	Steel forgings for steam boilers and pressure vessels
Steel castings	NA	Steel castings for steam boilers and pressure vessels
Nodular cast iron	≤ 300°C ≤ 40 bar ≤ DN 175 for valves and fittings	Nodular graphite iron castings
Lamellar (grey) cast iron: boiler parts only for unheated surfaces and not for thermal oil heaters valves and fittings	≤ 200°C ≤ 10 bar Φ ≤ 200 ≤ 200°C ≤ 10 bar ≤ DN 175	Grey iron castings
Bolts and nuts	NA	

				Bolts and nuts for elevated temperature
Valves and fittings of copper alloy castings			≤ 225°C ≤ 25 bar	Copper alloy castings
Φ *NA*	= =	diameter [mm] not applicable		

Material testing under supervision of 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 (3. 93 Inch) diameter, reinforcing plates, handhole, and manhole closures, forged flanges up to DN 150 and nozzles up to DN150 and

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

For the parts mentioned in a) and b), the properties of the materials shall be attested by Manufacturer Inspection Certificates.

If the design temperature is 450°C (842^{O} F) or higher or the design pressure is 32 bar (464.12 psi) or higher, pipes shall be non- destructively tested in accordance with Pt.2 Ch.4 Sec.7.

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

The materials of valves and fittings shall be tested under supervision of the Society in accordance with the data specified in Table 4. For these materials, an A-Type certificate needs to be issued.

Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc. shall be designed for the intended purpose and shall be made of suitable materials.

Table 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_{perm} x DN > 2500 [2] or DN > 250
Copper alloys	≤ 225	p_{perm} x DN > 1500 [2]

P_{perm} = working pressure [bar]
DN= nominal diameter [mm]

[1] No tests are required for grey cast iron

[2] Testing may be dispensed with if the nominal DN is ≤ 32

1.2.3. **Principles applicable to manufacture**

1.2.3.1. Manufacturing processes applied to boiler materials

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

Steam boiler parts whose microstructure has been adversely affected by hot or cold forming shall be subjected to heat treatment and testing in accordance with Pt.2.

1.2.3.2. Welding

Steam boilers shall be manufactured by welding.

The execution of welds, the approval of welding shops and the qualification testing of welders shall be in accordance with the Society's rules.

1.2.3.3. Tube expansion

Tube holes shall be carefully drilled and deburred. Sharp edges shall be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses.

Tube ends shall be expanded, cleaned and , checked for size and possible defects. Where necessary, tube ends shall be annealed before being expanded.

Smoke tubes with welded connections between tube and tube plate at the entry of the second path shall be roller-expanded before and after welding.

1.2.3.4. Stays, stay tubes and stay bolts

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

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

Stay bars and stay bolts shall be welded preferably by full penetration. Any vibrational stresses shall be considered for longitudinal stays.

Stay bars and stay bolts shall be drilled at both ends in such a way that the holes extend at least 25 mm (0.98 Inch) into the water or steam space. Where the ends have been upset, the continuous shank shall be drilled to a distance of at least 25 mm (0.98 Inch).

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 shall be minimized by suitable component geometry. Welds shall be executed as full penetration welds. In fire tube boilers, gusset stays shall be located at least 200 mm(7.87 Inch) from the fire tube.Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centers of the said bolts shall not generally exceed 200 mm (7.87 Inch)

1.2.3.5. Stiffeners, straps and lifting eyes

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

Doubling plates may not be fitted at pressure parts subject to flame radiation.

Where necessary to protect the walls of the boiler, strengthening plates shall be fitted below supports and lifting brackets.

1.2.3.6. Welding of flat unrimmed ends to boiler shells

Flat unrimmed ends (disc ends) on shell boilers are only permitted as socket-welded ends with a shell projection of ≥ 15 mm(0.59 Inch). The end/shell wall thickness ratio s_B/s_M shall not be greater than 1.8. The end shall be welded to the shell with a full penetration weld.

1.2.3.7. Nozzles and flanges

Nozzles and flanges shall be of rugged design and properly welded, preferably by full penetration to the shell.

The wall thickness of nozzles shall be sufficiently large to safely withstand additional external loads. The wall thickness of welded-in nozzles shall be appropriate to the wall thickness of the part into which they are welded.

Welding-neck flanges shall be made of forged material with favorable grain orientation.

1.2.3.8. Cleaning and inspection, openings, cut-outs and covers

Steam boilers shall be provided with manholes through which the space inside can be cleaned and inspected. Especially critical and high-stressed welds, parts subjected to flame radiation and areas of varying water level shall be sufficiently accessible to inspection. Boiler shells with an inside diameter of more than 1200 mm (47.24 Inch), and those measuring over 800 mm (31.49 Inch) in diameter and 2000 mm (78.74 Inch) in length, shall be provided with means of access. Parts inside drums shall not obstruct internal inspection or shall be capable of being removed.

Inspection and access openings are required to have the following minimum dimensions (Refer Table 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, shall be effectively reinforced if the plate has been unacceptably weakened by the cut-outs. The edges of openings closed with covers shall be reinforced by welded on edge-stiffeners.

Cover plates, manhole frames and crossbars shall be made of ductile material (not grey or malleable cast iron). Grey cast iron (at least GG-20) shall be used for handhole cover crossbars of headers and sectional headers, provided that the crossbars are not located in the heating gas flow.

Unless metal packings are used, cover plates shall be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening shall be uniform round the periphery and may not exceed 2 mm (0.078 Inch) for boilers with a working pressure of less than 32 bar (464.12 psi) , or 1 mm where the pressure is 32 bar (464.12 psi)or over. The height of the rim or spigot shall be at least 5 mm (0.19 Inch) greater than the thickness of the packing.

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

1.2.4. **Design**

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

Applicable statutory requirements of the flag state authority are to be observed additionally.

1.2.5. **Equipment and installation**

1.2.5.1. Feed and circulating equipment

Each boiler shall generally be provided with two feed-water pumps, each of which shall be capable of supplying a quantity of water equivalent to 1.25 times the boiler output.

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

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

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

c) In the event of a failure of the power supply to the feed water pump drive, the firing system shall shut- down automatically.

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

In the case of continuous-flow boilers a pump delivery rate equal to 1.0 times the boiler output is sufficient.

The feed water system shall be capable both of supplying the required quantity of feed water against the maximum allowable working pressure and of delivering the quantity of feed water corresponding to the steaming capacity against 1.1 times the maximum allowable working pressure.

For electrically driven feed water pumps, each motor shall be supplied via a separate line from the bus-bar. Each feed water pump shall be independently capable of being isolated from the suction and delivery lines.

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

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

The feed devices shall be fitted to the steam generator in such a way that it cannot be drained lower than 50 mm above the highest flue when the non-return valve is not tight.

The feed water shall be fed into the steam generator in such a way as to prevent damaging effects to the boiler walls and to heated surfaces.

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

One circulating pump is sufficient for continuous-flow boilers.

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

1.2.5.2. **Shut-off devices**

Each steam boiler shall be capable of being shut off from all connected pipes. The shut-off devices shall be installed as close as possible to the boiler shell and are to be operated without risk.

1.2.5.3. Scum removal, sludge removal, drain, venting and sampling devices

Steam boilers and external steam drums shall be fitted with devices to allow them to be drained and vented and the sludge to be removed. Where necessary, steam generators shall be fitted with a scum removal device.

Drain devices and their connections shall be protected from the effects of the heating gases and shall be capable of being operated without risk. Self-closing sludge removal valves shall be lockable when closed or, alternatively, an additional shut-off device shall be fitted in the pipe.

With the exception of once-through forced-flow steam generators, devices for taking samples from the water contained in the steam generator shall be fitted to the generator.

Scum removal, sludge removal, drain, venting and sampling devices shall be capable of safe operation. The media being discharged shall be drained away safely.

1.2.5.4. **Safety valves**

Each steam boiler which has its own steam space shall be equipped with at least two type-approved, spring- loaded safety valves. At least one safety valve shall be set to respond if the maximum allowable working pressure is exceeded.

In combination, the safety valves shall be capable of discharging the maximum quantity of steam which can be produced by the steam generator during continuous operation without the maximum allowable working pressure being exceeded by more than 10%.

The closing pressure of the safety valves shall be not greater than 10% below the response pressure. The minimum flow diameter of the safety valves shall be at least 15 mm (0.59 Inch).

The safety valves shall be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the highest point of the boiler or in the immediate vicinity.

The steam may not be supplied to the safety valves through pipes in which water may collect.

A drain which cannot be shut off shall be fitted at the lowest point at the discharge side of the safety valve.

1.2.5.5. **Water level indicators**

Each steam with a free surface is to be equipped with at least two indicators giving a direct reading of the water level.

Cylindrical glass water level gauges are not permitted.

The water level indicators shall be fitted so that a reading of the water level is possible when the ship is heeling and during the motion of the inland waterway vessel when it is at sea. The limit for the lower visible range shall be at least 30 mm above the highest flue, but at least 30 mm (1.18 Inch) below the lowest water level. The lowest water level shall not be above the center of the visible range.

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

The connection pipes shall have an inner diameter of at least 20 mm (0.787 Inch). Where water level indicators are linked by means of common connection pipes or where the connection pipes on the water side are longer than 750 mm (29.53 Inch), the inside diameter of these pipes shall be at least 40 mm (1.575 Inch).

Water level indicators shall be connected to the water and steam space of the steam boiler by means of quick-acting shut-off devices that are easily accessible and simple to control.

The devices used for blowing through the water level indicators shall be designed so that they are safe to operate and so that blow-through can be monitored. The discharged media shall be drained away safely.

In place of water level indicators, once-through forced flow boilers shall be fitted with two mutually independent devices which trip an alarm as soon as water flow shortage is detected. An automatic device to shut down the oil burner may be provided in place of the second warning device.

- Lowest water level

  The lowest water level (LWL) shall be located at least 150 mm (5.91 Inch) above the highest flue, even when the ship heels 4° to either side.

  The highest flue (HF) shall remain wetted even when the ship is at the static heeling angles laid down in Ch.1 Sec.1 Table 1.

  The height of the water level is crucial to the response of the water level limiters.

  The lowest specified water level shall be indicated permanently on the boiler shell by means of a water level pointer. The location of the pointer shall be included in the documentation for the operator. Reference plates shall be attached additionally beside or behind the water level gauges pointing at the lowest water level.

  The highest flue (HF)

  — is the highest point on the side of the heating surface which is in contact with the water and which is exposed to flame radiation, and

  — shall be defined by the boiler manufacturer in such a way that, after shut-down of the burner from full- load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400°C at the level of the highest flue, before, under the condition of interrupted feed water supply, the water level has dropped from the lowest water level to a level 50 mm (1.97 Inch) above HF

    The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes. The requirements relating to the highest flue do not apply to:

  — water tube boiler risers up to 102 mm (4.01 Inch) outer diameter

  — flues in which the temperature of the heating gases does not exceed 400 °C(752 °F) at maximum continuous power

  — once-through forced flow boilers

  — superheaters.

The heat accumulated in furnaces and other heated boiler parts may not lead to any inadmissible lowering of the water level due to subsequent evaporation when the oil burner is switched off.

This requirement with regard to an inadmissible lowering of the water level is met for example, if it has been demonstrated by calculation or trial that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400°C (752 °F) at the level of the highest flue, before, under the condition of interrupted feed water supply, the water level has dropped from the lowest water level LWL to a level 50 mm (1.97 Inch) above the highest flue HF.

The water level indicators shall be arranged in such a way that the distance 50 mm above HF can be identified.

1.2.5.6. Pressure indicators

Each steam boiler shall be fitted with at least one pressure gauge directly connected to the steam space. The maximum allowable working pressure shall be marked on the dial by means of a permanently and easily visible red mark. The indicating range of the pressure gauge shall include the test pressure.

At least one additional pressure indicator having a sensor independent from the pressure gauge shall be located at the machinery control station or at some other appropriate site.

The pipe to the pressure gauge shall have a water trap and shall be provided with a blow-through connection. A connection for a test gauge shall be installed close to the pressure gauge.

In the case of pressure gauges which are at a lower position, the test connection shall be provided close to the pressure gauge and close to the connection piece of the pressure gauge pipes.

Pressure gauges shall be protected against radiant heat and shall be well illuminated.

1.2.5.7. Name plate

A name plate shall be permanently affixed to each steam boiler, displaying the following information:

—manufacturer's name and address

—serial number and year of construction

—maximum allowable working pressure [bar]

—allowable steam production [kg/h] or [t/h].

The name plate shall be attached to the largest part of the boiler or to the boiler frame so that it is visible.

1.2.5.8. Special requirements for low capacity boilers

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

1.2.5.9. Special requirements for automatically controlled steam boilers not under permanent supervision

With the exception of steam boilers which are heated by exhaust gas, steam boilers shall be operated with rapid-control, automatic oil burners.

After the oil burner has been shut down, the heat stored in the firebox and the heating gas paths may not cause any inadmissible evaporation of the water contained in the steam generator.

The control system shall be capable of adapting the boiler to changes in the operating load without actuating the safety devices.

The steam pressure shall be automatically regulated by controlling the supply of heat. The steam pressure of boilers heated by exhaust gas may also be regulated by condensing the excess steam.

In the case of steam generators which have a specified minimum water level, the water level shall be regulated automatically by controlling the supply of feed water.

In the case of forced-circulation steam generators whose heating surface consists of a steam coil and of once-through forced flow steam generators, the supply of feed water may be regulated as a function of fuel supply.

Fired steam generators shall be equipped with a pressure limiter which cuts out and interlocks the oil burner before the maximum allowable working pressure is reached.

In steam generators on whose heating surfaces a highest flue is specified, two mutually independent water level limiters have to respond to cut out and interlock the oil burner when the water falls below the specified minimum water level.

In the case of forced-circulation steam generators with a specified lowest water level, two mutually independent safety devices shall be fitted in addition to the requisite water level limiters, which will cut out and interlock the oil burner in the event of any unacceptable reduction in water circulation.

In the case of forced-circulation steam generators where the heating surface consists of a single coil and once-through steam generators, two mutually independent safety devices shall be fitted in place of the water level limiters in order to provide a sure means of preventing any excessive heating of the heating surfaces by cutting out and interlocking the oil burner.

Where there is a possibility of oil or grease getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit shall be installed which trips an alarm and cuts off the feed water supply or the circulation resp. if the concentration at which boiler operation is put at risk is exceeded. The control device for oil or grease ingress may be waived for a dual circulation system

Where there is a possibility of acid, lye or seawater getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit shall be installed which trips an alarm and cuts off the feed water supply or the circulation, as applicable, if the concentration at which boiler operation is put at risk is exceeded. The control device for acid, lye or seawater ingress may be waived for a dual circulation system.

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

The safety devices have to trip visual and audible alarms at the steam boiler control panel.

The electrical devices associated with the limiters shall be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut out and interlock the systems unless an equivalent degree of safety is achieved by other means.

The electrical interlocking of the oil burner following tripping by the safety devices shall only be cancelled out at the oil burner control panel itself.

The receptacles for water level limiters located outside the steam boiler shall be connected to the steam boiler by means of lines which have a minimum inner diameter of 20 mm. Shut-off devices in these lines shall have a nominal diameter of at least 20 mm (0.787 Inch) and have to indicate their open or closed position. Where water level limiters are connected by means of common connection lines, the connection pipes on the water side are to have an inner diameter of at least 40 mm(1.57 Inch)

Operation of the oil burner shall only be possible when the shut-off devices are open or else, after closure, the shut-off devices are reopening automatically and in a reliable manner.

Water level limiter receptacles which are located outside the steam boiler shall be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines is carried out.

Emergency shut-down of the oil burner shall be possible from the burner control platform.

If an equivalent level of safety cannot be achieved by the self-monitoring of the equipment, the functional testing of the safety devices shall be practicable even during operation. In this case, the operational testing of the water level limiters shall be possible without dropping the surface of the water below the lowest water level (LWL).

1.2.5.10. Design and testing of valves and fittings

Valves and fittings for boilers shall be made of ductile materials as specified in Table 3 and all their components shall be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in Table 3, but shall not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow-off valves.

Testing of materials for valves and fittings shall be carried out as specified in Table 4. Care shall be taken to ensure that the bodies of shut-off gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets shall be safeguarded to prevent unintentional loosening of the bonnet.

All valves and fittings shall 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 shall be tested at twice the maximum allowable working pressure. In this case, the safety factor in respect of the 20 °C (68 °F) yield strength value shall not fall below 1.1. The sealing efficiency of the closed valve shall be tested at the nominal pressure or at 1.1 times the maximum allowable working pressure, as applicable.

Safety valves shall be subjected to a test of the set pressure. After the test the tightness of the seat shall be checked at a pressure 0.8 times the set pressure. The setting shall be secured against unauthorized alteration.

1.2.5.11. Installation of boilers

Steam boilers shall be installed in the inland waterway vessel with care and shall be secured to ensure that they cannot be displaced by any of the circumstances arising when the inland waterway vessel is at sea.

Means shall be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings shall be well accessible from all sides or shall be easily made accessible.

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

1.2.6. **Testing of boilers**

1.2.6.1. **Manufacturing test**

After completion, steam boilers are to undergo a constructional check.

The constructional check includes verification that the steam boiler complies with the approved drawings and is of satisfactory construction. For this purpose, all parts of the boiler shall be accessible to allow adequate inspection. If necessary, the constructional check shall be performed at separate stages of manufacture.

The following documents shall be–submitted: 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.

1.2.6.2. **Hydrostatic pressure tests**

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

The test pressure is generally required to be at least 1.5 times the maximum allowable working pressure, subject to a minimum of p_{perm} + 1 bar.

In the case of once-through forced flow boilers, the test pressure shall be at least 1.1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steam output. In the event of danger that parts of the boiler might be subjected to stresses exceeding 0.9 of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

1.3 Thermal oil heaters

1.3.1. **Hot water generators**

1.3.1.1. **Design**

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

1.3.1.2. **Equipment**

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

1.3.1.3. **Testing**

Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at least 1.5 times the maximum allowable working pressure, subject to a minimum of 4 bar.(58.01 psi)

1.3.2. **General**

1.3.2.1. **Scope**

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

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

1.3.2.2. **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.

1.3.2.3. **Documents for approval**

The following documents shall be submitted for approval.

— a description of the system stating the discharge and return temperatures, the maximum allowable film temperature, the total volume of the system and the physical and chemical characteristics of the thermal oil

— drawings of the heaters, the expansion vessel and other pressure vessels

— circuit diagrams of the electrical control system and monitoring and safety devices with limiting values respectively

— a functional diagram with information about the safety and monitoring devices and valves provided.

If specially requested, mathematical proof of the maximum film temperature in accordance with a recognized standard, accepted by the Society, shall be submitted.

1.3.2.4. **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.2 Sec.1 for pipes, pumps, valves and fittings

However, grey cast iron is not permitted for components of the hot thermal oil circuit. Welded structures are subject to Pt.2.

1.3.2.5. Thermal oils

The thermal oil has to remain serviceable for at least 1 year at the specified thermal oil temperature. Its suitability for further use shall be verified at appropriate intervals, but at least once a year.

Thermal oils may only be used within the limits set by the manufacturer. A safety margin of about 50 °C(122°F) is to be maintained between the discharge temperature and the maximum allowable film temperature specified by the manufacturer.

Precautions shall be taken to protect the thermal oil from oxidation.

Copper and copper alloys, which due to their catalytic effect lead to an increased ageing of the thermal oil shall be avoided or oils with specific additives shall be used.

1.3.2.6. Manual operation

For thermal oil heaters which are operated automatically, means for operation and supervision shall be provided which allow a manual operation with the following minimum requirements by using an additional control level:

At least the temperature limiter on the oil side and the flow limiter shall remain operative at the oil-fired heater.

The safety equipment not required for manual operation may only be deactivated by means of a key- operated switch. The actuation of the key-operated switch shall be indicated.

For details of requirements in respect of the manual operation of the oil firing equipment, refer [4]. Manual operation requires constant and direct supervision of the system.

1.3.3. Heaters

1.3.3.1. Design

The heater shall be equipped with an automatic, rapidly controllable heating system.

Heaters shall be designed thermodynamically and by construction in a way that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil shall be ensured by forced circulation.

The surfaces contact with the thermal oil shall be designed for the maximum allowable working pressure, subject to a minimum gauge pressure of 10 bar(145.03 psi).

Oil-fired heaters shall be provided with inspection openings for the examination of the combustion chamber.

Sensors for the temperature measuring and monitoring devices shall be introduced into the system through welded-in immersion pipes.

Heaters shall be fitted with devices for completely drain whenever required.

1.3.3.2. Equipment and safety devices

Temperature-indicating devices shall be fitted at the discharge and return line as well as in the flue gas outlet of the heater.

The outlet of the circulating pump is to be fitted with a pressure gauge. The maximum allowable working pressure PB shall be indicated on the scale by a red mark which is permanently fixed and well visible. The indicating range has to include the test pressure.

For automatic control of the discharge temperature, oil-fired heaters shall be fitted with an automatic and rapidly adjustable heat supply in accordance with [4].

If the allowable discharge temperature is exceeded for oil-fired heaters, the oil burner shall be switched off and interlocked by a temperature limiter.

Parallel-connected heating surfaces shall be monitored individually at the discharge side of each coil. At the oil-fired heater, the oil burner shall be switched off and interlocked by a temperature limiter in case the allowable discharge temperature is exceeded in at least one coil. An additional supervision of the allowable discharge temperature of the heater is not necessary.

A flow monitor switched as a limiter shall be provided at the oil-fired heater. If the flow rate falls below a minimum value, the oil burner shall be switched off and interlocked.

1.3.3.3. When the circulating pump is at standstill starting of the oil burner shall be prevented by interlocks.

If the specified flue gas temperature is exceeded, the heating shall be switched off by a temperature limiter. Electrical equipment items are subject to Ch.4 and Ch.5 Sec.1.

