Polski Rejestr Statków

RULES
FOR THE CLASSIFICATION AND CONSTRUCTION OF NAVAL SHIPS

PART VIII

ELECTRICAL EQUIPMENT AND AUTOMATION

2008

GDAŃSK

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF THE NAVAL SHIPS prepared and edited by Polski Rejestr Statków S.A., hereinafter referred to as PRS, consist of the following Parts:

Part I – Classification Regulations
Part II – Hull
Part III – Hull Equipment
Part IV – Stability and Subdivision
Part V – Fire Protection
Part VI – Machinery Installations and Refrigerating Plants
Part VII – Machinery, Boilers and Pressure Vessels
Part VIII – Electrical Equipment and Automation
Part X – Statutory Equipment and Automation

while in respect to materials and welding *Part IX – Materials and Welding* of the *Rules for the Classification and Construction of Sea-Going Ships* applies.

Part VIII – Electrical Equipment and Automation is extended and complemented by the documents referred to in Part VIII, in particular by NATO standardisation agreements, national standards and by the below-listed Publications issued by PRS S.A.:

Publication No. 9/P – Requirements for Computer Based Systems,
Publication No. 15/P – Current Rating Tables for Cables, Wires and Busbars in Marine Installations,
Publication No. 25/P –
Publication No. 42/P – Testing of Electric Machines.
Publication No. 75/P – Environmental Tests o Naval Ship Equipment

Part VIII – Electrical Equipment and Automation, 2005, was approved by the PRS Board on ... and enters into force on ....
From the entry into force, the requirements of *Part VIII – Electrical Equipment and Automation* apply, in full, to new naval ships.

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CONTENS

Page

1 GENERAL PROVISIONS

1.1 Application

1.1.1 *Part VIII – Electrical Equipment and Automation* applies to electrical installations and automatic systems in naval ships subject to PRS supervision as well as to individual types of equipment, systems and their components in accordance with 1.3.

1.1.2 The relevant requirements of the *Part VIII* are recommended to be also extended to cover electrical equipment installed in naval ships, although not specified in 1.3.2 and 1.3.3.

1.1.3 PRS may accept other arrangements of electrical systems, which considers equivalent to the arrangements specified in *the Rules* or which conform to the requirements specified for Marine Navy, e.g. STANAG 1008. Electrical systems of small naval ships e.g. those having gross tonnage up to 300 t as well as of naval ships which can be assigned restricted navigation or special navigation mark in the symbol of class, may be subject to separate consideration by PRS.

1.2 Definitions

Definitions related to the general terminology of *the Rules for the Classification and Construction of the Naval Ships* (hereinafter referred to as *the Rules*) are given in *Part I – Classification Regulations*. Where definitions explained in other parts of the Rules are used in *Part VIII*, reference to relevant parts has been made.

In Part VIII the following additional definitions have been applied:

Alarm system – the system intended to give warnings of conditions when deviations from the preset limits on the selected parameters or changes in normal working conditions occur.

Automated machinery – an engine, machinery, installation or other devices equipped with automatic or remote control systems.

Automatic control system – the system intended to control the machinery without human interference according to the specified control function.

Automatic system – a defined number of components, units and their connections forming structural and functional integrity, intended to perform control and monitoring functions.

Component of automatic system – the simplest and functionally self-independent structural item used in automatic systems (e.g. relay, resistor, logic element, sensor, final control element).

Earthing – metallic connection of equipment terminal with the ship's metal hull or metal plate fitted to the hull and defined in Chapter 22.

Emergency lighting – lighting of the naval ship's compartments and spaces by means of lighting fixtures fed from the emergency source of power or from the transitional source of emergency electric power.

Emergency source of electric power – a source of electric power intended to supply emergency switchboard for distribution of power to all the essential consumers onboard the naval ship in the case of loss of voltage in the main switchboard busses.

Emergency switchboard– a switchboard which, in the case of the loss of voltage in the main switchboard busbars, is directly supplied from emergency source of electric power or from transitional source of emergency electric power and is intended to distribute power to consumers which are necessary to maintain safety of the naval ship during emergency.