1.3.4. **Pressure vessels**

1.3.4.1. All pressure vessels, including those open to the atmosphere, shall be designed for a pressure of at least 2 bar (29.00 psi), unless provision shall be made for a higher working pressure

Air ducts shall be installed above the free deck and shall be fitted with automatic shut-off devices. Drains shall be self-closing.

1.3.4.2. **Expansion vessel**

An expansion vessel shall be placed at a high level in the system. The space provided for expansion shall be such that the increase in the volume of the thermal oil at the maximum thermal oil temperature can be safely accommodated. The following shall be regarded as minimum requirements: 1.5 times the increase in volume for charges up to 1000 litres, and 1.3 times the increase for charges over 1000 litres. The volume is the total quantity of thermal oil contained in the system up to the lowest liquid level in the expansion vessel.

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

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

A limit switch is to be fitted which shuts down and interlocks the oil burner and switches off the circulating pumps if the liquid level falls below the allowable minimum.

Additionally, an alarm for low liquid level shall be installed, e.g. by means of an adjustable level switch on the level indicator, in order to give an early warning of a falling liquid level in the expansion vessel (e.g. in case of a leakage).

An alarm is also to be provided for the maximum liquid level.

The expansion vessel shall be provided with an overflow line leading to the drainage tank.

For rapid drainage in case of danger, a quick-opening valve shall be fitted directly to the expansion vessel with remote control from outside the space in which the equipment is installed.

The quick drainage line may be routed jointly with the overflow line to the drainage tank.

The opening of the quick drainage valve shall activate an alarm. At the same time, a non-safety related shut- down of the oil burner at the oil-fired heater should be carried out.

Where the expansion vessel is installed outside the engine room, the quick drainage valve may be replaced by an emergency shut-off device which, in the event of danger, prevents the ingress of large quantities of thermal oil.

A safety expansion line shall connect the system to the expansion vessel. This shall be installed with a continuous positive gradient and shall be dimensioned in a way that a pressure increase of more than 10 above the maximum allowable working pressure in the system is avoided.

The dimensions of the expansion, overflow, drainage and venting pipes shall comply with Table 6.

All parts of the system in which thermal oil can expand due to the absorption of heat from outside shall be safeguarded against excessive pressure. Any thermal oil emitted shall be safely drained off.

Table 6 Nominal diameter of expansion, overflow, drainage and venting pipes depending on the output of the heaters

Total output of heaters [kW]	*Expansion and overflow pipes - nominal diameter DN*	*Drainage and venting pipes - nominal diameter DN*
≤ 600	25	32
≤ 900	32	40
≤ 1200	40	50
≤ 2400	50	65
≤ 6000	65	80

1.3.4.3. **Pre-pressurized systems**

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

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

A pressure limiter which gives an alarm and shuts down and interlocks the oil burner at a set-pressure below the set-pressure of the safety valve shall be provided at the expansion vessel.

1.3.4.4. **Drainage tanks**

At the lowest point of the system, a drainage tank shall be installed , the capacity sufficient to hold the volume of the largest isolatable system section.

In exceptional cases, approval may be given for the drainage tank and the storage tank to be combined. Combined storage/drainage tanks shall be dimensioned in a way that in addition to the stock of thermal oil, there is volume for the content of the largest isolatable system section.

For air ducts and drains, refer [3.3.1].

For sounding pipes, refer Ch.2 Sec.1 [13].

1.3.5. **Fire precautions**

Refer Ch.7 Sec.1 [4.3].

1.3.6. **Testing**

After completion of installation on board, the system including the associated monitoring equipment shall be subjected to pressure, tightness and functional tests in the presence of the surveyor.

1.4 Oil burners and oil firing equipment

1.3.7. General

1.3.7.1. **Scope**

The following requirements apply to oil burners and oil firing equipment that shall be used for the burning of liquid fuels and installed in auxiliary steam boilers, thermal oil heaters and hot water generators, these being referred to as heat generators in the following.

The oil firing equipment of automatically controlled auxiliary steam boilers and thermal oil heaters is subject to the rules in [4.2].

The following general requirements of this subsection are mandatory for all installations and appliances.

1.3.7.2. **Documents for approval**

The following documents shall be submitted for approval.

—General drawings of the oil burner

—Piping and equipment diagram of the burner including parts list

—Description of function

—Electrical diagrams

—List of equipment regarding electrical control and safety.

1.3.7.3. **Approved fuels**

Refer Ch.1 Sec.1 [2.6].

1.3.7.4. **Equipment of the heat generators and burner arrangement**

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

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

Observation openings shall be provided at suitable points on the heat generator or burner through which the ignition flame, the main flame and the lining can be observed.

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

Fuel leaking from potential leak points shall be safely collected in oil tight trays and to be drained away.

1.3.7.5. **Simultaneous operation of oil burners and internal combustion machinery**

The operation of oil burners in spaces containing other plants with a high air consumption, e.g. internal combustion engines or air compressors, shall not be impaired by variations in the air pressure.

1.3.8. **Oil firing equipment for boilers and thermal oil heaters**

1.3.8.1. **Preheating of fuel oil**

The equipment has to enable the heat generators to be started up with the facilities available on board.

Where only steam-operated preheaters are present, fuel which does not require preheating shall be available to start up the boilers.

Any controllable heat source may be used to preheat the fuel oil. Preheating with open flame is not permitted.

The fuel oil supply temperature shall be selected so as to avoid excessive foaming, the formation of vapor or gas and also the formation of deposits on the heating surface.

Temperature or viscosity control shall be done automatically. For monitoring purposes, a thermometer or viscosimeter shall be fitted to the fuel oil pressure line in front of the burners. Should the oil temperature or viscosity high or low, an alarm system has to signal this fact to the heat generator control panel.

When a change over from heavy to light oil, the light oil shall not be passed through the heater or be excessively heated (alarm system).

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

Electrically heated continuous-flow heaters shall be fitted with temperature safety trips in accordance with [1.5.3].

1.3.8.2. **Pumps, pipelines, valves and fittings**

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

Pipelines shall be permanently installed and joined by oil tight welds, oil tight threaded connections of approved design or with flanged joints. Flexible hoses may be used only immediately in front of the burner or to enable the burner to swivel. They shall be installed with adequate bending radii and shall be protected against undue heating. For non-metallic flexible pipes and expansion compensators,-refer Ch.2 Sec.1 [14].

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

By means of a hand-operated, quick-closing device mounted at the fuel oil manifold, it shall be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on the design and method of operation, a quick-closing device may also be required directly in front of each burner.

1.3.8.3. **Safety equipment**

The correct sequence of safety functions when the burner is started up or shut down shall be confirmed by means of a burner control box.

Two automatic quick-closing devices shall be provided at the fuel oil supply line to the burner.

For the fuel oil supply line to the ignition burner, one automatic quick-closing device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.

The automatic quick-closing devices shall not release the oil supply to the burner during start-up and shall interrupt the oil supply during operation (automatic restart possible) if one of the following faults occurs:

— failure of the required pressure of the atomizing medium (steam and compressed-air atomizers) failure of the oil pressure needed for atomization (pressure atomizers) or

insufficient rotary speed of spinning cup or primary air pressure too low (rotary cup atomizers)

— failure of combustion air supply

— failure of control power supply

— failure of induced-draught fan or insufficient opening of exhaust gas register

— burner not in operating position.

The fuel oil supply shall be interrupted by closing the automatic quick-closing devices and interlocked by means of the burner control box if

— the flame does not develop within the safety period following start-up

— the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or

— limit switches are actuated.

Every burner shall be fitted with a safety device for flame monitoring suitable for the particular fuel oil (spectral range of the burner flame is to be observed) in use. This appliance has to comply with the following safety periods on burner start-up or when the flame is extinguished in operation:

—on start-up 5 seconds

—in operation 1 second.

Where it is justified, longer safety periods may be permitted for burners with an oil throughput of up to 30 kg/h. Measures shall be taken to confirm ensure that the safety period for the main flame is not prolonged by the action of the igniters (e.g. ignition burners).

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

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

In an emergency, it shall be possible to close the automatic quick-closing devices from the heat generator control platform and - where applicable - from the engine control room.

1.3.8.4. **Design and construction of burners**

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

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

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

Burners that can be retracted or pivoted shall be provided with a catch to hold the burner in the swung-out position.

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

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

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

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

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

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

1.3.8.5. **Purging of combustion chamber and flues, exhaust gas ducting**

The combustion chamber and flues shall be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

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

Bends and dead corners in the exhaust gas ducting shall be avoided.

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

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

1.3.8.6. **Electrical equipment**

Electrical equipment and its degree of protection has to comply with the rules in Ch.8.

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

The equipment in the oil firing system shall be suitable for the use in oil firing systems and on ships. The proof of the suitability of the limiters and the alarm transmitters for e.g. burner control box, flame monitoring device and automatic quick-closing device shall be demonstrated by a type approval examination according to the requirements of the Society's rules.

High-voltage igniters shall be adequately protected against unauthorized interference.

1.3.8.7. **Manual operation**

For oil burners at heat generators that are operated automatically, means for operation and supervision shall be provided which allow a manual operation with the following minimum requirements by using an additional control level.

1.3.8.8. Flame monitoring shall remain active.

1.3.8.9. The safety equipment not required for manual operation may only be set out of function by means of a key-operated switch. The actuation of the key-operated switch shall be indicated.

1.3.8.10. Manual operation requires constant and direct supervision of the system.

1.3.8.11. **Testing**

Test at the manufacturer's workshop

For burners of heat generators, the following examinations shall be performed at the manufacturer's shop and documented by a Society approval certificate:

—visual inspection and completeness check

—pressure test of the oil preheater, if available and required according to this chapter

—pressure test of the burner

—insulation resistance test

—high voltage test

—functional test of the safety-related equipment.

Tests on board

After installation, a pressure and tightness test of the fuel system, including fittings, shall be performed.

The system, including the switchboard installed at the heat generator on board the vessel, shall be functionally tested as follows; in particular, the required purging time shall be identified and manual operation shall be demonstrated.

—completeness check for the required components of the equipment
—functional test of all safety-relevant equipment
—functional test of the burner control box
—identification of maximum and minimum burner power
— identification of flame stability on start-up, at maximum and at minimum burner power, under consideration of combustion chamber pressure (unspecified pressure changes are not permitted).
— proof regarding required purging of flues and safety times
— in case the oil burner is operated with different fuel oils, the proper change-over to another fuel oil quality and especially the safe operation of the flame monitoring, the quick-closing devices and the preheater, if existing, are to be checked
— proof regarding combustion properties, e.g. volumetric content of CO_2 (and possibly O_2 and CO) and soot number at minimum, mean and maximum power, in case of statutory requirements.

The correct combustion at all settings as well as the function of safety equipment shall be verified. An INTLREG approval Certificate of the oil burner regarding examination at the manufacturer's shop shall be presented to the Society during functional testing.

Burners for warm water generators shall be delivered with a test protocol issued by the manufacturer.

CHAPTER 4 ELECTRICAL INSTALLATIONS

CONTENTS

SECTION 1 GENERAL

Contents

1.1 General

1.1.1 Scope

These requirements 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 deviations from these Rules in individual cases or to stipulate special requirements for new types of installation or operating equipment.

1.1.2 Rules and standards

Beside these Rules electrical equipment shall meet a standard approved by the Society such as IEC and EN.

1.1.3 Basic requirements

1.1.3.1 All electrical machinery, appliances, cables and accessories shall be selected, designed and constructed for satisfactory performance under the conditions stated in Table 1.

Where other conditions are likely (e.g. in the case of inland vessels for non-European waters) proper account shall be taken of these.

Table 1 Working conditions

Conditions	
Permanent list to port or starboard 1)	
Permanent trim 1)	
Ambient temperature	(104°F)
1) May occur simultaneously	

Ambient temperature inside 0 to +40°C (104°F)

Ambient temperature on open decks –20°C(68 °F) to +40°C(104°F)

Remark:

For vessels built in line with the EU Directive 2006/87/EC the equipment shall be designed for permanent lists of up to 15°.

1.1.3.2 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 shall be based on the variations shown in Table 2.

Networks or sub-networks with greater voltage variations shall be approved for consumers intended for operation with greater variations.

Table 2 Voltage and frequency variations

	Variable	*Variations*	
		Permanent	*Transient*
General	Frequency Voltage	± 5% + 6% − 10%	± 10% 5 s ± 20% 1.5 s
Battery operation	Voltage	± 20%	-

1.1.3.3 In equipment with electronic frequency converters, the voltage waveform may deviate from that specified in 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 shall be used for separation from the mains. The total harmonic distortion shall be less than or equal to 5%.

1.1.3.4 Electrical machines and appliances shall be so constructed and installed that they will not be damaged by the vibrations occurring in normal shipboard service.

The natural frequencies of foundations, fastenings and suspensions for machines, appliances and electrical components (including those inside appliances) shall not lie within the frequency range 5 − 100 Hz.

If, for reasons of design, the natural frequency has unavoidably to–be within the aforementioned frequency range, the accelerations shall be sufficiently damped to exclude the likelihood of malfunctions or damage.

1.1.3.5 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 shall conform to IEC 60664-1 or EN 60664-1. Relaxations may be allowed for installations up to 50 V.

1.1.4 **Protective measures**

1.1.4.1 Protection against shock and water

The type of protection or enclosure of every machine and every other item of equipment shall be compatible with the site where it is installed. The particulars in Table 3 are minimum requirements.

1.1.4.2 Protection against electric shock: direct

Protection against direct contact includes all the measures designed to protect persons against the dangers arising from contact with live parts of electrical appliances. Live parts are deemed to be conductors and conductive parts of appliances which are live under normal operating conditions.

Electrical appliances shall be so designed that the person cannot touch or come dangerously close to live parts, in way of the determined operation.

Protection against direct contact may be dispensed with in the case of equipment using safety voltage.

In service spaces, live parts of the electrical appliances shall remain protected against accidental contact when doors and covers which can be opened without a key or tool are opened for operation purposes.

Table 3 Minimum degrees of protection

Type of space	*Minimum type of protection in accordance with IEC Publication 60529*							
	Genera-tors	*Motors*	*Trans-former*	*Switchboards, consoles, distribution boards*	*Measuring instruments*	*Switchgear*	*Inshallah-Tien material*	*Lamp fittings*
Service spaces, machinery and steering gear spaces	IP22	IP22	IP22	IP22 1),4)	IP22	IP22 1),4)	IP44	IP22
Refrigerated holds		IP44		IP44		IP44	IP55	IP55
Cargo holds		IP55		IP55		IP55	IP55	IP55
Storage battery, paint storage and lamp room								IP44 5) and (EX)
Ventilating trunks (deck)		IP44					IP55	
Exposed deck, steering stations on open deck		IP55 3)		IP55 3)	IP55 3)	IP55 3)	IP55 3)	IP55

Closed wheel-house		IP22	IP22	IP22	IP22	IP22	IP22	IP22
Accommo-dation and public rooms				IP22			IP20 IP55 2)	IP20
Sanitary facilities and commissary spaces		IP44	IP44	IP44			IP55	IP44

1) IP12 for appliances generating a large amount of heat.
2) Where laid behind ceiling.
3) IP56 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.

1.1.4.3 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 (refer [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.

Table 4 Cross-section of earthing conductors

Cross-section of main conductors [mm²]	*Minimum cross-section of earthing conductor*	
	Earthing conductor incorporated in the cable [mm²]	*Earthing conductor separated from the cable [mm²]*
0.5 up to 4	Equal to the main conductor	4
> 4 up to 16	Equal to the main conductor	Equal to the main conductor
> 16 up to 35	16	16
> 35 up to 120	Equal to the half main conductor	Equal to the half main conductor
> 120	70	70

1.1.4.4 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 shall be earthed except where their mounting already provides a conductive connection to the vessel's hull.

Special earthing may be dispensed with in the case of:

a) metal parts insulated by a non-conductor from the dead or earthed parts

b) bearings of electrical machines which are insulated to prevent currents flowing between them and the shaft

c) electrical equipment whose service voltage does not exceed 50 V

Where machines and equipment are earthed to the hull via their mountings, care shall be taken to confirm 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 shall be fitted for this purpose.

For the earthing of metal sheaths, armouring and cable braiding, refer 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 armoring may not be used as an earthing conductor.

A conductor normally carrying current may not be used simultaneously as an earthing conductor and may not be connected with the latter by a common connection to the vessel's hull.

The cross-section of the earthing conductor shall be at least in accordance with Table 4.

The connections of earthing conductors to the metal parts to be earthed and to the vessel's hull shall be made with care and shall be protected against corrosion.

The casings of mobile power consumers and portable devices shall, during normal operation, be earthed by means of an additional earthing conductor, that is incorporated into the power cable. That provision shall not apply where a protective circuit separation transformer is used, nor to appliances fitted with protective insulation (double insulation).

Electrical equipment in hazardus area to be fitted with an earthing conductor irrespective of the type of mounting used.

1.1.4.5 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(140°F) ,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 organization recognized by the Society

1.1.4.6 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 (140°F) ,if these liquids are heated to a temperature higher than 10 °C (50°F) 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 shall be observed.

Certified safe type equipment listed in Table 5 is permitted.

Cables in hazardous areas zone 0 and 1 shall be armored or screened, or run inside a metal tube.

1.1.4.7 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 shall 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 fume tight-encapsulated (minimum protection type IP55) and whose surfaces do not attain any unacceptable temperatures

Table 5 Certified safe type equipment

Permitted equipment	
Intrinsic safety	Ex i
Flameproof enclosure	Ex d
Pressurized apparatus	Ex p
Increased safety	Ex e
Special type of protection	Ex s
Oil immersion	Ex o
Encapsulation	Ex m
Sand filled	Ex q

1.1.4.8 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 shall be gastight with self-closing devices without holding back means.

1.1.4.9 Protective measures in the case of ignitable dust

Only lighting fittings with IP55 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(0.19 Inch) thick layer of the dust.

1.1.4.10 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 (140°F) , all the equipment and devices in pipe tunnels shall be certified explosion-protected in accordance with [1.4.6] (zone 1).

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 shall be observed for this reason.

1.1.4.12 Batteries room

Refer Sec.5.

1.1.4.13 Electromagnetic compatibility (EMC)

Where necessary, appropriate measures shall be- adopted 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.

1.2 Documents for approval

1.2.1. **New buildings**

1.2.1.1 The drawings and documents listed below shall be submitted to the Society, at least, in triplicate for examination in sufficiently good time to enable them to be reviewed/approved and made available to the Building Yard and the Surveyor by the time the manufacture or installation of the electrical equipment begins.

Where non-standard symbols are used in circuit and wiring diagrams, a legend explaining the symbols shall be provided.

All documents for approval shall bear the yard number and the name of the shipbuilder.

The Society reserves the right to request additional documents and drawings should those stipulated in [2.1.2] to [2.1.9] prove insufficient for an assessment of the plant.

1.2.1.2 Details of the nature and extent of the electrical installations including the power balance (electrical balance).

1.2.1.3 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.

1.2.1.4 Cable layout or tabulated list of cables showing cable sections and types as well as generator and consumer loads (currents).

1.2.1.5 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

1.2.1.6 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

1.2.1.7 Steering gear circuit diagrams with details of the drive, control and monitoring systems. The steering gear includes lateral thrust propellers, active rudder equipment, etc.

1.2.1.8 **Installation plan**

The plan shall provide details of the exact location of the switchboard, the size of service passageways, distances from bulkheads and frames, etc.

1.2.1.9 For tankers carrying cargo with a flash point of ≤ 61 °C(141.8°F) additional plans shall be submitted which shall show the following:

— the installation sites of all electrical equipment

— the limits of the cargo area with differentiation of those parts of the installation situated above and below deck

— machines and equipment whose use is forbidden during loading, unloading and gas-freeing shall be marked in red

1.3 Systems, voltages and frequencies

1.3.1. Systems

1.3.1.1 As a general principle, systems listed in [3.1.2] to [3.1.4] are permitted.

1.3.1.2 For direct current and single-phase alternating current:

— 2 conductors, one of which is earthed

— single conductors with hull return, restricted to systems of limited extent (e.g. starting equipment of internal combustion engines and cathodic corrosion protection)

— 2 conductors insulated from the vessel's hull

1.3.1.3 For 3-phase alternating current:

—4 conductors with earthed neutral and no hull return

—3 conductors insulated from the hull

—3 conductors with hull as neutral conductor, however, not in final subcircuits.

1.3.1.4 Other systems shall be approved by the Society in each case.

1.3.1.5 Special requirements

Systems using the hull as neutral conductor are not permitted:

—on floating craft or vessels whose hull can be dismantled.

The power supply lines from one barge to another in pusher tug trains shall be insulated on all poles.

1.3.2. Voltages and frequencies

1.3.2.1 Standard voltages

Remark:

The use of standard voltages and frequencies is recommended.

Generators may have rated voltages up to 5% higher than the rated voltage of the consumers.

1.3.2.2 Operating voltages

The operating voltages indicated in Table 6 may not be exceeded.

In special installations (e.g. radio equipment, specific power systems, ignition equipment) higher voltages are permitted subject to compliance with the necessary safety measures.

1.4 Type approvals

1.4.1 General

1.4.1.1 The installations, equipment and assemblies mentioned in [4.1.5] are subject to mandatory type approval.

1.4.1.2 Type tests shall be carried out in the presence of a Surveyor from the Society either in the manufacturer's works or, by agreement, in suitable institutions.

1.4.1.3 Type tests are carried out according to the Society's Rules for approval of equipment.

1.4.1.4 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.

1.4.1.5 Installations, apparatuses and assemblies subject to type testing

Following installations, apparatuses and assemblies shall be subject to type testing:

—steering gear electronic control systems

—variable pitch propeller electronic control systems

—main engine electronic control systems for speed and power

—fire detection- and alarm systems on passenger vessels

—tank level gauging equipment on tankers

—computer systems with Requirement Class 3 and higher

Table 6 Maximum permissible operating voltages

Type of installation	Maximum permissible operating voltage		
	DC	1-phase AC	3-phase AC
Power and heating installations including the relevant sockets	250 V	250 V	500 V
Lighting, communications, command and information installations including the relevant sockets	250 V	250 V	–
Sockets intended to supply portable devices used on open decks or within narrow or damp metal lockers, apart from boilers and tanks:			
— In general	50 V 1)	50 V 1)	–
— Where a protective circuit-separation transformer only supplies one appliance	-	250 V 2)	–
— Where protective-insulation (double insulation) appliances are used	250 V	250 V	–
— Where ≤ 30 mA default current circuit breakers are used	–	250 V	500 V

Mobile power consumers such as electrical equipment for containers, motors, blowers and mobile pumps which are not normally moved during service and whose conducting parts which are open to physical contact are grounded by means of a grounding conductor that is incorporated into the connecting cable and which, in addition to that grounding conductor, are connected to the hull by their specific positioning or by an additional conductor	250 V	250 V	500 V
Sockets intended to supply portable appliances used inside boilers and tanks	50 V 1)	50 V 1)	–
Where that voltage comes from higher voltage networks galvanic separation shall be used (safety transformer). All of the poles of the secondary circuit shall be insulated from the ground.			

1.4.2 **Exceptions**

Instead of the stipulated type approvals in well-founded cases routine tests in the presence of a Surveyor may be carried out. An agreement with the Society prior to testing is required.

SECTION 2 DESIGN AND CONSTRUCTION OF POWER GENERATING PLANT

Contents

2.1 General requirements

Every power supply system on inland vessels shall comprise at least one main and one auxiliary power source.

2.2 Power source

2.2.1 Design

The power source may take the form of:

a) Two diesel sets. Special restrictions for the supply of steering gear systems see 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 maneuvering 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 are considered by the Society case-by-case.

2.3 Power balance

2.3.1 Power requirements

A power balance for the electrical plant shall be furnished as proof that the generator rating is sufficient. The power requirements shall be determined for day/night running service and emergency supply, if any.

A table shall be compiled listing all the installed electrical consumers together with their individual power ratings:

a) Details of the full power rating of those consumers permanently required for the operation of the vessel.

b) The installed capacity of consumers kept in standby shall 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 shall 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, shall 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, shall be used when deciding the generator rating.

Unless some other standby capacity such as a floating battery is available, some spare capacity shall be designed into the system to cover short-lived peak loads like those caused by the automatic start-up of large motors.

2.4 Generator ratings control

2.4.1 DC generators

2.4.1.1 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

2.4.1.2 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.

2.4.2 **Single and 3-phase AC generators**

2.4.2.1 **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. While the starting of the motor with the greatest starting current results to an under voltage 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 shall be so designed that for two minutes the generator can be loaded with 150 % of its rated current with an inductive power factor of 0.5 while approximately maintaining the rated voltage. Generators may suffer no damage as a result of a short-circuit and the short circuits which may occur in the supply network in later service. The design shall take account of the short time delay of

the generator switches which is necessary to the selectivity of the system and during which the short-circuit current is sustained.

With voltage-regulated generators it is necessary to ensure that an input data failure cannot lead to unacceptable high terminal voltages.

2.4.2.2 **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 shall be satisfied under the following conditions:

The idling generator, excited to its rated voltage, shall 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 shall be suddenly disconnected.

c) Sustained short-circuit current

The sustained short-circuit current at a single, two or 3-phase terminal short shall not be less than three times the rated current. The generator and its exciter shall be able to carry the sustained short-circuit current for a period of one second without suffering damage.

Exemptions from these requirements may be granted subject to proof in each instance that the selective disconnection of short circuits in the vessel's network is assured at even lower sustained short-circuit currents.

2.4.2.3 **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 afore mentioned load range shall not exceed the smaller of the following values, assuming proportionally equal sharing of the active load:

a) 10 % of the rated reactive power of the largest machine

b) 25 % of the rated reactive power of the smallest machine.

2.5 Generator prime movers

2.5.1 Design and control

The design and control of generator prime movers shall conform to Ch.1 Sec.2.

2.5.2 Parallel operation

The governing characteristics of prime movers in the case of single or 3-phase alternator sets of the same output operating in parallel shall ensure that, over the range from 20 % to 100 % of the total active power, the share of each machine does not deviate from its proportionate share by more than 15 % of its rated active power.

Where the units are differently rated, the deviation from the proportionate share within the load range stated shall not exceed the lesser of the following values:

a) 15 % of the rated active power of the largest machine

b) 25 % of the rated active power of the smallest machine.

2.5.3 Cyclic irregularity

The permissible cyclic irregularity shall be agreed upon between the prime mover and generator manufacturers. The following shall be ensured:

a) faultless parallel operation of 3-phase generators

b) Regular or irregular load variations shall not give rise to fluctuations in active power output exceeding 10% of the rated output of the machine concerned.

c) practically non-flicker lighting at all working speeds

2.6 Special rules

2.6.1 General

Notwithstanding the conditions set out above, other speed and control characteristics may be approved for generators with outputs of up to 10 kW (kVA) provided that trouble-free 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

Contents

3.1 Construction

3.1.1 General

3.1.1.1 Unless otherwise stated in the following Rules, all motors and generators shall conform to a standard accepted by the Society.

3.1.1.2 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 shall be so designed and constructed that the permissible temperature rises stated in Table 1 are not exceeded.

The insulation classes shall be accordance 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 vapors. On DC machines, the commutating pole windings shall be connected symmetrically to the armature,

Wherever possible. Anti-interference capacitors shall be connected directly to the armature terminals. Anti- interference capacitors on generators shall have built-in cut-outs.

3.1.1.3 The carbon brushes shall be compatible with the slip ring and commutator materials and, in the case of the latter, with the commutating conditions.

The working position of the brush holder shall be clearly marked.

3.1.1.4 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 shall be clearly marked.

The class of protection shall match that of the machine and shall be at least IP44. Exceptions to this Rule may be permitted for machines with a working voltage of ≤ 50 V.

3.1.1.5 The manufacturer shall provide every generator and motor with a name plate containing the machine's complete specifications and all essential operating data.

3.1.1.6 Commutators, slip rings 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.

3.1.1.7 Generators driven by the main engine, the propeller shaft or by an auxiliary set intended for other purposes shall be designed with respect to the range of rotational speeds which can occur during normal operation.

3.2 Testing of electrical machines

3.2.1 Certification requirements

3.2.1.1 For generators and electrical motors with rated power less than 50 kVA or 50 kW, which have not been tested in the presence of a Surveyor, works test certificates (W) shall be supplied.

3.2.2 **Scope of tests**

3.2.2.1 **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 Table 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 may be recognized.

The referenced temperature rise shall be at least 10 % lower than that listed in Table 1.

The following tests ([2.2.2] to [2.2.7]) shall be carried out at approximately normal operating temperatures.

Table 1 Permitted temperatures-rises of air cooled machines at an ambient temperature of 40 °C (difference values in K)

No.	*Machinery component*	*Method of measurement* 3)	*Installation class*				
			A	*E*	*B*	*F* 1)	*H* 1)
	AC windings of machines	R					
	Commutator windings	R					
	Field windings of AC and DC machines with DC excitation, other than those specified under 4	R					
	a) Field windings of synchronous machines with cylindrical rotors having DC excitation winding, embedded in slots except synchronous induction motors	R					
	a) Stationary field windings of DC machines having more than one layer	R					
	a) Low-resistance field windings of AC and DC machines and compensation windings of DC machines having more than one layer	Th					
	a) Single-layer field windings of AC and DC machines with exposed bare or varnished						

	metal surfaces and single- layer compensation windings of DC machines		Th					
	Permanently short-circuited, insulated windings		Th					
6	Permanently short-circuited, uninsulated windings		The temperature rises of these parts shall in no case reach such values that there is a risk of injury to any insulation or other material on adjacent parts or to the item itself					
7	Iron cores and other parts not in contact with windings							
8	Iron cores and other parts in contact with windings		Th	60	75	80	100	120
9	Commutators and slip rings, open or closed		Th	60	70	80	90	110
10	Plain bearings	measured in the lower bearing shell or in the oil sump after shut-down		50				
11	Roller bearings Roller bearings with special grease	measured in the lubrication nipple bore		50				
		or near the outer bearing seat		80				
12	Surface temperature			Reference 40 2)				

The values may need correction in the case of high-voltage AC windings

Higher temperature rises may be expected on electrical machines with insulation material for high temperatures. Where parts of such machinery may be accidently touched and there is a risk of burns (> 80 °C), the Society reserves the right to request means of protection such as a handrail to prevent accidental contacts

R = resistance method

Th = thermometer method

Table 2 Test voltages for the winding test

	Machine or machinery component	*Test voltage (r.m.s) dependent on rated voltage U of the subject winding [V]*
	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
	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
	Separately excited field windings of DC machines	1000 + twice the maximum excitation voltage but not less than 1500

	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

No.	Machine or machinery component	Test voltage (r.m.s) dependent on rated voltage U of the subject winding [V]
	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

3.2.2.2 **Load characteristics**

On generators the voltage and on motors the speed is measured as a function of the applied load.

3.2.2.3 **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.

3.2.2.4 **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

b) operation (see Sec.2 [5.2.2] c).

c) A short-circuit withstand test may be demanded:

— to determine the reactances

— if there is any concern regarding mechanical and electrical strength.

3.2.2.5 **High-voltage test (winding test)**

a) The test voltage shall be as shown in Table 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 shall be used as reference in determining the test voltage.

b) Any repetition of the voltage test which may be necessary shall be performed at only 80 % of the nominal test voltage specified in Table 2.

3.2.2.6 **Over speed test**

As proof of mechanical strength, a two-minute overspeed test shall 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 over speed test may be dispensed with in the case of squirrel cage induction motors.

3.2.2.7 **Measurement of insulation resistance**

Measurement of insulation resistance shall be performed, wherever possible, on the machine at service temperature at the end of the test schedule. The test shall be carried out using a DC voltage of at least 500

V. The minimum insulation resistance shall be not less than 1 Mega ohm.

3.2.3 **Testing in the presence of a Surveyor**

3.2.3.1 All electrical machines shall be tested at the manufacturer's works. Where the test procedure is not specified, requirements of IEC 60034 apply.

3.2.3.2 All generators and electrical motors with an output of 50 kVA or 50 kW and over shall 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 shall 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

Contents

4.1 General

4.1.1 General requirements

4.1.1.1 Transformers shall be installed in well ventilated locations or spaces. Transformers with exposed live parts shall be installed in special spaces accessible only to the responsible personnel. The installation of liquid-cooled transformers requires the Society's special approval.

4.1.1.2 As a general principle, the primary and secondary windings of transformers shall be separated electrically. For the adjustment of the secondary voltage, taps shall be provided corresponding to ± 2.5% of the rated voltage.

Starting transformers are excepted from this requirement.

4.1.1.3 Power transformers shall be tested according to IEC 60076.

Transformers with a power rating of 50 kVA or more shall 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.

4.1.1.4 The manufacturer shall fix to transformers/reactors a name plate containing complete specification of the unit and all essential operating data.

SECTION 5 STORAGE BATTERIES

Contents

5.1 General

5.1.1 Application

5.1.1.1 These requirements apply to permanently installed storage batteries.

5.1.1.2 Only storage batteries suitable for vessels use can be used.

5.2 Design and construction of cells

5.2.1 General

Cells shall be so designed that they retain their normal operation at inclination of up to 15° and no electrolyte leaks out at inclination of up to 40°. Cells should be combined in cabinets, containers or racks if the weight of single cells allows this.

The weight of a battery or battery element shall not exceed 100 kg.

5.3 Data plate and operation instructions

5.3.1 General requirements

5.3.1.1 Each battery or battery element shall be marked with maker's name and type of battery, containing all relevant data for operation.

5.3.1.2 For each type of battery an operation manual shall be delivered. It shall contain all information for proper maintenance and operation.

5.4 Installation and location

5.4.1 General requirements

5.4.1.1 Storage batteries shall 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 may be accepted, e.g. in case of internal power source of emergency lighting fittings.

5.4.1.2 Storage batteries shall not 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 shall be installed in such a way, that adjacent equipment is not damaged by the effects of escaping electrolyte vapours.

5.4.1.3 Lead-acid batteries and alkaline storage batteries shall not be installed in the same room or in the immediate vicinity of each other.

5.4.1.4 Storage batteries are secured well from shifting. The braces used shall not impede ventilation.

5.4.1.5 For the installation of storage batteries the total power of associated charger shall be considered.

The charging power shall 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].

5.5 Battery room equipment

5.5.1 General requirements

5.5.1.1 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.

5.5.1.2 Where leakage is possible, the inner walls of battery rooms, cabinets and containers shall be protected against the injurious effects of the electrolyte.

5.6 Ventilation

5.6.1 General requirements

All battery installations in rooms, cabinets and containers shall be constructed and ventilated in such a way as to prevent the accumulation of ignitable gas mixtures.

Gastight NiCd-, NiMH- or Li- batteries may not be ventilated.

5.6.2 Batteries installed in switchboards charging power up to 0.2 kW

Lead batteries with charging power up to 0.2 kW may be installed without separation to the switchgear, if:

a) the batteries are of the valve regulated type (VRL), provided with solid electrolyte and

b) the switchboards are not closed completely (IP 2X will be suitable) and

c) the charger is an automatic IU-charger with a maximum continuous charging voltage of 2.3 V/cell and rated power is limited on 0.2 kW.

5.6.3 Ventilated spaces, battery charging power up to 2 kW

Batteries with charging power up to 2 kW may be installed in ventilated cabinets or containers arranged in ventilated rooms (except in rooms according to [4.1.1] and [4.1.2]). The unenclosed installation (IP 12) in well-ventilated positions in machinery spaces is permitted, provided that they are protected against falling objects and dripping water.

Remark:

The charging power for automatic IU-charging should be calculated as follows: $P = U \cdot I$

$I = 8 \cdot C/100$ *for Pb - batteries*

$I = 16 \cdot C/100$ *for NiCd - batteries*

P = *charging power [W]*

U = *rated battery voltage [V]*

I = *charging current [A]*

C = *rated battery capacity [Ah]*

Battery's gassing voltage shall not be exceeded. If several battery sets are used, the sum of charging power shall be calculated.

The room free air volume should be calculated depending on battery size as follows:

$V = 2.5 \cdot Q$

V = free air volume [m^3]

Q = air quantity [m^3/h]

$0.25 \cdot f \cdot I \cdot x \cdot n$

n = number of battery- cells in series connection

f = 0.03 for lead batteries (VRL) with solid electrolyte

= 0.11 for batteries with fluid electrolyte

If several battery sets are 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: $A = 5.6 \cdot Q$

A = cross section [cm^2]

The required minimum cross-sections of ventilation ducts are shown in Table 1.

Remark:

Small air ducts and dimensions of air inlet and outlet openings should be calculated based on lower air speed (≤ 0.5 m/s).

5.6.4 Ventilated rooms, battery charging power more than 2 kW

If the charging power of batteries exceeds 2 kW, they shall 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 shall exhaust to open deck area by forced ventilation.

Doors to battery rooms shall be gastight with self-closing devices without holding back means.

5.6.5 Ventilation requirements

Ventilation inlet and outlet openings shall be so arranged to confirm 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 top

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, weather tight closures shall be applied 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.

5.6.6 Forced ventilation

If natural ventilation is not sufficient or required cross-sections of ducts according to Table 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 other rooms ventilation systems . Air ducts for forced ventilation shall be resistant to electrolyte and shall lead to the open deck.

5.7 Warning signs

5.7.1 General

At doors or openings of battery rooms, cabinets or containers warning notices shall be mounted drawing attention to the explosion hazard in those areas and that smoking and handling of open flames are prohibited.

Table 1 Cross-sections of ventilation ducts

Calculation based on battery charging power (automatic IU- charging)			
Battery charging power	*Cross-section*		*[cm^2]*
[W]	Lead battery solid electrolyte VRL	Lead battery fluid electrolyte	Nickel- Cadmium battery
< 500	40	60	80
500 < 1000	60	80	120
1000 < 1500	80	120	180
1500 < 2000	80	160	240
2000 < 3000	80	240	forced ventilation
> 3000	forced ventilation		

5.8 Starter batteries

5.8.1 General requirements

5.8.1.1 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.

5.8.1.2 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.

5.8.1.3 Starting internal combustion engines with the vessel's supply battery is permitted only in emergencies.

5.8.1.4 Wherever possible storage batteries used for starting and preheating internal combustion engines shall be located close to the machines.

5.9 Rating of storage battery chargers

5.9.1 General requirements

Charging equipment shall be so rated that discharged storage batteries can be charged to 80% of their rated capacity within a period not greater than 15 hours without exceeding the maximum permissible charging currents.

Only automatic chargers shall be used with charging characteristic adapted to the type of batteries.

If consumers are simultaneously supplied during charging, the maximum charging voltage shall not exceed 120% of the rated voltage. The power demand of the consumers shall be considered for the selection of the chargers.

Battery chargers with a rated power of 2 kW upwards shall be tested in manufacturer’s works in the presence of the Society's surveyor.

SECTION 6 POWER DISTRIBUTION

Contents

6.1 Subdivision of the distribution network

6.1.1 General

Consumers shall be arranged in sections or consumer groups. The following main groups shall be supplied separately:

- lighting circuits
- power plants
- heating plants
- navigation, communication, command and alarm system.

6.2 Hull return

6.2.1 General

In systems using hull return, the final sub-circuits for space heating and lighting shall be insulated on all poles. The earth for the hull return connection shall 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 shall be tinned. The terminal screws shall be made of brass and shall be compatible with the cable cross-sections. The smallest permissible size is M 6.

6.3 Final sub-circuits

6.3.1 General

6.3.1.1 Final lighting sub-circuits and plug socket circuits within the accommodation and day rooms shall be fitted with fuses rated for not more than 16 A. The load on each lighting sub-circuit shall not exceed 10 A.

The number of lighting points supplied by a final sub-circuit shall not exceed the maximum number defined in Table 1.

6.3.1.2 Plug sockets (outlets) shall be connected to separate circuits wherever possible.

Final sub-circuits for lighting in accommodation spaces may, as far as practicable, include socket outlets. In that case, each socket outlet counts for 2 lighting points.

6.3.1.3 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 shall be so arranged that adequate lighting is maintained even if one of the circuits fails.

Table 1 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

6.4 Navigation lights and signal lamps

6.4.1 General

6.4.1.1 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.

6.4.1.2 Each navigation light shall be individually supplied, protected and controlled from the navigation lights switchboard.

6.4.1.3 The navigation lights switchboard may be enlarged to provide connections for other signal lamps. No other consumers may be connected to this switchboard.

6.4.1.4 A number of locally grouped signal lamps may be jointly supplied, controlled and monitored provided that the monitoring system indicates or signals the failure of even one such lamp. However it shall not be possible to use both light sources in a double light (two lights mounted one above the other or in the same housing) simultaneously.

6.4.1.5 The switchboard shall 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.

6.4.1.6 Navigation lights shall be designed for the standard voltages: 24 V, 110 V or 220 V.

6.4.1.7 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].

6.5 Shore connection

6.5.1 General

6.5.1.1 Shore line terminal containers shall be connected to the main switchboard by a permanently laid cable. The shore connection shall be protected against short-circuit and overload at the main switchboard by a switch or contactor with control switch and fuses or a power circuit breaker with overload protection. Switch, contactor or power circuit breaker shall be interlocked with the generator circuit in such a way as to prevent the vessel's generator operating in parallel with the shore mains or another external network. A brief period of concurrent operation shall be permitted when changing from one system to another without break in voltage.

6.5.1.2 When using plug-type shore connectors with a current rating of more than 16 A, an interlocking device with switch shall be fitted so that the connection on board can only be made in the dead condition.

Short-circuit protection at the connection may then be dispensed with.

In order to prevent contact with live parts, plug-type shore connectors shall 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 shall 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.

6.5.1.3 Shore connection power source indicator shall be provided on Main Switch Board.

6.5.1.4 Instruments shall be available for comparing the polarity of a DC power supply or the phase sequence of a 3-phase power supply from the shore with that of the vessel's network. The installation of a phase change-over switch is recommended.

6.5.1.5 Shore power terminal box name plate shall contain following details

—kind of current, rated voltage and frequency for alternating current

—concerning measures to be taken for the shore connection

6.5.1.6 To reduce the load on the terminals, the shore line shall be provided with a tension relief device.

6.5.1.7 Only flexible, oil-resistant and flame retardant cables shall be used as feeder cables.

6.6 Power supply to other vessels

6.6.1 General

A separate junction box shall be provided in the case of supplying power to other vessels. The branch shall be fitted with fuses and an on-load switch or with a power circuit breaker with overcurrent and short- circuit protection. Where voltages of more than 50V and/or currents of more than 16 A are transmitted, it

is necessary to ensure that the connection can only be made in the dead condition. Where a connecting line carrying a voltage of more than 50 V is wrenched out of its connector, it shall immediately be de-energized by a forcing circuit. The same applies to a rupture of the connecting cable.

Vessel hulls shall be conductively connected. Facilities shall be provided to allow this.

Connecting cable suspensions shall be tension-relieved.

SECTION 7 SWITCHGEAR INSTALLATIONS AND SWITCHGEAR

Contents

7.1 Switchboards

7.1.1 General rules

7.1.1.1 Switchboards shall contain all the gear, switches, fuses and instruments necessary for operating and protecting the generators and main power distribution systems. They shall be clearly, easily and safely accessible for the purposes of maintenance, repair or renewal. Terminals for voltages up to 50 V, and those for voltages higher than 50 V, shall be kept separately and marked appropriately.

7.1.1.2 Built-in gear, instruments and operating equipment shall be indelibly marked. The current ratings of fuses and the response values of protective devices shall be indicated.