Essential equipment – equipment which, under normal operation, ensures safe navigation, safety of equipment and safety of human life on board the ship.

Fire-retardant insulating material– material satisfying the requirements specified in *Publication No. 75/P – Environmental Tests on Naval Ships Marine Equipment*.

Indicating system – the system intended to indicate values of given physical quantities or significant states.

Lightning conductor – conductor, which ensures connection of spike with earthing.

Lightning protection zone – zone protected against direct lightning stroke.

Low-rated electrical installation – a shipboard electrical installation with the total output of sources of electric power not exceeding 50 kVA (kW).

Machinery space – see sub-chapter 1.1, *Part V – Fire Protection*.

Main generating station – a space where the main source of electrical power is situated.

Main source of electric power – a source intended to supply electric power to the main switchboard for distribution to all services necessary for maintaining the naval ship in normal operational and combat conditions as well as for ensuring appropriate habitable conditions.

Main switchboard – a switchboard, which is directly supplied by the main source of electric power and is intended to distribute electric power to the naval ship's services.

Monitoring systems – general term for alarm, safety and indicating systems.

Remote control system – the system intended to affect remotely the machinery in order to achieve control function given by the operator.

Safe voltage – any voltage not causing potential danger of electric shock or burn in normal conditions. This condition is considered to be satisfied if the windings of transformers, converters and other devices stepping down voltage are isolated electrically, and if the value of the stepped-down voltage across these devices or sources of electric power does not exceed:

– 50 V between conductors for direct current;
– 50 V between conductors or between the hull and the phase for alternating current.

Safety system – the system intended to intervene in a specific way upon the machinery controlled in order to prevent the failure of machinery or enlargement of its consequences.

Shaft generators – generators driven by the ship main propulsion plant and supplying the naval ship power network or individual consumers onboard the ship.

Special electrical spaces– spaces or locations intended exclusively for electrical equipment and accessible only for authorised personnel.

Spike – the upper part of the lightning conductor designed for the direct receiving of lightning strokes.

Transitional source of emergency electric power – a source of electric power intended to supply all the essential consumers from the moment the loss of voltage occurs in the main switchboard busbars until the emergency generating set picks up the load.

Unit of automatic system – part of the automatic system consisting of a certain number of components forming structural and functional integrity.

1.3 Scope of Supervision

1.3.1 General Provisions

The general provisions relating to the classification procedure, supervision during naval ship construction, manufacture of equipment and to surveys, are given in *Part I – Classification Regulations.*

1.3.2 Supervision of Electrical Installation in a Naval Ship

1.3.2.1 The following types of equipment and systems are subject to PRS supervision during installation onboard:

.1 electrical propulsion plant:
.2 main and emergency, including transitional, sources of electric power;
.1 transformers supplying equipment listed in 1.3.2.1 and electric power converters;

.2 distribution gear and control and monitoring panels;
.3 emergency supply network
.4 electric drives for:
- machinery essential for the operation of propulsion engines,
- steering gear and all devices for active steering of the naval ship,
- controllable-pitch propellers,
- windlasses, mooring and towing winches,
- boat winches,
- starting air compressors and air compressors for sound signals,
- bilge and ballast pumps;
- watertight doors and fire doors,
- pumps and compressors of the smothering system,
- ventilating fans in machinery spaces, cofferdams, explosion hazardous spaces,

.5 main and emergency lighting of spaces and locations of essential machinery and means of escape;
.6 navigation lights and signalling lamps;
.7 electric engine-room telegraphs;
.8 internal service communication;
.9 general alarm system;
.10 fire detection signalling and warning system indicating the smothering system operation;
.11 watertight door and fire door signals;
.12 electrical equipment in explosion hazardous rooms and spaces;
.13 cabling;
.14 earthing devices;
.15 lightning conductors;
.16 electrical heaters of fuel and lubricating oil;
.17 heating appliances and space heaters;
.18 main propulsion control system;
.19 main propulsion safety system;
.20 automatic control system for generating sets;
.21 safety system of engines driving generating sets;
.22 automatic system of pumps and air compressors;
.23 automatic system of oil and fuel separators;
.24 remote or automatic control system of bilge, ballast and fuel transfer installations;
.25 machinery alarm system;
.26 control system of steam boilers;
.27 system regulating temperature, pressure and viscosity;
.28 naval ship dynamic positioning system;
.29 other machinery and facilities not listed above, as required by PRS.