7.1.1.3 The replacement of fuse elements shall be possible without removing panels or covers. Different voltages and types of current shall be clearly indicated.

7.1.1.4 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 (refer Sec.1 [1.4]).

7.1.1.5 Busbars and bare connections shall be made of copper. Even under adverse operating conditions, their temperature rise may not exceed 40°C(104°F) . Busbars shall 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.

7.1.1.6 All screwed joints and connections shall be secured against spontaneous loosening. Screws up to M 4 size may be secured with lacquer or enamel.

7.1.1.7 With the exception of the connections between switchgear and outgoing terminals, switchboards may only contain lines with cross-sections of up to 50 mm^2. If larger cross-sections are required, a main busbar system shall be provided for connecting generators and consumers.

7.1.1.8 The power feed for the control of consumers shall be picked up on the consumer side downstream of the main fuses. Exceptions will be permitted only in special cases.

7.1.1.9 Where fuses and switches are used, the sequence shall be busbar - fuse - switch.

7.1.1.10 Neutral conductors in 3-phase systems shall have at least half the cross-section of the outer conductors. For line cross-sections of up to 16 mm^2, neutral conductors shall have the full cross-section of the outer conductors. Equalizer lines for 3-phase alternator exciters shall be designed to carry half the exciting current of the largest alternator and shall be laid separately from other lines.

7.1.1.11 The smallest permissible cross-section for wiring inside the switchboard, including measuring wires and control lines, is generally 0.5 mm^2. Smaller cross-sections are allowed only in automation and telecommunication equipment and for data bus/data cables. Lines without fuse protection from the main

busbar to fuses and protective switches shall be as short as possible not longer than 1 m. They may not be laid and fastened together with other lines.

Shunt circuits within the switchboard shall be laid separately from other lines and shall generally not be protected by fuses.

Important control lines shall be laid and protected in such a way they cannot be damaged by arcing due to switching operations or, as far as possible, short-circuits.

7.1.1.12 It shall be possible to observe meters and indicators and to operate the switchgear from the front of the switchboard with the doors closed.

7.1.1.13 Operating handles shall generally not be located less than 300 mm(11.81 Inch) above floor level. The operating handles of generator switches shall be located at a distance of at least 800 mm (31.49 Inch) from the floor.

7.1.2 Installation of switchboards

7.1.2.1 Switchboards shall be installed in easily accessible and adequately ventilated spaces in which no flammable gases can gather. They shall be protected against water and mechanical damage.

Switchboards on the floor plates over the bilges shall be closed from below.

Pipes and air trunks shall be so arranged that any leakage does not endanger the switchgear.Pipes and trunks close to switchboards shall have no flanged or screwed joints in this section

Cabinets and recesses for housing switchboards shall be made of non-combustible material or shall be protected by a metal or other fireproof lining. The doors of cabinets and recesses shall bear a notice drawing attention to the switchboard installed therein. A service passageway at least 0.6 m(1.96 Foot) wide shall be provided in front of switchboards.

The materials of switchboard shall have suitable mechanical strength and be durable, flame retardant and self-extinguishing. They shall not ne hygroscopic.

7.1.2.2 A service passageway of not less than 0.5 m (1.64 Foot) behind the switchboard is required only when required by its construction or maintenance.

7.1.2.3 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.(0.98 Foot)

7.1.3 Distribution boards

7.1.3.1 The requirements set out in [1.1] apply in analogous manner.

7.1.3.2 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.

7.1.3.3 Distribution circuits shall be protected in accordance with [3.1] and [3.9] against damage due to short-circuit and overload. Final sub-circuits with fuses rated at more than 63 A shall be fitted with on-load switches. On-load switches may be dispensed with in final sub-circuits with fuses rated up to 63 A provided that each connected consumer can be disconnected by a switch located nearby.

7.1.3.4 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 shall be provided to show whether the distribution board is live.

7.1.3.5 Motor switchgear shall be accessible for the purposes of inspection and repair without the need to disconnect other important circuits.

Mechanical devices, ammeters or indicator lights shall show whether the motor is switched on.

Motor switchgear units or their control switches are normally to be located close to their respective motors. Where for operational reasons they are placed out of sight of the motor, personnel working on the motor shall be provided with means of protecting themselves against the unauthorized switching on of the motor.

Motors shall be disconnected on all poles as a matter of principle.

7.1.4 Switchboard testing

7.1.4.1 Before being installed on board, every switchboard together with all its equipment shall be subjected to the following test ([1.4.2] to [1.4.4]).

7.1.4.2 A test at the manufacturer's works in the presence of a surveyor from the Society shall 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 require a works test on other switchboards where there are special reasons for this.

7.1.4.3 **Operational test**

As far as possible, the proper operation of the equipment shall be checked in accordance with the design.

7.1.4.4 **High-voltage test**

High-voltage test shall be performed for a period of one minute at the test voltage shown in Table 1. Measuring instruments and other ancillary equipment may be disconnected during the test.

7.1.4.5 **Insulation resistance measurement**

Insulation resistance measurement shall be performed using at least 500 V DC. For the purpose of this test, large switchboards may be divided into a number of test sections. The insulation resistance of each section shall be at least 1 Megohm.

Table 1 Test voltages for main circuit

Rated insulation voltage Ui [V]	Test voltage A.C. (r.m.s) [V]
Ui ≤ 60	1000
60 < Ui ≤ 300	2000
300 < Ui ≤ 690	2500

7.2 Switchgear

7.2.1 General

As a general principle, switchgear shall be designed and constructed in accordance with standard IEC, EN or to other standards recognized by the Society.

7.2.2 Selection of switchgear

Switchgear shall be selected not merely by reference to its rated current but also on the basis of its thermal and dynamic strength and its making and breaking capacity.

On-load breakers shall be designed to carry at least the rated current of the series-connected fuse.

Circuit breakers shall act on all live conductors simultaneously. It shall be clearly apparent whether the breaker is in the open or closed position.

Installation switches in lighting systems up to 16 A are exempted from this requirement.

7.2.3 Power circuit breaker

Power circuit breakers shall 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.

7.2.4 Fuses

7.2.4.1 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.

7.2.4.2 It shall be possible to replace the fuse elements or cartridges without exposing the attendant to the danger of touching live components or suffering burns. Where grip-type fuses are used, a detachable grip is permissible. If high rupture capacity (HRC) fuses are installed in electrical switchboards, accessories and personal protective equipment shall be available for installing and removing such fuses.

7.3 Switchgear, protective and monitoring equipment

7.3.1 General

7.3.1.1 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.

7.3.1.2 The protective devices shall 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.

7.3.1.3 All non-earthed poles shall be connected and disconnected simultaneously. In earthed systems, lines shall contain neither switches nor fuses in their earthed pole or conductor.

7.3.2 Equipment for 3-phase AC generators

7.3.2.1 Switchgear and protective devices for individual operation 3-phase AC generators shall 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 shall be designed as follows:

a) The overload trip, shall be set at an overcurrent of between 10 % and 50%, shall open the power circuit breaker with a maximum time delay of two minutes.

A setting of more than 50% overcurrent may be approved if required by the operating conditions and compatible with the generator or prime-mover design.

b) The short-circuit trip shall 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 shall be designed for at least twice the rated generator current.

7.3.2.2 **Switchgear and protective devices for parallel**

The following equipment shall be provided in addition to the switchgear and protective devices specified above [3.2.1].

a) 3-phase AC generators rated at 50 kVA and above shall be provided with reverse-power protection with a time delay of 2 to 5 seconds.

The protective device shall be selected and adjusted to suit the characteristics of the prime mover. Reference values for the setting are 4% to 10% of the rated current for diesel-driven generators. The protection should, wherever possible, be set to 50% of the prime mover trailing power. A voltage drop to 60% of the rated voltage shall not render the reverse-power protection ineffective within the specified range.

b) The generator switches shall be fitted with undervoltage protection which prevents the contact assemblies from closing when the generator is de-energized. If the voltage drops to between 70% and 35% of the rated voltage, the generator switch shall open automatically. Under voltage trips shall have a short time delay matched to the short-circuit trip called for in [3.2.1] b).

c) A synchronizing device shall 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 shall 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 shall 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.

7.3.3 Equipment for DC generators

7.3.3.1 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 shall conform to [3.2.1] (for individual operation) with the difference that the short-circuit trip shall have a short time delay of up to about 200 ms.

b) A polarity-reversing facility, if necessary.

7.3.3.2 Switchgear and protective devices for parallel operation

The following equipment shall 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) Under voltage 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.

7.3.4 **Special requirements**

On-load switches, power circuit breakers and, generally speaking, reverse-current cut-outs can be dispensed with in the case of generators with outputs of up to 10 kW (kVA) and a voltage of 50 V or less which, because of their control equipment, do not need to be subjected to switching operations in service. Further exemptions may be allowed depending on the design of the equipment.

7.3.5 **Disconnection of non-essential consumers**

It is recommended that a device be installed which, when the generator reaches its rated output, emits a warning signal after about 5 s and automatically cuts off consumers whose temporary disconnection will not jeopardize the safety of the vessel and its machinery installation. The disconnection of the loads may be effected in one or more steps. The automatic disconnection of non-essential consumers is mandatory on larger passenger vessels and on vessels with automated engine operation.

7.3.6 **Measuring and monitoring equipment**

7.3.6.1 The measuring error of switchboard instruments may not exceed 1.5% of the scale terminal value. Directionally sensitive instruments shall 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 shall 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 range shall be deviations of down to ± 5 Hz from the rated frequency. Vibrating reed instruments with 21 reeds are recommended.

The main switchboard (main distribution board) shall 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 shall be marked on the instrument scales, or on a separate panel in the case of multi-circuit instruments with changeover switch. The rated service values shall be marked in red on the scales of all instruments.

7.3.6.2 **Generator measuring and monitoring equipment**

a) Each DC generator shall be provided with: 1 voltmeter

1 ammeter

1 blue pilot light (generator live)

Where circuit breakers are used, the following additional lights shall be provided: 1 green pilot light (circuit breaker closed)

1 red pilot light (circuit breaker open)

b) Each 3-phase AC generator shall 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

7.3.6.3 **Special requirements**

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.

7.3.6.4 **Protection of generator monitoring and control circuits**

The following circuits shall be supplied by the generator direct and shall be individually fused (using fusible cut-outs):

—generator protective relay and generator switch under voltage trip

—measuring instruments

—synchronizing equipment

—pilot lights

—speed adjuster

—electrical generator switch drive

—automatic power supply system (measuring voltage)

7.3.6.5 **Earth fault indication**

Every non-earthed primary or secondary system shall 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.

7.3.6.6 **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.

Remark:

For vessels built in line with the EU Directive 2006/87/EC, monitoring equipment giving audible and visual alarm signals is mandatory.

7.3.7 **Transformer protection**

The windings of transformers shall be protected against short circuit and overload by multi-pole power circuit breakers or by fuses and on-load switches in accordance with the above Rules. Transformers for parallel operation shall be fitted with isolating switches on the secondary side.

Overload protection primary side may be dispensed with where it is protected on the secondary side.

7.3.8 Motor protection

Motors rated at more than 1 kW shall be individually protected against overloads and short circuits. For steering gear motors see 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 shall be staggered in time.

The under voltage protection shall work reliably between 70% and 35% of the rated voltage.

7.3.9 Circuit protection

Every distribution circuit shall be protected against damage due to overloads and short circuits by means of multi-pole power circuit breakers or fuses in accordance with the above Rules. Final sub-circuits 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 shall be designed for the rated amperage of the fuse.

For steering gear circuits see Sec.8 [1]. Automatic cut-outs and protective motor switches shall, where necessary, be backed up by the series-connected fuses specified by the manufacturer. In the case of important consumers, automatic cut-outs without selectively staggered disconnecting delay may not be arranged in series.

7.3.10 Storage battery protection

Batteries, except starter batteries, shall be provided with short-circuit protection situated near the batteries, but not in battery's cabinet or container. Emergency batteries supplying essential services may only be provided with short-circuit protection sufficient for their cables. The value of the fuses may be two stages higher than the corresponding values for the rated cable current shown in Sec.12 Table 2 and Sec.12 Table 3, column 3, or of power circuit breakers with suitably adjusted short-circuit protection.

7.3.11 Protection of measuring instruments,

Indicators, measuring instruments and pilot lights shall be protected by fuses. Pilot lights with operating voltage over 24 V shall 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.

7.3.12 Exciter circuits

Exciter circuits and similar circuits whose failure might endanger the operation of essential systems may not be protected, or may be protected only against short circuits.

7.3.13 Emergency disconnecting switches

Oil burner equipment, fuel pumps, boiler fans, separators, machinery space and pump room ventilators shall be provided with an individual emergency disconnecting switch located at a central position outside the machinery space unless other means are available for rapidly interrupting the fuel and air supply outside the room in which the equipment is installed.

7.4 Control and starting equipment

7.4.1 Operating direction of hand wheels and

Hand wheels and levers of starters and drum controllers not intended for reversing shall be arranged to turn clockwise for starting the motors. Motor speed and generator voltage control shall 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.

7.4.2 Hand-operated controllers, resistors

The temperatures of handles and other parts which shall be touched in order to operate equipment may not exceed the following values in service:

— Metal parts 50°C (122°F)

— Insulating material 60°C (140°F)

Resistor casings whose temperature is liable to exceed 60°C (140°F) shall 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 (329°F) in the case of resistors integral to starters and controllers or 190°C (374°F) for separately mounted resistors.

SECTION 8 STEERING GEARS, LATERAL THRUST PROPELLER SYSTEMS AND ACTIVE RUDDER SYSTEMS

Contents

8.1 Steering gears

8.1.1 General requirements

As a general principle, two steering gears, as constructionally independent as possible, shall be provided, i.e.:

— 1 main and 1 auxiliary steering gear system, or

— 2 main steering gear systems

8.1.2 Definitions

8.1.2.1 Main steering gear system

The main steering gear system comprises all the system components needed to steer the vessel under normal design conditions.

8.1.2.2 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.

8.1.3 Design features

8.1.3.1 In general, all parts of main and auxiliary steering gears shall be designed in conformity with Ch.10 Sec.1.

8.1.3.2 The rated output of the electrical machinery shall be related to the maximum torque of the steering gear. For hydraulic steering gears, the rated output of the drive motors shall 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 electro-hydraulic steering gears S 3: 40% for motors of electromechanical steering gears

b) For steering gears with a constant power demand the machines shall be designed for continuousservice

S 1.

Remark:

For definition of service factor S, refer IEC 60024.

8.1.3.3 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.

8.1.4 System requirements

8.1.4.1 Systems may be differentiated as follows:

a) hydraulically driven main steering gear with electro-hydraulic auxiliary steering gear

b) electrohydraulic main steering gear comprising two equivalent rudder drives

c) hydraulic main and auxiliary steering gear systems

8.1.4.2 Electrical and electro-hydraulic power unit shall be supplied via separate cable. The necessary fuse junctions and switchgear devices shall be housed in separate switch containers. If installed together in switchboards, they shall be suitably isolated from the feeder panels of other consumers.

8.1.4.3 The systems shall 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.

8.1.4.4 Where a system is supplied from a battery, a voltage monitor shall 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%.

8.1.4.5 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.

8.1.4.6 The changeover from the main to the auxiliary steering gear system shall be able to be effected within 5 seconds.

8.1.4.7 Following a power failure, the steering gear drive systems shall automatically re-start as soon as the power supply is restored.

8.1.4.8 If the steering gear is operated only by electrically driven power units or electrohydraulic power units, then at least one of the power units or rudder drives shall, in the event of failure of the vessel's network,

be automatically supplied by a battery until an auxiliary diesel set has been started and has taken over the power supply.

The battery is not required in the case that the standby auxiliary diesel set starts automatically and takes over the power supply within 5 seconds after black-out.

8.1.4.9 Installations other than that described require the Society's approval case by case.

8.1.5 Protective equipment

8.1.5.1 The control circuits and motors of steering gear systems shall be protected against short circuits only.

8.1.5.2 Where fuses are used, their rated current shall 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.

8.1.5.3 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 shall be disabled or shall be set to twice the rated current of the motor.

8.1.5.4 Control circuits shall be fused for at least twice the maximum circuit current rating. They shall be located on the load side of the main fuse of the electrical drive concerned.

8.1.5.5 The protective devices shall 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 shall be fitted with fuses and shall be connected and disconnected simultaneously.

8.1.5.6 On relays and magnetic valves rectifiers or capacitors in parallel shall be fitted to quench arcs.

8.1.6 Indicating and monitoring equipment

8.1.6.1 As a general principle, separate indicators or monitors, as appropriate, shall 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.

8.1.6.2 A failure of the control voltage and any deviation 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.

8.1.6.3 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 shall be subjected to a time delay in order to bridge voltage dips caused by starting operations (where a system is supplied by a battery).

8.1.6.4 In addition, 3-phase AC systems shall 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 shall be set at 0.7 times the rated current of the motor.

8.1.7 Rudder control

8.1.7.1 Main and auxiliary steering gears shall be controlled from the main steering station. The controls shall be so arranged that the rudder angle cannot be altered unintentionally.

8.1.7.2 Where more than one power drive is installed, the wheelhouse shall be provided with at least two mutually independent steering gear control systems.

Separate cables and lines shall 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.

8.1.7.3 A common selector switch shall be provided for change over one control system to another.

8.1.8 Auto pilot systems

An indicator light showing that the autopilot is operative shall 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 shall be supplied separately from each other.

8.1.9 Rudder angle indicator

The actual position of the rudder shall be clearly indicated in the wheelhouse and at every steering station. In the case of electrical or hydraulic control systems, the rudder angle shall be indicated by a device (rudder angle transmitter) which is independent of the control system and actuated either by the rudder-stock 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.

8.2 Lateral thrust propellers and active

8.2.1 General

8.2.1.1 The short-circuit protection of the supply shall conform to 1.5.

8.2.2 Drives

8.2.2.1 Active rudder systems shall be rated for continuous service.

Lateral thrust propeller systems shall 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 shall be protected against short circuits and overloads. The overload protection shall 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.

8.2.3 Monitoring

8.2.3.1 The wheelhouse shall be equipped with the monitors and indicators described in [2.3.2] to [2.3.6].

8.2.3.2 A blue indicator light signalling that the system is operative.

8.2.3.3 A yellow indicator light for signalling an overload.

8.2.3.4 Depending on the type of system, further indicators shall be provided for signalling operational level and the desired direction of movement of the vessel.

8.2.3.5 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.

8.2.3.6 Where fuses are installed for short-circuit protection, a phase monitor shall confirm that the system cannot be started in the event of a phase failure.

SECTION 9 ELECTRIC HEATING APPLIANCES

Contents

9.1 General

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).

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.

9.2 Space heaters

9.2.1 Arrangement of heaters

9.2.1.1 No hooks or other devices on which clothing can be hung may be fitted above heaters without temperature limitation.

9.2.1.2 Where heaters are fitted in the bulkhead lining, a trough made of non-combustible material shall be mounted behind each heater in such a way as to prevent the accumulation of heat behind the lining.

9.2.1.3 Only waterproof heaters according to IEC 60335 may be used in washrooms, bathrooms and other damp spaces as well as in machinery spaces.

9.2.2 Enclosures

Heater enclosures shall be so designed that no objects can be deposited on them and air can circulate freely round the heating elements.

9.2.3 Thermal design of heaters

Electrical space heaters shall be 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, Refer Sec.7 [2]

9.2.4 Electrical equipment of heaters

9.2.4.1 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 shall be equipped with thermal protection which interrupts the current as soon as the maximum permissible heater temperature is exceeded. Automatic restarting shall be prevented.

9.2.4.2 Self-regulating material in heating elements may be dispensed with.

9.2.4.3 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.

9.2.4.4 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.

9.3 Oil and water heaters

9.3.1 General

Refer Ch.7 Sec.1

9.4 Electric ranges and cooking equipment

9.4.1 Cooking plates

Only enclosed-type cooking plates may be used.

9.4.2 Switches

The switches of the individual cooking plates shall disconnect all live conductors when in the off position. The switch steps shall be clearly marked.

Switches and other control elements shall be so fitted that they are not exposed to radiant heat from the cooking plates or heating elements. The maximum permissible temperature limits specified in Sec.7 [4.2] are applicable.

SECTION 10 LIGHTING INSTALLATIONS

Contents

10.1 General

Lighting installations shall be designed in compliance with the paragraphs listed below:

— Sec.1 [3.2], Voltages and frequencies

— Sec.6 [3.1], Final sub-circuits

— Sec.6 [4.1], Navigation lights

— Sec.1 [1.4.2], Sec.1 [1.4.3] and Sec.1 [1.4.5] to Sec.1 [1.4.13]

10.2 Design of lighting installations

10.2.1

The number of lamps and their distribution shall be to confirm satisfactory illumination.

10.2.2

In machinery and service spaces, service passageways, cargo holds and commissary spaces, lighting fixtures shall be provided which are sufficiently robust for this application. The lighting fixtures shall be fitted with impact-resistant covers.

10.2.3

Wherever possible, separate circuits shall be provided for plug sockets.

10.2.4

The use of normal shore type light fittings is permitted in accommodation, day rooms and commissary spaces provided that they comply with the requirements contained in [3].

10.3 Design of lighting fixtures

10.3.1

Lighting fixtures shall have a base which reflects and dissipates the heat produced by the light source. The mountings used shall provide a gap of at least 5 mm(0.19 Inch) 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 an especially robust construction.

10.3.2

The temperature of lighting fixtures shall not exceed 60 °C(140°F) where they can be touched easily.

10.3.3

Heat-resistant leads shall be used for the internal wiring of lamp-holders.

10.3.4

Metal lighting fixtures shall be fitted with an earthing screw in the casing or base. All metal parts inside a lighting fixture shall be conductively connected to each other.

The connecting terminals shall be directly fastened to the lighting fixture.

10.3.5

Every lighting fixture shall be permanently marked with the maximum permissible wattage of the lamps to be fitted.

10.4 Mounting of lighting fixtures

10.4.1 General

10.4.2 All lighting fixtures shall be mounted in such a way that combustible structural elements such as wood etc. shall not be ignited by the heat produced and the lighting fixtures themselves are not exposed to damage.

10.4.3 In bathrooms and shower rooms lighting fixtures shall be mounted in accordance with IEC.

10.4.4 Lighting appliances on open decks shall be so installed as not to impede the recognition of navigation lights.

10.5 Lighting in cargo holds

10.5.1 **General**

Where a lighting system is permanently installed, each final sub-circuit or each section shall be provided with switches having clearly marked settings or with pilot lamps showing whether the system is switched on. The switches shall be located outside the holds accessible to authorized personnel only

The lighting fixtures shall be fitted with sufficiently robust wire guards or impact-resistant covers. Their method of mounting shall confirm that they cannot be damaged while work is in progress.

For explosion protection refer also Sec.1 [1.4.5] to Sec.1 [1.4.13].

SECTION 11 INSTALLATIONS MATERIAL

Contents

11.1 Design and mounting

11.1.1

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.

11.1.2

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.

11.1.3

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.

11.1.4

Mobile appliances shall be provided with means of relieving tension in the cable so that the conductors are not subjected to tensile load.

11.1.5

Terminals, screws and washers shall be made of brass or another corrosion-resistant material.

11.2 Plug connections and switches

11.2.1

The live contact components of sockets (outlets) and plugs shall be so enclosed that they cannot be touched under any circumstances, even during insertion of the plug.

11.2.2

The sockets for amperages over 16 A shall be interlocked with a switch in such a way that the plug can be neither inserted nor withdrawn as long as the socket contact sleeves are live.

11.2.3

Where a vessel is provided with sockets for a variety of distribution systems differing in voltage or frequency, use shall 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.

11.2.4

Plug connections shall conform to the required class of enclosure irrespective of whether or not the plug is in or out.

11.2.5

Wherever possible, appliances shall be so designed and mounted that the plugs are inserted from below.

11.2.6

Apart from the sockets standardized and specifically approved for use in shipbuilding practice, accommodation and day rooms may also be provided with sockets designed for use on shore provided that they are mounted in a dry position.

11.2.7

Only sockets with a permissible operating voltage in accordance with Sec.1 Table 6 are allowed in washrooms and bathrooms. No sockets or switches may be fitted in shower cubicles, shower cabinets or close to bathtubs. Exempted from this requirement are razor sockets with an isolating transformer.

11.2.8

Switches shall simultaneously connect and disconnect all the non-earthed conductors of a circuit. Single-pole disconnection is permitted only in the accommodation area for the switches of lighting circuits not carrying more than 16 A.

11.2.9

No plug connections are normally to be provided in cargo holds.

Where power sockets are essential in special cases, e.g. for supplying power to refrigerated containers, they shall be supplied from their own sub-distribution boards with fused outlet switches which can be centrally disconnected and are located outside the cargo holds.

The sub-distribution 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

Contents

12.1 General

12.1.1

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.

12.1.2

Except for lighting and space heating, only cables with multi-strand conductors shall be used.

12.1.3

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 shall 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.

12.2 Choice of cables

12.2.1 Temperatures

In positions liable to be subjected to high ambient temperatures, only cables whose permissible temperature is at least 10 K above the maximum ambient temperature to be expected shall be used. A correction factor shall be applied to the permissible loading (referTable 1).

Cables on diesel engines, heaters etc. liable to be exposed to high temperatures shall be routed so that they are protected against excessive external heating. If this is not possible, oil-resistant cables with high heat resistance shall be used. Cables not previously used shall be submitted to the Society for approval prior installation.

12.2.2 Fire resistance

Cables and insulated wires shall be flame-retardant and self-extinguishing (Refer IEC 60332).

12.2.3 Cable sheaths

On open decks, in damp or wet rooms, in service rooms and wherever condensation or harmful vapours (oil vapours) may occur, only cables with impermeable sheaths resistant to the environmental influences may be used.

PVC (polyvinyl chloride), CSP (chlorosulphonated polyethylene) and PCP (polychloroprene) sheaths are deemed to fall into this category, although they are unsuitable for long-term immersion in liquids.

12.2.4 Movable connections

Machines or equipment mounted on rubber or spring vibration absorbers shall 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 shall be specifically marked.

In spaces in the accommodation area, lightweight flexible cords are also permitted.

12.3 Determination of conductor cross-sections

12.3.1 General requirements

12.3.1.1 The sizes of cables and wires shall conform to the details in Table 2 respectively in Table 3 unless other conductor cross-sections are necessitated by the permissible voltage drop for particular equipment items (see [3.1.3]) or by the elevated ambient temperature or by a special permissible working temperature (see also [3.2.1] - Minimum cross-sections). Refer Table 1 for the correction factor.

Table 1 Correction factors for cables in higher ambient temperatures

Maximum permissible conductor operating temperature		Ambient temperature [°C]				
[°C]	Table	40	45	50	60	70
60	Table 2	1	0.87	0.71	-	-
85	Table 3	1	0.94	0.89	0.74	0.57

12.3.1.2 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 any case, only cables of the same cross-sectional area and length shall be used as parallel cables.

12.3.1.3 The cross-section of cables and wires shall 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.

12.3.2 Minimum cross-sections

The minimum cross-section of permanently laid cables and wires in power, heating, lighting systems and control circuits for power plants shall be 1.0 mm^2; in control circuits of safety systems 0.75 mm^2; in automation and telecommunication equipment 0.5 mm^2; in telecommunication systems not relevant to the safety of the vessel and for data bus/data cables 0.2 mm^2.

Within accommodation and day rooms, flexible leads with a conductor cross-section of 0.75 mm^2 and over may also be used for the mobile connection of appliances with a current input of up to 6 A.

12.3.3 Hull return conductors

Refer Sec.6 [2.1]

12.3.4 Protective earth wires

Refer Sec.1 [1.4.4]

12.3.5 Neutral conductors of 3-phase systems

The cross-section of neutral conductors of 3-phase systems shall 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.

12.4 Cable overload protection

12.4.1 General requirements

12.4.1.1 All cables and wires with the exception of hull return, neutral and earthing conductors shall be fitted with fuses in accordance with Table 3 respectively Table 4.

12.4.1.2 Where protection is afforded by power circuit breakers with overcurrent and short-circuit trip, the overcurrent trip shall be set in accordance with the maximum permissible current loads shown in

Table 2 respectively Table 3. The short-circuit trip shall be set to 4-6 times the indicated amperages. For short-circuit protection, refer also Sec.7 [3.9].

12.4.1.3 The exciter conductors of DC motors and DC generators operating in parallel may not be fitted with fuses except in the case of special installations. The exciter conductors of individually connected DC

generators and 3-phase synchronous machines may be fused only where there are special grounds for doing so, e.g. where the cables are run through several of the vessel's main vertical zones.

Table 2 Current rating of cables with a maximum permissible conductor temperature of 60 °C (140 °F at an ambient temperature of 40°C (104°F)

1	2	3	4	5	6	7
Nominal cross-	Continuous service		Short time service S 2 = 30 min		Short time service S 2 = 60 min	
section of the copper conductor [mm2]	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	2	3	4	5	6	7
Nominal cross-section of the copper conductor [mm2]	Continuous	service	Short time service S2	= 30 min	Short time service S2	= 60 min
	Maximum permissibe current	Rated fuse current	Maximum permissible current	Rated fuse current	Maximum permissible current	Rated fuse current
	[A]	[A]	[A]	[A]	[A]	[A]
1.0	6	6	7	10	7	10
1.5	9	10	10	10	10	10
2.5	14	16	15	16	15	16
4	18	20	19	20	19	20
6	24	25	25	25	25	25
10	32	36	36	36	34	36
16	43	36	50	50	46	50
25	57	50	70	63	60	63
35	71	63	88	80	75	80
50	89	80	115	100	100	100
70	109	100	151	125	125	125
95	132	125	194	200	161	160
120	1	160	234	225	161	200
5 to 24-core cables 1.5 mm2						
5	8	6				
7	7	6				
10	6	6				
12	6	6				
14	6	6				
16	6	6				
19	5	4				
24	5	4				

Table 3 Current rating of cables with a maximum permissible conductor temperature of 85°C at an ambient temperature of 40°C (104°F)

1	2	3	4	5	6	7
Nominal cross-	Continuous service		Short time service S 2 = 30 min		Short time service S 2 = 60 min	
Section of the copper conductor [mm2]	Maximum permissibe current	Rated fuse current	Maximum permissible current	Rated fuse current	Maximum permissibe 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	2	3	4	5	6	7
Nominal cross-section of the copper conductor [mm2]	Continuous service		Short S2 time service = 30 min		Short S2 time service = 60 min	
	Maximum permissible current	Rated fuse current	Maxim permissible current	Rated fuse current	Maximum permissibe current	Rated fuse current
	[A]	[A]	[A]	[A]	[A]	[A]
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				

12.5 Cable laying

12.5.1 General

12.5.1.1 Cables from generators and all cables output 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 confirmed by compensation bends.

12.5.1.2 In DC systems without hull return multi-core cables shall 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.

12.5.1.3 In 3-phase systems without hull return, 3-core cables shall be used for 3-phase connections; and 4- core cables shall 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.

12.5.1.4 In single or 3-phase AC systems, single-core cables carrying a current above 20 A shall be avoided. If such a method of installation cannot be avoided, the measures to be taken shall be agreed with the Society.

12.5.1.5 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.

12.5.1.6 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 shall be agreed with the Society in each case.

12.5.1.7 Table 4 indicates the minimum internal radius of curvature of cable bends according to the type and outside diameter of the cable concerned.

12.5.1.8 Terminations and joints in all conductors shall be made as to retain the original electrical, mechanical, flame-retardant and, where necessary, fire resistant properties. The number of joints shall be kept to a minimum.

12.6 Cable runs

12.6.1 General

12.6.1.1 Cable runs shall 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.

12.6.1.2 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 shall be shielded from radiant heat.

12.6.1.3 Where, for safety reasons, an installation is provided with double feeder cables, these shall be laid as far apart as possible.

Cable runs shall be protected against corrosion.

12.7 Fastening of cables and wires

12.7.1 General

12.7.1.1 Cables shall be fastened to trays or carriers. Individually run cables shall be fixed with clips.

12.7.1.2 Cables and wires shall 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 shall be used for fixing cables to Aluminium surfaces.

Clips used for mineral-insulated copper-sheathed cables shall be made of copper alloy if in electrical contact with the cable-sheath.

Table 4 Minimum internal radius of curvature

Outer diameter of cable, D [mm]	Cables without metal sheath or braid	Cables with metal sheath or braid
up to 25	4·D	6·D
over 25	6·D	6·D

12.8 Tension relief

12.8.1 General

Cables shall 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.

12.9 Protection against mechanical damage

12.9.1 General

Cables in cargo holds, on deck and in locations where they are particularly exposed to the danger of mechanical damage, including especially cables laid up to a height of 500 mm (19.68 Inch) above floor, shall be provided with additional protection in form of sheaths or ducts.

Cable coverings shall be conductively connected to the vessel's hull.

12.10 Laying of cables and wires in conduits or enclosed metal ducts

12.10.1 General

12.10.1.1 Conduits and ducts shall be smooth on the inside and shall have ends shaped to avoid damaging the cable covering or sheath. They shall 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.

12.10.1.2 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.

12.10.1.3 Extensive cable ducts and conduits shall be fitted with inspection and draw containers.

12.11 Laying in non-metallic conduits and ducts

12.11.1 General

The conduits or ducts shall be made of flame-retardant material.

12.12 Bulkhead and deck penetrations

12.12.1 General

12.12.1.1 Where cables pass through bulkheads or decks, the cable penetrations shall not impair the mechanical strength, water tightness or fire resistance of the bulkheads and decks concerned.

12.12.1.2 Cable lead-throughs in watertight bulkheads or decks shall 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 effected with casting resins or elastic plugs.

If casting resin is used, the cables shall be run and encased in the resin over a length of at least 150 mm inside the lead-through.

12.13 Cables laid in refrigerated spaces

12.13.1 General

Cables may be laid neither in nor directly upon the thermal insulation of these spaces. They shall 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.

12.14 Cable laying to wheelhouses using extending cable feeds (moveable cable loops)

12.14.1 General

The following points shall 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

12.15 Cable junctions and branches

12.15.1 General

12.15.1.1 Branches from cables and wires may only be made inside containers.

12.15.1.2 Junction and distribution containers shall be located in easily accessible positions and shall be clearly marked.

12.15.1.3 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 shall be so arranged that similar circuits are adjacent to each other. The terminals for dissimilar systems or for systems with different working voltages shall be separated from each other by partitions. All terminals shall be clearly and indelibly marked. A terminal connection diagram shall be mounted on the box cover.

12.15.1.4 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 shall be earthed.

Remark:

The earthing at one end only of cables and wires in electronic systems is recommended.

SECTION 13 POWER ELECTRONICS

Contents

13.1 General

For power electronics in electrical propulsion plants, see Sec.15.

13.2 Construction

13.2.1 General

13.2.1.1 The rules set out in Sec.1 to Sec.12 shall be observed, wherever applicable.

13.2.1.2 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.

13.2.1.3 Equipment shall be readily accessible for purposes of measurement and repair. Devices such as simulator circuits, test sockets, indicating lights, etc. shall be provided for functional supervision and fault location.

13.2.1.4 Control and alarm electronics shall be galvanically separated from power circuits.

13.2.1.5 External pulse cables shall be laid twisted in pairs and screened, and kept as short as possible.

13.3 Rating and design

13.3.1 General

13.3.1.1 Mains reactions of power electronics facilities shall be taken into consideration in the planning of the overall installation, refer Sec.4 [1] and Sec.8 [1].

13.3.1.2 Rectifier systems shall guarantee secure operation even under the maximum permissible voltage and frequency fluctuations, refer Sec.4 [1]. In the event of unacceptably large frequency and/or voltage variations in the supply voltage, the system shall shut-off or remain in a safe operating condition.

13.3.1.3 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.

13.3.1.4 Electrical charges in power electronic modules shall drop to a voltage of less than 50 V in a period of less than 5 s after disconnection from the mains supply. Should longer periods be required for discharge, a warning label shall be affixed to the appliance.

13.3.1.5 If the replacement of plug-in printed circuit boards while the unit is in operation can cause the destruction of components or the uncontrolled behaviour of drives, a caution label shall be notifying to this effect.

13.3.1.6 The absence of external control signals, e.g. due to a circuit break, shall not cause a dangerous situation.

13.3.1.7 Control-circuit supplies shall be safeguarded against unintended disconnection, if this could endanger or damage the plant.

13.3.1.8 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.

13.3.1.9 Special attention shall be paid to the following points:

- mutual interference of static converters connected to the same busbar system
- voltage distortion and reacting to other consumers
- the selection of the ratio between the sub-transient 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 shall 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

13.4 Cooling

13.4.1 General

13.4.1.1 Natural cooling shall be preferred.

13.4.1.2 A comparable level of safety in operation shall be proved for liquid cooling and forced cooling.

13.4.1.3 An impairment of cooling shall not result in unacceptable high temperatures. To prevent this, an high temperature alarm shall be provided.

13.5 Control and monitoring

13.5.1 General

Control, adjustment and monitoring shall confirm that the permissible operating values of the facilities are not exceeded.

13.6 Protection equipment

13.6.1 General

13.6.1.1 Power electronic equipment shall be protected against accedence of their current and voltage limits. For protective devices, it shall be ensured that upon actuating:

— the output will be reduced or defective part-systems will be selectively disconnected

— drives will be stopped under control

— the energy stored in components and in the load circuit cannot have a damaging effect, when switching off

13.6.1.2 Special semiconductor fuses shall be monitored. After tripping the equipment shall be switched off, if this is necessary for the prevention of damage. Activating of a safety device shall trigger an alarm.

13.6.1.3 Equipment without fuses is permissible if a short circuit will not lead to the destruction of the semiconductor components.

13.7 Tests

13.7.1 General

Power electronics assemblies shall be individually tested at the maker's works. A Works Test Report shall be rendered on the tests carried out. Essential equipment from 50 kW/kVA upwards shall be tested in the presence of a surveyor from the Society.

13.7.2 Extent of route tests

13.7.1.1 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 shall be:

duration = 1 minute

$U = 2 \cdot U_n + 1000 \geq 2000$ [V]

U_n = maximum nominal voltage between any two points on the power electronics device [V]

For this purpose, switchgear in power circuits shall be bridged, and the input and output terminals of the power electronics devices and the electrodes of the rectifiers 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.

13.7.1.2 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.

13.7.1.3 Operational test

The function shall be demonstrated as far as possible.

SECTION 14 ELECTRICAL PROPULSION PLANTS

Contents

14.1 General

14.1.1

A vessel has an electrical main propulsion plant if the main drive to the propeller is provided by at least one electrical propulsion motor.

14.1.2

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 designed that following a fault in the static converter or in the regulation- and control system at least a limited propulsion capability remains.

14.1.3

Auxiliary propulsion plants are considered as additionally propulsion systems.

14.1.4

The engines driving the generators supplying the electrical propulsion plant are main engines. Motors driving the propeller shaft are propulsion motors.

14.1.5

If electrical main propulsion plants are supplied from the vessel's general mains, the requirements in this section apply also to the generators and the associated switchgear. For auxiliary propulsion plants, the requirements of this section shall be met correspondingly.

14.2 Drives

14.2.1 Basis for dimensioning

14.2.1.1 The electrical machinery and plants shall, in accordance with their service and operating conditions, be designed for short periods of overload and for the effect of manoeuvres.

14.2.1.2 The lubrication of machinery and shafting shall be designed to be adequate for the entire speed range of rotation in both directions including towing.

14.2.2 Main engines

14.2.1.3 The main engines shall also conform to the requirements of Ch.1.

14.2.1.4 The diesel governors shall allow safe operation over the whole speed range and under all running and manoeuvring conditions, for both, single operation and parallel operation.

14.2.1.5 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.

14.2.3 Propulsion motors

14.2.1.6 The propulsion motors shall also conform to the requirements of Sec.1 to Sec.8.

14.2.1.7 The effects of the harmonics of currents and voltages shall be taken into consideration for the design of the propulsion motors.

14.2.1.8 The winding insulation shall be designed to withstand the over voltages which may arise from maneuvers switching operations.

14.2.1.9 Machines with forced ventilation shall be so dimensioned that in case of ventilation failure a limited operation is still possible. Deviations from this principle require an agreement with the Society.

14.2.1.10 Electrical propulsion motors shall be able to withstand without damage a short circuit at their terminals and in the system under rated operating conditions until the protection devices respond.

14.3 Static converter installations

14.3.1

Power-electronic equipment shall also conform to the requirements of this section.

14.3.2

If static converters are separately cooled, the plant shall be capable to continue operation at reduced power level if the cooling system fails.

14.3.3

Static converters shall be designed for the load to be expected under all operating and maneuvering conditions, including overloads and short circuits.

14.3.4

The circuits for main power supply and exciter equipment shall be supplied directly from the switchboard and shall be separate for each motor and each winding.

14.3.5

Exciter circuits whose failure can endanger the operation shall only be protected against short circuit.

14.3.6

The static converters shall be easily accessible for inspection, repair and maintenance.

14.4 Control stations

14.4.1

Should the remote control system fail, local operation shall be possible. Changeover shall be possible within a reasonably short time. This operation can be made, e.g. from the control cabinet of the propulsion plant. Voice communication with the bridge shall be provided.

14.4.2

The main control station on the bridge shall be provided with an emergency stop device independent of the operating elements of the main control system. Also an emergency stop device in the engine room shall be provided.

14.4.3

All operating functions shall be made logical and simple, to prevent mal-operation. The operating equipment shall be clearly arranged and marked accordingly.

14.4.4

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.

14.5 Vessel's mains

14.5.1

It shall be arranged to connect and disconnect generators without interrupting the propeller drive.

14.5.2

If a power management system is available, the automatic stop of main engines during maneuvering shall be prevented.

14.6 Control and regulating

14.6.1

If computer systems are used, the requirements of Sec.16 shall be observed.

14.6.2

An automatic power limitation of the propulsion motors shall ensure that the vessel mains will not be overloaded.

14.6.3

The reverse power during reversing or speed-reducing maneuvers shall be limited to the acceptable maximum values.

14.7 Protection of the plant

14.7.1

Automatic stop of the propulsion plant, which impairs the vessel's maneuvering capability, shall be limited to such failures which would result in serious damage within the plant.

14.7.2

Protection devices shall be set to such values that they do not respond to overload occurring during normal operation, e.g. while maneuvering.

14.7.3

Defects in reducing and stopping devices shall not impair the limited operation in accordance with [1.2].

14.7.4

In the event of failure of an actual or reference value it shall be ensured that the propeller speed does not increase unacceptably, the propulsion will be not reversed or dangerous operating conditions arise. The same applies to failure of the power supply for control and regulating.

14.7.5

The following additional protection equipment shall be provided:

— Where drives can be mechanically blocked in an uncontrolled manner, they shall be provided with protection devices to prevent damage to the plant

— Over speed protection

— protection against overcurrent and short circuit

— differential protection and earth fault monitoring for propulsion motors with an output of more than 1500 kW

14.7.6

The actuation of protection, reducing and alarm devices shall be indicated optically and audibly. The alarm condition shall remain recognizable even after switching-off.

14.8 Measuring, indicating, monitoring and alarms equipment

14.8.1 General

Failures in measuring, monitoring and indicating equipment shall not cause a failure of control and regulating.

14.8.2 Measuring equipment and indicators

14.8.1.1 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].

14.8.1.2 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

14.8.1.3 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

14.8.3 Monitoring equipment

Abnormal values of the different parameters of the equipment listed here below shall trigger an alarm which is signaled 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.