1.3.2.2 The classification survey of PRS onboard the naval ship covers such automatic systems, which control or monitor machinery, equipment or installations subject to PRS supervision in accordance with the provisions of the relevant Parts of the *Rules.*

1.3.2.3 Electrical equipment intended for domestic and living application is to be supervised by PRS within the following scope:

.1 influence of this equipment operation on the ship's electric network parameters;
.2 choice of cable types, cable sections and the ways of running the cables;
.3 means of protection, insulation and earthing condition.

1.3.3 Supervision of Manufacture of Electrical Equipment

1.3.3.1 The following items of electrical equipment intended for systems and devices specified in 1.3.2.1 are subject to PRS supervision during manufacture:

.1 generating sets;
.2 generators and electric motors of rating 100 kVA (kW) and above;
.3 transformers above 3 kVA rating;
.4 switchboards;
.5 control and monitoring panels;
.6 electric couplings and brakes;
.7 switchgear, protection and control devices;
.8 apparatus and devices of internal communication and signalling;
.9 rotary converters and power-electronic equipment;
.10 fuel and oil heaters;
.11 accumulators;
.12 cables;
.13 heating appliances and space heaters;
.14 photoluminescent materials and electrically powered lights of low-location lighting;
.15 lamps of additional emergency lighting;
.16 automatic pilots;
.17 public address system and general alarm systems;
.18 computers and programmable logic controllers;
.19 sensors and transducers;
.20 automation system controllers;
.21 power operated valves;
.22 servo-motors;
.23 electric, hydraulic and pneumatic relays;
.24 data loggers (if they perform functions covered by the *Rules*);
.25 other items of electrical equipment not listed above, as required by PRS.

1.3.3.2 Each item of explosion-proof electrical equipment is to be supervised by a special body recognised by PRS for this purpose, irrespective of whether or not this equipment is subject to supervision according to the requirements specified in 1.3.3.1.

1.3.3.3 Test programme for electrical equipment will be specially considered by PRS in each particular case and the values of the relevant test parameters are given in Appendix 2.

1.4 Technical Documentation of a Naval Ship

1.4.1 Classification Documentation of a Naval Ship under Construction

1.4.1.1 Prior to the commencement of the naval ship construction, documentation mentioned in 1.4.1.2 and 1.4.1.3 is to be submitted to the PRS for consideration and approval.

1.4.1.2 Classification documentation of electrical equipment:

- **.1** principle diagrams of power generation and distribution circuits of the main and emergency electric power sources (up to branch circuit board);
- **.2** specification of data on the circuits with indication of current values, the applied protective devices, as well as the types and cross-sectional areas of cables;
- **.3** principle diagrams and a general view of the main and emergency switchboards, ship's navigation control and monitoring console, navigation light tables and other devices of non-standard design;
- **.4** calculation results of electric power plant output necessary to provide operation of the ship in conditions specified in 3.1.6, as well as the basis for the choice of the number and output of generators and the calculation of power of electric power emergency sources;
- **.5** emergency supply network diagrams;
- **.6** principle or detailed diagrams of main, excitation, control, monitoring, signalling, protection and interlocking circuits of the ship's electric propulsion plant machines;
- **.7** calculation results of the ship's electric propulsion plant generators output necessary to provide operation in all conditions;
- **.8** calculation results of short-circuit currents on the main switchboard busbars and in the other points of power network – as the basis for the choice of switching and protecting apparatus of generators and consumers, as well as for checking electrodynamic and thermal loads to which distributing devices, apparatus, wiring and busbars of main switchboard and other distribution equipment are to correspond – together with the selection of protective devices;
- **.9** results of calculation of illumination intensity for important compartments and open locations, for information;
- **.10** diagrams of internal communication and signalling;
- **.11** principle diagrams of essential electric drives according to 1.3.2.1.5;

.12 diagram of lubricating and air cooling systems of main propulsion electric motors;
.13 diagrams of protective earthing, drawings and if necessary, calculation of lightning conductors;
.14 principle diagram of cable passages with indication of compartments through which they pass;
.15 results of capacity calculations of accumulator batteries supplying emergency lighting, navigation lanterns, general alarm and fire detection systems;
.16 data on electrical equipment in spaces where explosion hazard exists;
.17 diagrams of remote switching-off ventilation, fuel pumps and lubricating pumps;
.18 arrangement plans of main and emergency generators, main and emergency switchboards, accumulator batteries, equipment of explosion-proof design.
.19 calculation results for expected voltage deviations in case of fitting power-electronic equipment onboard.

1.4.1.3 Classification documentation of shipboard automated machinery:
.1 technical description including: specification of parameters covered by alarm, safety and automatic control systems, information concerning continuity of lubrication of cylinders and machinery of main engine, supply of fuel, steam, etc. and other means necessary for execution of unattended operation, as well as accepted method of repair and maintenance of particular units or elements of automatic systems, data concerning reliability of particular systems and/or their units;
.2 functional diagrams of particular automatic systems, equipment, machinery and installations, as well as information concerning: method of supply, functional features, structure, connections with other systems as well as the kind and limit values of parameters monitored by these systems;
.3 drawings of particular units of automatic systems such as desks, consoles, showing their elevation and arrangement of internal components, as well as their location and arrangement onboard the naval ship;
.4 in the case of applying computer systems for control or checking the machinery and installations, the above documentation is to be supplemented according to 1.4 of *Publication No. 9/P – Requirements for Computer Based Systems*.

1.4.2 Workshop Documentation of a Naval Ship under Construction

The following workshop documentation is to be submitted to PRS for agreement:
.1 drawings of cabling and cable fastening, including emergency supply cables;
.2 diagrams of final circuits of emergency switchboard and emergency lighting;

.3 diagrams of final circuits of lighting switchboards;
.4 programme for mooring test and sea trials of ship's electrical equipment and automated machinery.

1.4.3 Classification Documentation of a Naval Ship under Modernisation

1.4.3.1 Prior to the commencement of modernisation of a naval ship, documentation relating to installations, systems and equipment subject to modernisation is to be submitted to the PRS for consideration and approval.

1.4.3.2 Where new machinery or arrangements covered by the requirements of the *Rules*, which differ substantially from those initially fitted, are installed, additional documentation of the arrangements and associated systems, within the scope required for a naval ship under construction, is to be submitted to the PRS for consideration and approval (see 1.4.1).

1.5 Technical Documentation of Equipment

1.5.1 Prior to the commencement of supervising the manufacture of electrical equipment, the following documentation is to be submitted to PRS for consideration:

.1 description of the principle of operation and the basic particulars;
.2 material specification which is to contain elements, instruments and materials used and their technical characteristics;
.3 assembly drawing with sections;
.4 circuit diagram;
.5 technical specifications and the test programme;
.6 the rotor shaft mechanical strength calculations, drawings of poles and commutator fastenings for machines of rating 100 kW (kVA) and above;
.7 for distribution switchboards – calculation of thermal and electrodynamic strength of busbars under short-circuit conditions and the choice of apparatus to fit these conditions where the current rating of a generator or generators running in parallel exceeds 1000 A;
.8 for generating sets – selection of output of internal combustion engine for generator, list of sensors and their limit values, as well as calculation of torsional vibrations;
.9 for power-electronic systems, calculations concerning selection of short-circuit, overload and overvoltage protection as well as the naval ship power network interference;
.10 data on static or dynamic interference resistance, means of interference damping and the means of testing the electro-magnetic compatibility;

Where necessary, PRS may require that additional documentation and data on equipment reliability should be submitted.

2 GENERAL REQUIREMENTS

2.1 Operating Conditions

When designing, selecting and arranging electrical equipment, the operating conditions specified in 2.1.1 ÷ 2.1.4 are to be taken into account.