14.8.4 Power reduction

In case abnormal operating power may be automatically reduced, this information shall be indicated at the propulsion control position.

14.9 Cables and cable installation

14.9.1 General

The cable network for electrical propulsion plants shall comply with the requirements of 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.

14.10 Testing and trials

14.10.1 General

14.10.1.1 A quality assurance plan shall be submitted to the Society.

14.10.1.2 Tests of machines, static converters, switchgear, equipment and cables shall be carried out at the maker's works in accordance with applicable requirements of Sec.1 to Sec.14.

14.10.1.3 **Shaft material for generators and propulsion motors**

Tests of the shaft material for generators and propulsion motors. Steel and Iron Materials, shall be made as for vessel's shafting.

14.10.1.4 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.

14.10.2 Tests after installation

Newly-constructed or enlarged plants require testing and trials on board. The scope of the trials shall be agreed with the Society.

14.1.2.1 **Dock trial**

For scope and extent of dock trials, refer Sec.17 [3.8].

14.1.2.2 **River trial**

For river trial program, refer Sec.17 [4.2].

SECTION 15 COMPUTER SYSTEMS

Contents

15.1 General

15.1.1 Scope

These requirements apply, if computers are used for tasks essential to the safety of the vessel, cargo, crew or passengers and are subject to classification.

15.1.2 References to other rules and regulations

IEC 61508 or EN 61508 "Functional safety of electrical/electronic/programmable electronic safety related systems".

15.1.3 Requirements applicable to computer systems

15.1.1.1 Computer systems shall fulfil the requirements of the process under normal and abnormal operating conditions. The following shall be considered:

—danger to persons

—environmental impact

—endangering of technical equipment

—usability of computer systems

—operability of all equipment and systems in the process

15.1.1.2 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.

15.1.1.3 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.

15.2 Requirement classes

15.2.1 General requirements

15.2.1.1 Computer systems are assigned, on the basis of a risk analysis, to requirement classes as shown in Table 1. This assignment shall be accepted by the Society. Table 2 gives examples for such an assignment.

15.2.1.2 The assignment is divided into five classes considering the extent of the damage caused by an event.

15.2.1.3 Considered is only the extent of the damage directly caused by the event, but not any consequential damage.

15.2.1.4 The assignment of a computer system to a corresponding requirement class is made under the maximum possible extent of direct damage to be expected.

15.2.1.5 In addition to the technical measures stated in this section also organisational measures may be required if the risk increases. These measures shall be agreed with the Society.

15.2.2 **Risk parameters**

15.2.2.1 The following aspects may lead to assignment to a different requirement class, see Table 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

15.2.2.2 The assignment of a system into the appropriate requirement class shall be agreed with the Society.

15.2.3 **Measures required to comply with the requirement class**

15.2.3.1 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.

15.2.3.2 **Protection against modification of programs and data**

The measures required depend on the requirement class and the system configuration (see Table 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 shall be retraceable.

For systems of requirement class 4 and 5 all modifications, also the modifications of parameters shall be submitted for approval.

The examples of program and data protection shown in Table 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.

Remark:

A significant modification is a modification which influences the functionality and/or safety of the system.

15.3 System configuration

15.3.1 General requirements

15.3.1.1 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 confirmed.

15.3.1.2 For functional units, evidence shall be proved that the design is self-contained and produces no feedback.

15.3.1.3 The computer systems shall be fast enough to perform autonomous control operations and to inform the user correctly and carry out his instructions in correct time under all operating conditions.

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

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
	Controls for auxiliary machinery Speed governors "On line" cargo computers, networked (bunkers, draughts, etc.) Remote control for main propulsion Fire detection systems Fire-extinguishing systems Bilge draining systems Integrated monitoring and control systems Control systems for tank, ballast and fuel Rudder control systems Course control systems Machinery protection systems/ equipment
	Burner control systems for boilers and thermal oil heater Electronic injection systems
	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

15.3.1.4 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.

15.3.1.5 In the event of failure and restarting of computer systems, the process shall be protected against undefined and critical states.

15.3.2 Power supply

15.3.2.1 The power supply shall be monitored and failures shall be indicated by an alarm.

15.3.2.2 Redundant systems shall be separately protected against short circuits and overloads and shall be selectively fed.

15.3.3 Hardware

15.3.3.1 The design of the hardware shall be clear for easy access to interchangeable.

15.3.3.2 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.

15.3.3.3 For integrated systems, it is recommended that subsystems be electrically isolated from each other.

15.3.3.4 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.

15.3.4 Software

15.3.4.1 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

15.3.4.2 The manufacturer shall prove that a systematic procedure is followed during all the phases of software development.

15.3.4.3 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.

15.3.4.4 The quality assurance measures and tests for the production of software and the punctual preparation of the documentation and tests shall be retraceable.

Table 3 Program and data protection measures in relation to the requirement class

Requirement class	*Program/Data memory*
1	Protection measures are recommended
2	Protection against unintentional/unauthorised modification
3	Protection against unintentional/ unauthorised modification and loss of data
4	No modifications by the user possible
5	No modifications possible

15.3.4.5 The version of the software with the relevant date and release shall be documented. The assignment to the particular requirement class shall be recognizable.

15.3.5 Data communication links

15.3.5.1 The reliability of data transmission shall be suitable for the particular application and the requirement class and specified accordingly.

15.3.5.2 The architecture and the configuration of a network shall be suitable for the particular requirement class.

15.3.5.3 The data communication link shall be continuously self-checking, for detection of failures on the link itself and for data communication failure on the nodes connected to the link. Detected failures shall initiate an alarm.

15.3.5.4 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

15.3.5.5 The characteristics of the data communication link shall be such as to transmit that all necessary information in adequate time and overloading is prevented.

15.3.5.6 When the same data communication link is used for two or more essential functions, this link shall be redundant.

15.3.5.7 Means shall be provided to ensure protection of the integrity of data and timely recovery of corrupted or invalid data.

15.3.5.8 Switching between redundant links shall not disturb data communication or continuous operation of functions.

15.3.5.9 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

15.3.5.10 If approved systems are extended, proof of trouble-free operation of the complete system shall be provided.

15.3.6 Additional requirements for wireless data links

15.3.6.1 These requirements are in addition to the requirements of 5. Data communication links apply to requirement class 2 using wireless data communication links to transfer data between distributed programmable electronic equipment or systems.

15.3.6.2 Functions that are required to operate continuously to provide essential services dependent on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

15.3.6.3 Wireless data communication shall employ recognized international wireless communication system protocols that incorporate the following:

— Message integrity:

Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

— Configuration and device authentication: Shall only permit connection of devices that are included in the system design;

— Message encryption. Protection of the confidentiality and or criticality the data content;

— Security management. Protection of network assets, prevention of unauthorized access to network assets.

Remark:

The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements. Consideration shall be given to system operation in the event of national local port regulations.

15.3.7 Integration of systems

15.3.7.1 The integration of functions of independent systems shall not decrease the reliability of a single system.

15.3.7.2 A defect in one of the subsystem of the integrated system shall not affect the functions of other subsystems.

15.3.7.3 A failure of the transfer of data between connected autarkic subsystems shall not impair their independent functions.

15.3.8 User interface

15.3.8.1 The handling of a system shall be designed for ease of understanding and user-friendliness and shall follow ergonomic standards.

15.3.8.2 The status of the computer system shall be recognizable.

15.3.8.3 Failure or shutdown of sub-systems or functional units shall be indicated by an alarm and displayed at every operator station.

15.3.8.4 For using computer systems, a general comprehensible user guide shall be provided.

15.3.9 **Input devices**

15.3.9.1 The feedback of control commands shall be indicated.

15.3.9.2 Dedicated function keys shall be provided for frequently recurring commands. If multiple functions are assigned to keys, it shall be possible to recognize which of the assigned functions are active.

15.3.9.3 Operator panels located on the bridge shall be individually illuminated. The lighting shall be adapted non glare to the prevailing ambient conditions.

15.3.9.4 Where equipment operations or functions may be changed via keyboards, appropriate measures shall be provided to prevent an unintentional operation of the control devices.

15.3.9.5 If the operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the execution by a single action only, such as:

—use of a special key lock

—use of two or more keys

15.3.9.6 Competitive control interventions shall be prevented by means of interlocks. The control station in operation shall be indicated as such.

15.3.9.7 Controls shall correspond with regard to their position and direction of operation to the controlled equipment.

15.3.10 **Output devices**

15.3.10.1 The size, color 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.

15.3.10.2 Information shall be displayed in a logical priority.

15.3.10.3 If alarm messages are displayed on color monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary color.

15.3.11 **Graphical user interface**

15.3.11.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data which is directly relevant for the user.

15.3.11.2 When general-purpose graphical user interfaces are employed, only the functions necessary for the respective process shall be available.

15.3.11.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

15.3.12 Remote access

15.3.12.1 Remote access during a voyage of a ship shall be used for monitoring purposes and the prior acknowledgment by the ship's responsible crew member only.

15.3.12.2 If remote software maintenance is arranged for onboard, the installation of software shall require the following items and or actions to be fulfilled:

— no modification shall be possible without the acceptance and acknowledgement by the ship's responsible crew member (for example the captain) and shall be carried out in a harbor only;

— any revision which may affect compliance with the rules shall be approved by the Society and evidence of such shall be available onboard;

— an installation procedure shall be available;

— the security of the installation process and integrity of the changed software shall be verified after the software update is complete;

— a test program for verification of correct installation and correct functions shall be available;

— evidence for the reason for updating a software shall be documented in a software release note;

— in case that the changed software has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

15.4 Testing of computer systems

15.4.1 General

15.4.1.1 Computer systems of requirement class 3 and higher are subject to mandatory type approval.

15.4.1.2 Evidence, tests and assessments of computer systems shall be carried out in accordance to the requirement class.

15.4.1.3 By the use of demonstrably service-proven systems and components, the extent of the evidence and tests required may be adapted by agreement.

15.4.1.4 If other proofs and tests are provided by the manufacturer which are of an equivalent nature, they may be recognized.

15.4.1.5 The test schedule of system testing shall be specified and submitted before the hardware and software test will be carried out.

15.4.1.6 Modifications after completed tests which have influence on the functionality and/or the safety of the system shall be documented and retested in accordance to the requirement class.

15.4.2 Tests in the manufacturer's works

Following tests shall be carried out in the manufacturer's works:

— function tests

— simulation of the operating conditions

— fault simulation

— simulation of the application environment

15.4.3 Tests on board

15.4.3.1 Complete system tests

15.4.3.1.1 Integration tests

For wireless data communication equipment, tests during harbor and sea trials shall be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self fail as a result of external electromagnetic interference during expected operating conditions.

Remark:

Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for requirement class 3, 4 and 5 systems, the layout and / or equipment shall be changed to prevent further failures occurring.

SECTION 16 TESTS ON BOARD

Contents

16.1 General

The tests are divided into:

— tests during construction

— tests during commissioning

— tests during trial voyages

16.2 Tests during construction

16.2.1

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.

16.2.2

Test certificates for tests which have already been performed shall be presented to the Society's surveyor on request.

16.2.3 Protective measures

a) protection against foreign bodies and water

b) protection against electric shock, such as protective earthing, protective separation or other measures as stated in Sec.1

c) measures of explosion protection

16.2.4 Testing of the cable network

Inspection and testing of cable installation and cable routing with regard to:

a) acceptability of cable routing with regard to:

— separation of cable routes

— fire safety

— reliable supply of emergency consumers (where applicable)

b) selection and fixation of cables

c) construction of bulkhead and deck penetrations

d) insulation resistance measurement

16.3 Testing during commissioning of the electrical equipment

16.3.1 General

Proofs are required of the satisfactory condition and proper operation of the main and emergency power supply systems, the steering gear and the aids of maneuvering, as well as of all the other installations specified in the rules.

Unless already required in the rules, the tests to be performed shall be agreed with the Society's surveyor in accordance with the specific characteristics of the subject equipment.

16.3.2 Generators

A test run of the generator sets shall be conducted under normal operating conditions, and shall be reported on appropriate form.

16.3.3 **Storage batteries**

The following shall be tested:

a) installation of storage batteries

b) ventilation of battery rooms, cupboards/containers, and cross-sections of ventilation ducts

c) storage-battery charging equipment

d) the required caution labels and information plates

16.3.4 **Switchgear**

The following items shall be tested under observance of:

a) accessibility for operation and maintenance

b) protection against the ingress of water and oil from ducts and pipes in the vicinity of the switchboards, and sufficient ventilation

c) equipment of main and emergency switchboards with insulated handrails, gratings and insulating floor coverings

d) correct settings and operation of protection devices and interlocks.

The Society reserves the right to demand the proof of selective arrangement of the vessel's supply system.

16.3.5 **Power electronics**

The following items shall be tested:

a) ventilation of the place of installation

b) function of the equipment and protection devices

16.3.6 **Power plants**

The following items shall be tested:

a) motor drives together with the driven machines, which shall, , 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) 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

16.3.7 **Control, monitoring and vessel's safety systems**

For these systems operational tests shall be performed.

16.3.8 **Electrical propulsion plant**

Functioning of the propulsion plant shall be proved by a dock trial before river trials.

At least the following trials/measurements shall be carried out in the presence of the Society's 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

16.3.9 Computer systems

Regarding scope of tests refer Sec.15.

16.4 Testing during trial voyages

16.4.1 General

Proof is required that the power supply meets the requirements under the various operating conditions of the vessel. All components of the system shall function satisfactorily under service conditions, i.e. at all main engine speeds and during all maneuvers.

16.4.2 Electrical propulsion plant

16.4.2.1 Trial program

The trial program shall at least include:

a) Continuous operation of the vessel at full propulsion load until the entire propulsion plant has reached steady-state parameters.

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 maneuvers

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

SECTION 17 ADDITIONAL REQUIREMENTS WITH REGARD TO THE APPLICATION OF THE DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL 82/14/EEC(2006/87/EC)

Contents

17.1 Electronic equipment

17.1.1

Electronic equipment shall be in line with Directive 2006/87/EC, Article 9.20.

17.2 Electromagnetic compatibility

17.2.1

The operation of the electric and electronic systems shall not be impaired by electromagnetic interference. General measures shall, with equal importance, extend to:

a) Disconnection of the transmission paths between the source of interference and affected devices.

b) Reducing the causes of disturbance at their source.

c) Reducing the sensitivity of affected devices to interference.

CHAPTER 5 CONTROL AND MONITORING SYSTEMS

CONTENTS

.

SECTION 1 CONTROL, MONITORING, ALARM AND SAFETY SYSTEMS

Contents

1.1 Scope

1.1.1 General requirements

The following are the requirements for the control, monitoring, alarm and safety systems essential to operate equipment for vessel's propulsion, steering and safety.

The requirements include installations of the main propulsion and associated machinery, which are required for manned supervision.

Requirements for automatic and remote control systems and equipment which shall be approved in lieu of continuous manning have to be agreed with the authority.

1.1.2 Planning and design

1.1.2.1 The design of safety measures, open and closed loop controls and monitoring of equipment shall limit any potential risk in the event of breakdown or defect to a justifiable level of residual risk.

1.1.2.2 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 behavior in the event of power failure, restoration and of faults

— unambiguous operation

— maintainability, the ability to recognize faults and test capability

— reproducibility of values

1.1.2.3 Automatic interventions shall be provided where damage cannot be avoided by manual intervention.

1.1.2.4 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.

1.1.2.5 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.

1.1.2.6 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.

1.1.3 Design and construction

1.1.3.1 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.

1.1.3.2 For machinery and systems which are controlled remotely or automatically, control and monitoring facilities shall be provided to permit independent manual operation.

Manual operation shall override all remote and automatic control.

1.1.3.3 In the event of disturbances automatically switched off plants shall not be released for restarting until having been manually unlocked.

It shall be possible to start, stop and reverse the ship's propulsion reliably and quickly.

1.1.4 Application of computer systems

If computer systems are used, Ch.4 Sec.15 shall be observed.

1.1.5 Maintenance

1.1.5.1 Access shall be provided to systems to allow measurements and repairs to be carried out. Facilities such as simulation circuits, test jacks, pilot lamps, etc. shall be provided to allow functional checks to be carried out and faults to be located.

1.1.5.2 The operational capability of other systems shall not be impaired as a result of maintenance procedures.

1.1.5.3 Where the replacement of circuit boards in equipment which is switched on may result in the failure of components or in the critical condition of systems, a warning sign shall be fitted to indicate the risk.

1.1.5.4 Circuit boards and plug-in connections shall be protected against unintentional mixing up. Alternatively they shall be clearly marked to show where they belong.

1.2 Machinery control and monitoring installations

1.2.1 General

1.2.1.1 Where vessels have only one main engine, that engine shall not be shut down automatically except in order to protect against over speed.

1.2.1.2 Where vessels have only one main engine, that engine may be equipped with an automatic device for the reduction of the engine speed only if an automatic reduction of the engine speed is indicated both optically and acoustically in the wheelhouse and the device for the reduction of the engine speed can be switched off from the helmsman's position.

1.2.2 Protective devices for machinery plants

1.2.2.1 Protective devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

1.2.2.2 When reaching dangerous limits, protective devices shall adapt the operation to the remaining technical capabilities.

1.2.2.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

1.2.2.4 Protective devices shall be so designed that potential faults such as, for example, loss of voltage or a broken wire shall not create a hazard to human life, ship or machinery.

1.2.2.5 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

1.2.2.6 The monitored open-circuit principle shall be applied to protective devices which can activate an automatic shut-down. Equivalent monitoring principles are permitted.

1.2.2.7 The tripping of a protective device and faults shall be alarmed. The reason for the tripping shall be identifiable.

1.2.2.8 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

1.2.2.9 The adjustment facilities for protective devices shall be so designed that the last setting is traceable.

1.2.2.10 Protective devices which can activate an automatic shut down of the main propulsion plant shall be equipped with overriding facilities from the wheelhouse.

1.2.3 Reductions of the main propulsion plant

1.2.3.1 Reductions shall be initiated automatically or by a request for manual reduction.

1.2.3.2 Reductions may be a function of the machinery alarm system.

1.2.3.3 Overriding capabilities have to be provided for automatic reductions from the wheelhouse.

1.2.4 Manual Emergency stop

1.2.4.1 Manual emergency stops shall be protected against unintentional activation.

1.2.4.2 The manual emergency stop shall not be automatically cancelled.

1.2.4.3 It shall be recognizable which manual emergency stop has been activated.

1.2.4.4 The monitored open-circuit principle shall be applied to manual emergency stops. Equivalent monitoring principles are permitted.

1.2.5 Safety devices for machinery plants

1.2.5.1 Safety devices shall be independent of open and closed loop control and alarm systems and shall be assigned to systems which need protection.

1.2.5.2 When reaching dangerous limits, safety devices shall initiate an automatic shut down.

1.2.5.3 Protective devices shall be supplied from the main power source and shall have battery support for at least 15 minutes.

1.2.5.4 Where faults which affect the operation of the devices cannot be identified, appropriate test facilities shall be provided which shall be actuated periodically.

1.2.5.5 The monitored open-circuit principle shall be applied to safety devices. Equivalent monitoring principles are permitted.

1.2.5.6 The tripping of a safety device and faults shall be alarmed and recorded. The reason for the tripping shall be identifiable.

1.2.5.7 Disturbed units which are automatically shut down shall be restarted only directly at the unit after a manual release.

1.2.5.8 The adjustment facilities for safety devices shall be so designed that the last setting is traceable.

1.2.5.9 Safety devices of the main propulsion plant may be equipped with overriding facilities. The overspeed protection is excluded.

1.2.6 Safety systems for machinery plants

1.2.6.1 The safety system of a machinery plant is the subsumption of the protective and safety devices related to this machinery plant.

1.2.6.2 It is allowed to combine protective and safety devices for one individual system only.

1.2.7 Open-loop control

1.2.7.1 Main engines and essential equipment shall be provided with effective means for the control of its operation. All controls for essential equipment shall be independent or so designed that failure of one system does not impair the performance of other systems, refer also [1.2.2].

1.2.7.2 Control equipment shall have built-in protection features where incorrect operation would result in serious damage or in the loss of essential functions.

1.2.7.3 The consequences of control commands shall be indicated at the respective control station.

1.2.7.4 Controls shall correspond with regard to their position and direction of operation to the system being controlled respective to the direction of motion of the vessel.

1.2.7.5 It shall be arranged to control the essential equipment at or near to the equipment concerned.

1.2.7.6 Where controls are possible-arranged from several control stations, the following shall be observed:

— Competitive commands shall be prevented by suitable interlocks. The control station in operation shall be recognizable as such.

— Taking over of command shall only be possible with the authorization of the user of the control station which is in operation.

— Precautions shall be taken to prevent changes to desired values due to a change-over in control station.

1.2.7.7 Open-loop control for speed and power of main engines shall be type approved.

1.2.8 Closed-loop control

1.2.8.1 Closed-loop control shall keep the process variables under normal conditions within the specified limits.

1.2.8.2 Closed-loop controls shall maintain the specified reaction over the full control range. Anticipated variations of the parameters shall be considered during the planning.

1.2.8.3 Defects in a control loop shall not impair the function of operationally essential control loops.

1.2.8.4 The power supply of operationally essential control loops shall be monitored and power failure shall be signaled by an alarm.

1.2.8.5 Closed-loop control for speed and power of main engines shall be type approved.

1.2.9 Alarm systems

1.2.9.1 Alarm systems shall indicate unacceptable deviations from operating figures optically and audibly. The operative state of the system shall be indicated in the wheelhouse and on the equipment.

1.2.9.2 Alarm delays shall be kept within such time limits that any risk to the monitored system is prevented if the limit value is exceeded.

1.2.9.3 Optical signals shall be individually indicated. The meaning of the individual indications shall be clearly identifiable by text or symbols.

If a fault is indicated, the optical signal shall remain visible until the fault has been eliminated. It shall be possible to distinguish between an optical signal which has been acknowledged and one that has not been acknowledged.

1.2.9.4 It shall be possible to acknowledge audible signals.

The acknowledgement of an alarm shall not inhibit an alarm which has been generated by new causes. Alarms shall be discernible under all operating conditions.

Where this cannot be achieved, for example due to the noise level, additional optical signals, e.g. flashing lights shall be installed.

1.2.9.5 Transient faults which are self-correcting without intervention shall be memorized and indicated by optical signals which shall only disappear when the alarm has been acknowledged.

1.2.9.6 Alarm systems shall be designed according to the closed-circuit principle or the monitored open-circuit principle. Equivalent monitoring principles are permitted.

1.2.9.7 The power supply shall be monitored and a failure shall cause an alarm. Test facilities are required for the operation of light displays.

The alarm system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

1.2.9.8 Alarms shall be given at manned location in the machinery control position, if any, or in the wheelhouse and shall take the form of individual visual displays and collective audible signals. The audible alarm shall sound throughout the whole machinery space, at manned location in the machinery control position and at the wheelhouse. If this cannot be ensured because of the noise level, additional visual alarms such as flash signals shall be installed.

Simultaneously with a collective alarm signal, an acknowledgeable audible alarm shall be given at manned location in the machinery control position and in the wheelhouse which, following acknowledgement, shall be available for further signals.

It shall be possible to silence audible signals independently of acknowledging the visual signal.

Acknowledgement of optical alarms shall only be possible where the fault has been indicated as an individual signal and a sufficient overview of the concerned process is been given.

1.2.9.9 Where the alarm system contents individual visual displays in the machinery space, the visual fault signals in the wheelhouse may be arranged in at least three groups as collective alarms in accordance with their urgency, if this is necessary due the scope of the plant.

- Group 1: Alarms signaling faults which require immediate shutdown of the main engine (red light).
- Group 2: Alarms signaling faults which require a reduction in power of the main engine (red light).
- Group 3: Alarms signaling faults which do not require Group 1 or Group 2 measures (yellow light).

1.2.9.10 Alarm delays shall be kept within time limits to prevent any risk to the monitored system in the event of exceeding the limit value. Pressure alarms may in general not be delayed by more than 2 s. Level alarms shall be delayed sufficiently to ensure that the alarm is not tripped by brief fluctuations inlevel.

1.2.9.11 A failure of the power supply or disconnection of the system shall not alter the limit value settings at which a fault is signaled.

1.2.9.12 The fault signaling systems of main engines with engine-driven pumps shall be so designed that variations in operating parameters due to maneuvers do not trip the alarm.

1.2.9.13 Input devices shall be approved by the Society.

1.2.9.14 Alarm signals should be automatically suppressed when the main engine and auxiliaries are taken out of service.

1.2.10 Integration of systems for essential equipment

1.2.10.1 The integration of functions of independent equipment shall not decrease the reliability of the single equipment.

1.2.10.2 A defect in one of the subsystems (individual module, unit or subsystem) of the integrated system shall not affect the function of other subsystems.

1.2.10.3 Any failure in the transfer of data of autonomous subsystems which are linked together shall not impair their independent function.

1.2.10.4 Essential equipment shall also be capable of being operated independently of integrated systems.

1.2.11 Remote control of machinery installations

1.2.11.1 Machinery installations shall be equipped with monitoring equipment as detailed in Table 1.

1.2.11.2 The remote control shall be capable to control speed, direction of thrust, and as appropriate torque or propeller pitch without restriction under all navigating and operating conditions.

1.2.11.3 Single lever control shall be preferred for remote control systems. Lever movement shall be in accordance to the desired course of the vessel. Commands entered into the remote control system from the wheelhouse shall be recognizable at all control stations.

1.2.11.4 The remote control system shall carry out commands which are ordered, including emergency maneuvers, in accordance with the propulsion plant manufacturer's specifications.

Where critical speed ranges are incorporated, their quick passing shall be guaranteed and a reference input within them have to be inhibited.

1.2.11.5 With each new command, stored commands shall be erased and replaced by the new input.

1.2.11.6 In the case of set speed stages, a facility shall be provided to change the speed in the individual stages.

1.2.11.7 An overload limitation facility shall be provided for the propulsion machinery.

1.2.11.8 It shall be possible to stop the propeller thrust from the wheelhouse independently of the remote control system.

1.2.11.9 Following emergency manual shutdown or automatic shutdown of the main propulsion plant, a restart shall only be possible via the stop position of the command entry.

1.2.11.10 The failure of the remote control system and of the control power shall not result in any sudden change in the propulsion power nor in the speed and direction of rotation of the propeller. In individual cases, 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 shall be possible from local control positions. The local control positions shall be independent from remote control of propulsion machinery and continue to operate 15 minutes after a black-out.

1.2.11.11 The failure of the remote control system and of the control power shall be signaled by an alarm.

Table 1 Remote control of machinery installations

Symbol convention *H = High* *HH = Very high* *L = Low* *I= Individual alarm* *G = Group alarm*		*Monitoring*				
Identification of system parameter		Alarms	Indication local	Alarms wheelhouse[4]	Indication wheelhouse	Shut down
MAIN ENGINE						
Engine speed	All engines		x			
	Engine power > 220kW	HH	x	G		x
Shaft revolution indicator			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature		H	x	G		
Leakage of fuel injection pipe [5]		H		G		
Failure in electronic fuel injection system		H		G		
Fresh cooling water system inlet pressure [1]		L	x	G		
Fresh cooling water system outlet temperature [1]		H	x	G		
Fuel oil temperature for engines running on HFO		L	x	G		
Exhaust gas temperature (single cylinder when the dimensions permit)			x			
Starting air pressure		L	x	G	x	

Symbol convention *H = High* *HH = Very high* *L = Low* *I = Individual alarm* *G = Group alarm*		*Monitoring*				
Charge air pressure			x			
Control air pressure			x		x	
Exhaust gas temperature at turbocharger inlet/outlet (where the dimensions permit)			x			
Manual emergency stop of propulsion		x			x	x [3]
Fault in the electronic governor		x	x	G		
REDUCTION GEAR						
Tank level			x			
Lubricating oil temperature			x			
Lubricating oil pressure			x			
AUXILIARY MACHINE[2]						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system [1]			L	x	G	
Fresh cooling water system outlet temperature [1]			H	x	G	
Lubricating oil pressure			L	x	G	
Fault in the electronic governor			x	x	G	
DIESEL BOW THRUSTER[2]						
Engine speed	All engines		x			
	Engine power > 220 kW	HH	x	G		x
Low pressure cooling water system [1]		L	x	G		
Fresh cooling water system outlet temperature [1]		H	x	G		
Direction of propulsion			x		x	
Lubricating oil pressure		L	x	G		
Lubricating oil temperature			x			

Fault in the electronic governor	x	x	G		
PROPULSION					
Propulsion remote control ready		x		x	
Pitch control		x		x	
ELECTRICITY					

Symbol convention *H = High* *HH = Very high* *L = Low* *I = Individual alarm* *G = Group alarm*	*Monitoring*				
Earth fault (when insulated network)	x	x	G		
Main supply power failure	x	x	G		
FUEL OIL TANKS					
Fuel oil level in service tank or tanks supplying directly services essential for safety or navigation	L	x	G		
STEERING GEAR					
Rudder angle indicator		x		x	
Level of each hydraulic fluid	L	x	I	x	
Indication that electric motor of each power unit is running		x		x	
Failure of rate of turn control	x		I	x	
Overload failure	x	x	I	x	
Phase failure	x	x	I	x	
Loss of power supply	x	x	I	x	
Loss of control supply	x	x	I	x	
STEAM BOILER OR HEATING OIL					
High pressure	HH				
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 shall be detailed in the machinery space or control room (if any)

5) For diesel engines with more than two cylinders

1.2.11.12 Wheelhouse and engine room shall be fitted with indicators displaying that the remote control system is operative. The wheelhouse and the machinery space shall be provided with indicators showing:

—propeller speed and direction of rotation

—pitch of controllable pitch propeller

1.2.11.13 Remote control systems for main propulsion plants shall be type approved.

1.2.11.14 The transfer of control between the wheelhouse and machinery space shall be possible only from the machinery area.

1.2.11.15 It shall be ensured that control is only possible from one control station at any time. Transfer of command from one control station to another shall only be possible when the respective control levers are in the same position and when a signal to accept the transfer is done from the selected control station.

A display at each control station shall indicate whether the control station selected is in operation.

1.2.11.16 Each local control position, including partial control (e.g. local control of controllable pitch propellers or clutches) shall be provided with means of communication with the remote control position.

1.2.12 Fire detection and alarm

1.2.12.1 Any required fixed fire detection and fire alarm system shall be capable of immediate operation at all times.

1.2.12.2 The fixed fire detection and fire alarm system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

1.2.12.3 The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

1.2.12.4 The system shall be supplied from the main power source and shall have battery support for at least 15 minutes.

1.2.13 Detector requirements

1.2.13.1 Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

1.2.13.2 Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12.5 % obscuration per meter, but not until the smoke density exceeds 2 % obscuration per meter. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

1.2.13.3 Heat detectors shall be certified to operate before the temperature exceeds 78 °C(172.4°F) but not until the temperature exceeds 54 °C(129.2°F), when the temperature is raised to those limits at a rate less than 1 °C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

1.2.13.4 At the discretion of the Society, the permissible temperature of operation of heat detectors may be increased to 30 °C(86 °F) above the maximum deck head temperature in drying rooms and similar spaces of a normal high ambient temperature.

1.2.13.5 All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

1.2.13.6 The detectors shall be mounted in such a way that they can operate properly. Mounting places near ventilators, where the operation of detectors may be impaired or where mechanical damage is expected, shall be avoided.

1.2.13.7 Detectors mounted to the ceiling shall generally be placed at least 0.5 m(1.64 Foot) away from bulkheads, except in corridors, lockers and stairways.

1.2.13.8 The maximum monitored area, respectively the maximum distance between detectors shall not exceed the following values:

—Heat detectors 37 m^2 or distance not more than 9 m(29.52 Foot)

—Smoke detectors 74 m^2 or distance not more than 11 m(36.08 Foot)

1.2.13.9 The distance from bulkheads shall not exceed:

—4.5 m(14.76 Foot) for heat detectors

—5.5 m(18.04 Foot) for smoke detectors

1.2.13.10 The society may require or permit different spacing of detectors based upon test data which demonstrate the characteristics of the detectors.

1.2.14 System requirements

1.2.14.1 The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in the wheelhouse, the accommodation and the space to be protected.

1.2.14.2 Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

1.2.14.3 Accommodation and service spaces of cargo carriers shall be protected by a fixed fire detection and fire alarm system.

1.2.14.4 Machinery installations which have been designed for automatic and remote control in lieu of continuous manning have to be protected by a fixed fire detection and fire alarm system.

CHAPTER 6 STEERING GEAR

CONTENTS

SECTION 1 DESIGN REQUIREMENTS AND TESTING

Contents

1.1 Symbols

d_T = theoretical rudder stock diameter [mm] based on ahead run in accordance with Pt.3 Ch.6 Sec.1 [3.1]

d = minimum actual rudder stock diameter [mm]

$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$

R_{eH} = yield stress [N/mm^2] of the steel used, and not exceeding the lower of $0.7 \cdot R_m$ and 450 N/mm^2

R_m = minimum ultimate tensile strength [N/mm^2] of the steel used,

n_1 = coefficient$_2$

= 0.75 for $R_{eH} > 235$ N/mm$_2$

= 1.00 for $R_{eH} \leq 235$ N/mm

1.2 General

1.2.1 Scope

The following requirements apply to the steering gear, the steering station and all transmission elements from the steering station to the steering gear.

For the rudder and maneuvering arrangement, refer Pt.3 Ch.6 Sec.1

For the purpose of these requirements, steering gear comprises all the equipment used to operate the rudder from the rudder actuator to the steering station including the transmission elements.

This section shall be applied in analogous manner to rudder propellers in their function as steering gear.

1.2.2 Documents for approval

Assembly and general drawings of all steering gear (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 shall be submitted to the Society for approval.

The drawings and other documents shall contain all the information relating to materials, working pressures, pump delivery rates, drive motor ratings, etc. necessary to enable the documentation to be checked.

1.3 Materials

1.3.1 Approved materials

1.3.2.1 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 Pt.2.

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, Pt.2 is to be observed.

1.3.2.2 The pipes of hydraulic steering gear shall 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 shall be provided with protective shielding and shall be safeguarded against hardening due to vibration by the use of suitable fastenings.

1.3.2.3 High pressure hose lines may be used for short connections subject in compliance with Ch.1 Sec.2[7].

The materials used for pressurized components including the seals shall be suitable for the hydraulic oil in use.

1.3.2 Testing of materials

The materials of important load-transmitting components of the steering gear including the pressurized oil pipes and the pressurized casings of hydraulic steering gear shall possess mechanical characteristics conforming to Pt.2. Evidence of this may take the form of manufacturer's acceptance test certificate.

For welded pressurized casings, Pt.2 shall be applied.

1.4 Design and equipment

1.4.1 Number of steering gear

Every vessel shall be equipped with at least one main and one auxiliary steering gear. Each steering gear shall be able to operate the rudder on its own and independently of the other system. The Society may agree to components being used jointly by the main and auxiliary steering gear. For the electrical part of steering gear systems, refer Ch.4 Sec.8.

1.4.2 Main steering gear

1.4.2.1 Main steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 35° port to 35° starboard and vice versa and the vessel travelling at full speed, see Pt.3 Ch.6 Sec.1. The time required to put the rudder over shall not exceed 20 seconds.

The main steering gear shall normally be power-operated.

1.4.2.2 Manual operation is acceptable for rudder stock diameters up to 150 mm calculated for torsional loads in accordance with Pt.3 Ch.6 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 hand wheel shall be necessary to put the rudder from one hard over position port to starboard. Considering the efficiency of the system, the force required to operate the hand wheel should generally not exceed 200 N.

The manual wheel shall not be driven by a powered drive unit.

Regardless of rudder position, a kick-back of the wheel shall be prevented when the manual drive is engaged automatically.

1.4.3 Auxiliary steering gear

Auxiliary steering gear shall be designed to ensure continued adequate maneuverability 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.

1.4.4 Power unit

1.4.4.1 Where power operated hydraulic main steering gears are equipped with two or more identical power units, no auxiliary steering gear need be installed provided that the following conditions are fulfilled.

1.4.4.2 In the event of failure of a single component of the main steering gear, excluding the rudder tiller or similar components as well as the cylinders, rotary vanes and casing, means shall be provided for quickly regaining control of one steering system.

1.4.4.3 In the event of a loss of hydraulic oil, it shall be possible to isolate the damaged system in such a way that the second control system remains fully serviceable and may take over in not more than 5 sec.

1.4.4.4 If the second drive unit or manual drive is not placed in service automatically, it shall be possible to do so immediately by means of a single operation by the helmsman that is both simple and quick.

1.4.4.5 Hydraulic pumps should be protected by means of non-return valves mounted at the discharge part.

1.4.4.6 The second drive unit or manual drive shall ensure the manoeuvrability required by Pt.3 Ch.6 Sec.1 [3.1] as well.

1.4.5 Rudder angle limitation

The rudder angle of power-operated steering gear shall be limited to the specified maximum angle by devices fitted to the steering gear (e.g. limit switches).

1.4.6 End position limitation

1.4.6.1 For limitation of end positions, stoppers are to be provided. Where necessary, a mechanical safety device at the end position shall be provided.

1.4.6.2 In the case of hydraulic steering gear without an end position limitation of the tiller and similar components, an end position limiting device shall be fitted within the rudder actuator.

1.4.7 Locking equipment

Steering gear systems are to be equipped with a locking system effective in all rudder positions. For hydraulic plants shut-off valves directly at the cylinder are accepted instead.

1.4.8 Overload protection

1.4.8.1 Power-operated steering gear systems shall be fitted with overload protection (slip coupling, relief valve) to ensure that the driving torque is limited to the maximum permissible value. Means shall be provided for checking the setting while in service.

1.4.8.2 The pressurized casings of hydraulic steering gear which also fulfil the function of the locking equipment mentioned in [4.7] shall 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.

1.4.8.3 In the case of hydraulic steering gears, the torque transmitted by the rudder, e.g. as a result of grounding, shall in addition, be limited by safety valves.

1.4.9 Controls

Control of the main and auxiliary steering gears shall be exercised from a steering gear station. Controls shall be mutually independent and so designed that the rudder cannot move unintentionally.

Alarm for oil high temperature has to be provided.

1.4.10 Rudder angle indication

1.4.10.1 The rudder position shall be clearly indicated in the wheelhouse and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle shall be signaled by a device (rudder position indicator) which is actuated either by the rudder stock itself or by parts which are rigidly connected to it.

1.4.10.2 The rudder position at any moment shall also be indicated at the steering gear itself.

1.4.11 Piping

1.4.11.1 The pipes of hydraulic steering gear systems shall be installed in such a way as to confirm maximum protection while remaining readily accessible.

Pipes shall be installed at a sufficient distance from the vessel’s shell. As far as possible, pipes should not pass through cargo spaces.

Pipes shall be so installed that they are free from stress and vibration. Hydraulic hoses are:

a) only permissible if vibration absorption or freedom of movement of components makes their use inevitable;

b) to be designed for at least the maximum service pressure;

c) to be renewed at the latest every eight years.

Hydraulic cylinders, hydraulic pumps and hydraulic motors as well as electric motors shall be examined at the latest every eight years by a specialized firm and repaired if required.

1.4.11.2 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 1.5 times the maximum permissible working pressure.

1.4.11.3 No other power consumers may be connected to the hydraulic steering gear drive unit. Where there are two independent drive units such a connection to one of the two systems is however acceptable if the consumers are connected to the return line and may be disconnected from the drive unit by means of an isolating device.

1.4.11.4 For the design and dimensions of pressure vessels, pipes, valves, fittings, etc., see Ch.2 and Ch.3.

1.4.12 Oil level indicators, filters, etc.

1.4.12.1 Tanks forming part of the hydraulic system shall be fitted with oil level indicators.

1.4.12.2 The lowest permissible oil level shall be alarmed.

1.4.12.3 Filters for cleaning the operating fluid shall be located in the piping system.

1.4.12.4 Hydraulic tanks shall be provided with a low oil level alarm warning for safe operation

1.4.13 Arrangement

Steering gears shall be so installed that they are accessible at all times and can be maintained without difficulty.

1.5 Power and design

1.5.1 Power of steering gear

1.5.1.1 The power of the steering gear is governed by the requirements set out in [4.2] and [4.3]. The minimum requirement with regard to the maximum effective torque (M_{TR}) [N·m] for which the steering gear including piping shall be designed shall be calculated according to the following formula:

$$M_{TR} = \frac{{d_T}^3}{74 \cdot k_1}$$

For the determination of the pertinent working pressure (maximum pressure), the frictional losses in the steering gear including piping shall be considered.

The relief valves shall be set at this pressure value.

1.5.1.2 Electrical drive motors are also subject to Ch.4 Sec.8 [1].

1.5.2 Design of transmission components

1.5.2.1 The design calculations for those parts of the steering gear which are not protected against overload shall be based on the elastic limit torque of the rudder stock. The elastic limit torque [N·m] is:

$$M_F = \frac{26.6 \cdot d^3}{1000 \cdot k_1}$$

where, the value used for the minimum actual rudder stock diameter, d, need not be larger than $1.145 \cdot d_T$.

In the case of multi-surface rudders, the diameter of only one rudder stock, i.e. the largest, shall be taken into account.

The loads on the components of the steering gear determined in this way shall be below the yield strength of the materials used. The design of parts of the steering gear with overload protection shall be based on the loads corresponding to the response threshold of the overload protection.

1.5.2.2 **Tiller and rotary vane hubs**

Tiller and rotary vane hubs made of material with tensile strength of up to 500 N/mm^2 shall satisfy the following conditions in the area where the force is applied (refer Figure 1).

Height of hub [mm]: $H_0 \geq d$

Outside diameter [mm]: $da \geq 1.8 \cdot d$

In special cases the outer diameter may be reduced to:

$da \geq 1.7 \cdot d$

but the height of the hub shall then be at least:

$H_0 \geq 1.145 \cdot d$

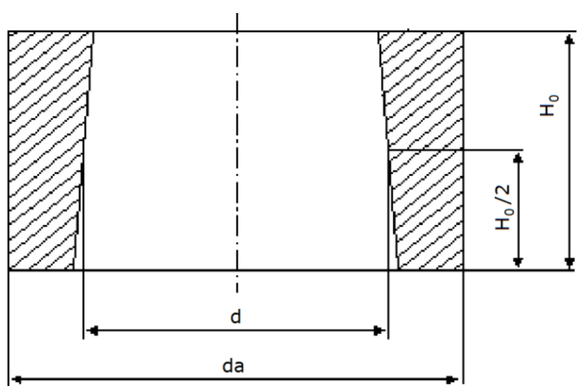


Figure 1 Hub dimensions

1.5.2.3 Tillers, tiller arms, quadrants and key ways

a) The scantling of the tiller shall be determined as follows:

the section modulus of the tiller arm in way of the end fixed to the boss shall not be less than the value Z_b [cm^3] calculated from the following formula:

$$Z_b = \frac{0.147 \cdot d^3}{1000} \cdot \frac{L'}{L} \cdot \frac{R_e}{R'_e}$$

L = distance from the centre line of the rudder stock to the point of application of the load on the tiller (refer Figure 2)

L' = distance between the point of application of the above load and the root section of the tiller arm under consideration (refer Figure 2)

R_e = value of the minimum specified yield strength of the material at ambient temperature [N/ mm^2]

R'_e = design yield strength [N/mm^2] determined by the following formulae:

= R_e, where $R \geq 1.4 \cdot R_e$

= $0.417 \cdot (R_e + R)$ where $R < 1.4 \cdot R_e$

R = value of the minimum specified tensile strength of the material at ambient temperature [N/ mm^2].

The width and thickness of the tiller arm in way of the point of application of the load shall not be less than one half of those required by the above formula.

In the case of double arm tillers, the section modulus of each arm shall not be less than one half of the section modulus required by the above formula.

b) The scantling of the quadrants shall be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm shall not 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 shall be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm^2
- the width of the key shall not be less than $0.25 \cdot d$
- the thickness of the key shall not be less than $0.10 \cdot d$
- the ends of the keyways in the rudder stock and in the tiller (or rotor) shall be rounded and the keyway root fillets shall 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.

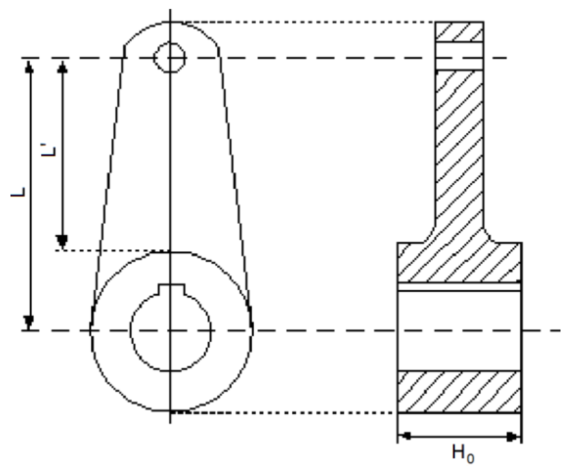


Figure 2 Tiller arm

1.5.2.4 Where materials with a tensile strength greater than 500 N/mm^2 are used, the section of the hub may be reduced by 10 %.

1.5.2.5 Where the force is transmitted by clamped or tapered connections, the elastic limit torque may be transmitted by a combination of frictional resistance and a positive locking mechanism using adequately tightened bolts and a key.

For the elastic limit torque according to formula given in [5.2.1], the thread root diameter, in mm, of the bolts can be determined by applying the following formula:

$$d_B = 9.76 \cdot d \cdot \sqrt{\frac{1}{z \cdot R_{eH} \cdot k_1}}$$

z = total number of bolts

1.5.2.6 Split hubs of clamped joints shall be joined together with at least four bolts. The key shall not be located at the joint in the clamp.

1.6 Tests in the manufacturer's works

1.6.1 Testing of power units

The power units are required to-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, refer Ch.4 Sec.3.

Hydraulic pumps shall be subjected to pressure and operational tests. Where the drive power of the hydraulic pump is 50 kW or more, these tests shall be carried out in presence of a surveyor.

1.6.2 Pressure and tightness tests

Pressure components are to undergo a pressure test, using the following testing pressure:

p_{ST} = $1.5 \cdot p$

p_{ST} = testing pressure [bar]

p = maximum allowable working pressure or pressure at which the relief valve is open

however, for working pressures above 200 bar(2900.75psi), the testing pressure need not exceed p + 100 bar

(1450.38 psi)

For pressure testing of pipes, their valves and fittings and also for hose assemblies, refer Ch.2. Tightness tests shall be performed on relevant components.

1.6.3 Final inspection and operational test

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of a surveyor. The overload protection shall be adjusted at this time.

CHAPTER 7 FIRE SAFETY

CONTENTS

SECTION 1 FIRE-PROTECTION AND FIRE-EXTINGUISHING

Contents

1.1 General

1.1.1 Scope

1.1.1.1 These rules apply to fire-protection and fire- extinguishing.

1.1.1.2 For fire detection, refer Ch.5 Sec.1 Table 1.

1.1.2 Approval

Hoses, nozzles, fire-extinguishers, fire-detection and alarm systems, fire-protection equipment and extinguishing media shall be approved.

1.1.3 Documents for approval

Plans of the following equipment shall be submitted to the Society:

- general water fire-extinguishing systems
- CO_2 extinguishing systems
- other gas fire-extinguishing systems
- foam extinguishing systems
- fire-detection and alarm systems
- fire control plan

The plan shall clearly show for each deck the control stations, the various fire sections enclosed by class A and B divisions together with particulars of the fire-detection and alarm systems, the sprinkler installation, provided , 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.

1.1.4 Definitions

1.1.4.1 The term "Type Approval" is defined in Pt.1 Ch.1 Sec.1 [1.2.16].

1.1.4.2 Non-combustible material

Non-combustible material is a material which neither burns nor gives off flammable vapors in sufficient quantity for self-ignition when heated to approximately 750 °C (see Guidance note).

Remark:

Reference is made to the Fire Test Procedure Code, Annex 1, Part 1, adopted by IMO by Resolution MSC.61(67).

1.1.4.3 A-class divisions

A-class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

b) they are suitably stiffened

c) they are insulated with type approved 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 refer Guidance note)

Remark:

Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61(67).

1.1.4.4 **B-class divisions**

B-class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved 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 (284 °F)above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225 °C(437°F) 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 (refer Guidance note)

Remark:

Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution MSC.61(67)."

1.1.4.5 **Low flame spread surface material**

Low flame spread means that the surface thus described will adequately restrict the spread of flame (see Guidance note).

Remark:

Reference is made to the Fire Test Procedure Code, Annex 1, adopted by IMO by Resolution MSC.61(67).

1.1.4.6 **Not readily ignitable material**

Not readily ignitable materials means a material which will not give rise to smoke or toxic and explosive hazards at elevated temperatures (refer Guidance note).

Remark:

Reference is made to the Fire Test Procedure Code, Annex 1, , adopted by IMO by Resolution MSC.61(67).

1.2 Fire protection

1.2.1 Installation of boilers

Auxiliary and domestic boilers shall be arranged in such a way that other equipment is not endangered, even in the event of overheating. They shall, in particular, be placed as far away as possible from fuel tanks, lubricating oil tanks and hold bulkheads. Oil tight trays shall be located below oil-fired boilers.

1.2.2 Insulation of exhaust gas lines

See Ch.1 Sec.2 [2.6.4].

1.2.3 Emergency stops, remotely operated

Fuel pumps, fan motors and boiler fans shall be provided with emergency stops. The outlet valves of fuel service tanks shall be fitted with remotely operated shut-off devices. Emergency stops and remotely operated shut-off devices shall be capable of being operated from permanently accessible open deck and protected from unauthorized use.

1.2.4 Airtight seals

Means shall be provided for the airtight sealing of boiler, engine and pump rooms. The air ducts to these spaces shall be fitted with closing appliances or equivalent devices made of non-combustible material which can be closed from the deck. Engine room skylights shall also be able to be closed from outside.

1.2.5 Escapes

1.2.5.1 Every engine room shall be provided with two means of escape as widely separated as possible. One of the means of escape shall be an emergency exit. If a skylight is permitted as an escape, it shall be possible to open it from the inside.

1.2.5.2 The escape trunk shall have clear dimensions of at least 0.6 × 0.6 m.(1.96 x 1.96 Ft)

1.2.5.3 In case of engine rooms of less than 35 m^2 (376.73 Ft^2) one means of escape may be accepted.

1.2.5.4 At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

1.3 Fixed fire-extinguishing system design

1.3.1 Automatic pressure water spraying system (sprinkler system)

1.3.1.1 General

Alternative systems complying with recognized standards may subject to approval be accepted.

1.3.1.2 Pressure water tanks

Pressure water tanks shall 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.3 Sec.1 shall 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 shall be fitted with a connection to enable the entire system to be refilled with fresh water. The pressure water tank shall be installed in a frost proof space.

Means shall be provided for replenishing the air cushion in the pressure water tank.

1.3.1.3 Pressure water-spraying pumps

The pressure pumps may only be used for supplying water to the pressure water-spraying systems.

In the event of a pressure drop in the system, the pump shall start up automatically before the fresh water charge in the pressure water tank has been exhausted. Suitable means of testing shall be provided.

For vessels with non-EU flag, 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 $\ell/(m^2 \times min)$, this is equivalent to a minimum delivery rate of 375 ℓ/min.

For vessels with EU flag, the capacity of the pump shall be sufficient to cover the area of the greatest protected space.

The pump shall be provided with a direct suction connection at the vessel’s side. The shut-off device shall be secured in the open position. A suitable raw water filter shall be fitted, the mesh size of which is able to prevent coarse impurities from clogging the nozzles. The pump delivery shall be fitted with a test valve with connecting pipes, the cross-section of which is compatible with the pump capacity at the prescribed head.

1.3.1.4 Location

Pressure water tanks and pressure water pumps shall be located outside, and at a sufficient distance from, the rooms to be protected.

1.3.1.5 Water supply

The system shall be completely charged with fresh water when not in operation.

In addition to the water supply to the spraying equipment located outside the spaces to be protected, the system shall also be connected to the fire main via a screw-down non-return valve.

The equipment shall be kept permanently under pressure and shall be ready at all times for immediate, automatic operation. With the test valve at the alarm valve in the fully open position, the pressure at the level of the highest spray nozzles shall still be at least 1.75 bar.(25.38 psi)

1.3.1.6 **Power supply**

At least two mutually independent power sources shall be provided for supplying the pump and the automatic indicating and alarm systems. Each source shall be sufficient to power the equipment.

1.3.1.7 **Piping, valves and fittings**

Lines between suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in Ch.2 Sec.1 Table 5. Lines shall be effectively protected against corrosion.

Check valves shall 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 shall be provided at suitable points on the port and starboard sides for supplying the equipment with water from the shore. The connecting valves shall be secured against being opened unintentionally.

Each line leading to a section of the system shall be equipped with an alarm valve (refer also [3.1.9]).

Shut-off devices located between the pump delivery and the alarm valves shall be secured in the open position.

1.3.1.8 **Spray nozzles**

The spray nozzles shall 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 shall be so arranged in the upper deck area that a water volume of not less than 5 ℓ/ ($m^2 \cdot min$) is sprayed over the area to be protected.

Inside accommodation and service spaces the spray nozzles shall be activated within a temperature range from 68 °C to 79 °C (154.4°F to 174.2°F). This does not apply to spaces such as drying rooms with higher temperatures. Here the triggering temperature may be up to 30 °C (86°F) above the maximum temperature in the deck head area.

The nozzles shall be made of corrosion-resistant material. Nozzles of galvanized steel are not allowed.

1.3.1.9 **Indicating and alarm systems**

Every spray nozzle section shall be provided with an alarm valve which, when a nozzle is opened, actuates a visual and audible alarm at one or more suitable positions, at least one of which shall be permanently manned. In addition, each alarm valve shall 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 shall be mounted which identifies the actuated sprinkler section.

The electrical installation shall be self-monitoring and shall be capable of being tested separately for each section.

1.3.2 Fixed gas fire-extinguishing systems

1.3.2.1 General

Fire-extinguishing systems, inert gas systems, CO_2 systems, etc. shall be installed after agreement with the Society in accordance with the Society's rules.

Fire-extinguishing systems not dealt with in these Rules shall be in compliance with other Society's rules.

1.3.2.2 Application

The following requirements apply to 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.

1.3.2.3 Extinguishing agents

The following extinguishing agents are permitted:

a) CO_2 (carbon dioxide)

b) HFC 227 ea (heptafluoropropane) (FM 200)

c) IG-541 (52 % nitrogen, 40 % argon, 8 % carbon dioxide) (INERGEN)

d) FK-5-1-12 (dodecafluoro-2-methylpentan-3-one)

The fixed fire-extinguishing systems according to b) and c) 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 shall be type-approved by the Society as well.

1.3.2.4 **Ventilation, air extraction**

a) The combustion air required by the combustion engines which ensure propulsion should not come from spaces protected by permanently fixed fire-extinguishing systems. This requirement is not mandatory if the vessel has two independent main engine rooms with a gastight separation or if, in addition to the main engine room, there is a separate engine room installed with a bow thruster that can independently ensure propulsion in the event of a fire in the main engine room.

b) All forced ventilation systems in the space to be protected shall be shut-down automatically as soon as the fire-extinguishing system is activated.

c) All openings in the space to be protected which permit air to enter or gas to escape shall be fitted with devices enabling them to be closed quickly from outside the space to be protected. It shall be clear whether they are open or closed.

d) Air escaping from the pressure-relief valves of the pressurized air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.

e) Overpressure or negative pressure caused by the diffusion of the extinguishing agent shall not cause an unacceptable over- or under pressure in the space concerned. It shall be possible to ensure the safe equalization of pressure.

f) Protected spaces shall be provided with a means of extracting the extinguishing agent. If extraction devices are installed, it shall not be possible to start them up during extinguishing.

1.3.2.5 **Fire-detection system**

The space to be protected shall be monitored by an appropriate type-approved fire-detection system. The alarm signal shall be audible in the wheelhouse, the accommodation and the space to be protected.

1.3.2.6 **Piping system**

a) The extinguishing agent shall be routed to and distributed in the space to be protected by means of a permanent piping system. Piping installed in the space to be protected and the reinforcements it incorporates shall be made of steel. This shall not apply to the connecting nozzles of tanks and compensators provided that the materials used are fire-resistant and type approved. Piping shall be protected against corrosion both internally and externally.

b) The discharge nozzles shall be so arranged as to ensure the regular diffusion of the extinguishing agent, also below the floor plates.

1.3.2.7 **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:

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 shall be at least in a language the master can read and understand and if this language is not English, French or German, they shall be at least in English, French or German in addition.

They shall include information concerning:

— the activation of the fire-extinguishing system

— the need to ensure that all persons have left the space to be protected

— the correct behavior of the crew in the event of activation

— the correct behavior of the crew in the event of the failure of the fire-extinguishing system to function properly

f) The instructions shall mention that prior to the activation of the fire-extinguishing system, combustion engines installed in the space and aspirating air from the space to be protected shall be shut-down. All ventilation inlet and outlet openings shall be closed prior to the activation of the fire-extinguishing system.

1.3.2.8 **Alarm device**

a) Permanently fixed fire-extinguishing systems shall be fitted with an audible and visual alarm device.

b) The alarm device shall be activated automatically as soon as the fire-extinguishing system is first activated. The alarm device shall function for an appropriate period of time before the extinguishing agent is released; it shall not be possible to turn it off.

c) Alarm signals shall be clearly visible in the spaces to be protected and their access points and be clearly audible under operating conditions corresponding to the highest possible sound level. It shall be possible to distinguish them clearly from all other sound and visual signals in the space to be protected.

d) Sound alarms shall also be clearly audible in adjoining spaces, with the communicating doors shut, and under operating conditions corresponding to the highest possible sound level.

e) If the alarm device is not intrinsically protected against short circuits, broken wires and drops in voltage, it shall be possible to monitor its operation.

f) A sign with the following text in red letters on a white ground shall be clearly posted at the entrance to any space the extinguishing agent may reach:

WARNING, FIRE-EXTINGUISHING SYSTEM!

LEAVE THIS SPACE IMMEDIATELY WHEN THE … (DESCRIPTION) ALARM IS ACTIVATED!

1.3.2.9 **Pressurized tanks, fittings and piping**

a) Pressurized tanks, fittings and piping shall conform to the requirements of the competent authority.

b) Pressurized tanks shall be installed in accordance with the manufacturer's instructions.

c) Pressurized tanks, fittings and piping shall not be installed in the accommodation.

d) The temperature of cabinets and storage spaces for pressurized tanks shall not exceed 50 °C.(122°F)

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.

1.3.2.10 **Quantity of extinguishing agent**

If the quantity of extinguishing agent is intended for more than one space, the quantity of extinguishing agent available does not need to be greater than the quantity required for the largest of the spaces thus protected.

1.3.2.11 **Fire-extinguishing system operating with CO_2**

In addition to the requirements contained in [3.2.1] to [3.2.10], fire-extinguishing systems using CO_2 as an extinguishing agent shall conform to the following provisions:

a) Tanks of CO_2 shall be placed in a gastight space or cabinet separated from other spaces. The doors of such storage spaces and cabinets shall open outwards; they shall be capable of being locked and shall carry on the outside the symbol "Warning: danger", not less than 5 cm (1.96 Inch) high and "CO_2" in the same colours and the same size.

b) Storage cabinets or spaces for CO_2 tanks located below deck shall only be accessible from the outside. These spaces shall have a mechanical ventilation system with extractor hoods and shall be completely independent of the other ventilation systems on board.

c) The level of filling of CO_2 tanks shall not exceed 0.75 kg/ℓ. The volume of depressurized CO_2 shall be taken to be 0.56 m^3/kg.

d) The concentration of CO_2 in the space to be protected shall be not less than 40 % of the gross volume of the space. 85 % of this quantity shall be released within 120 seconds. It shall be possible to monitor whether diffusion is proceeding correctly.

e) The opening of the tank valves and the opening of the directional valve shall correspond to two different operations.

f) The appropriate period of time mentioned in [3.2.8] b shall be not less than 20 seconds. A reliable installation shall ensure the timing of the diffusion of CO_2.

1.3.2.12 **Fire-extinguishing system operating with HFC-227 ea (heptafluoropropane) - FM 200**

In addition to the requirements of [3.2.1] to [3.2.10], 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 over pressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.

c) Every tank shall be fitted with a device permitting control of the gas pressure.

d) The level of filling of tanks shall not exceed 1.15 kg/ℓ. The specific volume of depressurized HFC-227 ea shall be taken to be 0.1374 m^3/kg.

e) The concentration of HFC-227 ea in the space to be protected shall be not less than 8 % of the gross volume of the space. This quantity shall be released within 10 seconds.

f) Tanks of HFC-227 ea shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected.

g) After discharge, the concentration in the space to be protected shall not exceed 10.5 %(volume).

h) The fire-extinguishing system shall not comprise aluminum parts.

1.3.2.13 **Fire-extinguishing system operating with IG- 541**

In addition to the requirements of [3.2.1] to [3.2.10], 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 (2900.75 psi) at a temperature of +15 °C.(59 °F)

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.

1.3.2.14 **Fire-extinguishing system operating with FK- 5-1-12**

In addition to the requirements in Ch.1, Ch.2, Ch.3, Ch.5, Ch.6 and Ch.7, 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).

1.4 General water fire-extinguishing system

1.4.1 Fire pumps

1.4.1.1 Self-propelled vessels shall be equipped with a power-driven pump suitable for use as a fire pump.

1.4.1.2 The capacity of the fire pump, acting through fire mains and hoses, shall be sufficient to project at least one jet of water to any part of the vessel. This shall be based on a length of throw of 12 m (39.37 Foot) from a 12 mm (0.47 Inch) diameter nozzle.

The minimum pump capacity shall be 10 m^3/h.

1.4.1.3 The pump shall have a drive independent of the main propulsion unit. On vessels with a gross volume (L · B · D) of up to 800 m^3 or with a propulsive power of up to 350 kW, a bilge pump or cooling water pump coupled to the main engine may also be used provided that the propeller shafting can be disengaged.

1.4.1.4 Combined ballast pumps, bilge pumps or other pumps exclusively pumping water may be accepted as fire pumps and shall be connected to the fire main by means of a non-return valve.

1.4.1.5 Fire pumps shall be located aft of the forward collision bulkhead.

1.4.1.6 Outboard connections for fire pumps shall be located as deep as possible. Pump suction shall be safeguarded even in lightship condition.

1.4.2 Fire mains and hoses

1.4.2.1 Fire mains shall 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 (65.61 Foot). At least three hydrants shall be provided.

For vessels less than 40 m (131.23 Foot) in length, at least two hydrants shall be provided. Deck-washing lines may be incorporated in the fire-extinguishing system.

1.4.2.2 Hoses shall be able to be connected to the fire mains via fire hydrants and quick couplings.

1.4.2.3 At least two hoses with dual purpose nozzles shall be provided. These shall be stowed in hose boxes placed close to the hydrants.

Hose boxes shall be properly marked. Hose wrenches shall be provided in every hose box.

1.4.3 Water fire-extinguishing systems for vessels without self-propulsion

Where a water fire-extinguishing system is provided on a vessel without self-propulsion, the requirements set out in [4.1] and [4.2] shall be applied as appropriate.

1.5 Portable fire-extinguishers

1.5.1 Extinguishing media and weights of charge

1.5.1.1 Fire-extinguishers shall have been type-approved, or approved by Authorities.

1.5.1.2 In the case of water and foam extinguishers, the charge shall not be less than 9 ℓ and not more than

13.5 ℓ.

The weight of the charge in dry powder extinguishers should be at least 6 kg. (13.22 Pound))The maximum weight of a portable fire extinguisher ready for use shall not exceed 20 kg. (44.09 Pound)

1.5.1.3 The extinguishing agent shall be suitable at least for the class of fire most likely to occur in the space (or spaces) for which the fire-extinguisher is intended.

On vessels with electrical installations having an operating voltage greater than 50 V, the extinguishing agent shall also be suitable for fighting fire in electrical equipment.

On motor vessels and vessels with oil-fired equipment, engine rooms and accommodation spaces shall be provided with dry powder extinguishers covering class A, B and C fires.

1.5.1.4 As extinguishing agent, fire-extinguishers may contain neither CO_2 nor agents capable of emitting toxic gases in use.

Nevertheless, CO_2 extinguishers may be used for galleys and electrical installations.

1.5.1.5 Fire-extinguishers with charges which are sensitive to frost or heat shall be mounted or protected in such a way that their effectiveness is guaranteed at all times.

1.5.1.6 Where fire-extinguishers are mounted under cover, the covering shall be properly marked.

1.5.2 Number of portable fire-extinguishers

1.5.2.1 One portable fire-extinguisher each shall 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 liquefiedgas
- 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

1.5.2.2 In the part of machinery spaces situated below deck and containing internal combustion engines, additional fire extinguishers shall be mounted in such a way that an extinguisher is accessible in the immediate vicinity of any part of the room.

The number of additional fire-extinguishers shall be as indicated in Table 2.

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

Table 2 Portable fire-extinguishers in machinery space

Total power [kW]	Number of fire- extinguishers
Over 100 up to 375	1
up to 750	2
over 750	1 further extinguisher for each additional 750 kW or part thereof