2.1.1 Climatic Hazards

2.1.1.1 The temperature values specified in Table 2.1.1.1 are to be taken as the rated ambient air and cooling water temperatures for electrical equipment.

Table 2.1.1.1

No.	Location in the ship	Ambient air and cooling water temperature, [°C]			
		Unrestricted service		Service outside the tropic	
		air	water	air	water
1	Machinery spaces, special electrical spaces, galleys	from 0 to 45	30	from 0 to 40	25
2	Open decks and spaces	from –25 to 45	–	from -25 to 40	–
3	Other spaces	from 0 to 40	–	from 0 to 40	–

Notes:

1) For electrical machines located in machinery room, maximum air temperature equal to +50 °C is to be accepted.

2) Electronic equipment and components intended to be installed in switchboards, desks and enclosures are to be capable of correct operation at the ambient air temperature of up to 55 °C. The temperature of up to 70°C should not cause damage to components, equipment and systems.

2.1.1.2 Electrical equipment is to be capable of correct operation at a relative air humidity of 75 ± 3 per cent and a temperature of + 45 ± 2 °C or at a relative air humidity of 80 ± 3 per cent and a temperature of + 40 ± 2 °C or at a relative air humidity of 95 ± 3 per cent and a temperature of + 25 ± 2 °C.

2.1.1.3 The structural parts of electrical equipment are to be made of materials resistant to sea air or reliably protected against its effects.

2.1.2 Mechanical Hazards

2.1.2.1 Electrical equipment is to be capable of correct operation at vibrations with a frequency of 2 Hz to 100 Hz, as follows:

– at a frequency from 2 Hz to 13.2 Hz with displacement amplitude ± 1.5 mm;
– at a frequency from 13.2 Hz to 100 Hz with acceleration amplitude ± 10 m/s^2.

Electrical equipment intended to be installed in locations in which specific severe vibration conditions prevail (e.g. internal combustion engines, compressors) or to be installed in the steering gear compartment is to be capable of correct operation at vibrations with a frequency of 2 Hz to 200 Hz, as follows:
– at a frequency from 2 Hz to 28 Hz with displacement amplitude ± 1.5 mm;
– at a frequency from 28 Hz to 200 Hz with acceleration amplitude ± 50 m/s^2.

2.1.2.2 Electrical equipment is to be capable of reliable operation with the ship continuously inclined from the normal up to 15° transversely and up to 5° of trimming, as well as with the ship rolling up to 22.5° with the period of rolling of 10 sec. or pitching up to 10°.

Emergency equipment is also to be capable of functioning reliably with the ship continuously inclined up to 22.5° transversely or up to 10° of trimming, or within the same limits of both transversely and longitudinally inclining occurring at the same time.

2.1.2.3 Electrical equipment is to have adequate mechanical strength and is to be so located that it is not exposed to a risk of mechanical damage (see also 2.6.4).

2.1.3 Power Supply Parameters

2.1.3.1 Electrical equipment is to be so designed that it remains operative under steady conditions in all cases, at all deviations from the rated supply voltage and frequency specified in Table 2.1.3.1 (see also 3.1.2.2, 10.8.2, 14.1.3.2 ÷ 14.1.3.5 and 16.8.3.3).

Table 2.1.3.1

Parameter	Deviations from rated values		
	Prolonged, [%]	Transient	
		Value, [%]	Time, [s]
Voltage	+ 6 to – 10	± 20	1.5
Frequency	± 5	± 10	5

Note: Where the source of power supply is an accumulator battery, the following prolonged deviations of voltage are to be taken:
– from +30% to –25% for equipment connected to the battery during charging;
– from +20% to –20% for equipment not connected to the battery during charging.

2.1.3.2 It is recommended that quality and integrity of power supply in naval ships comply with the requirements of STANAG 1008.

2.1.4 Electromagnetic Interference

2.1.4.1 Electrical and electronic shipborne equipment is to be resistant to the following electromagnetic interference:

.1 electrostatic discharge;

.2 radiated electromagnetic field;
.3 fast transient interference;
.4 conducted radio frequency interference;
.5 surge voltage immunity;
.6 conducted audio frequency interference.

Testing parameters are specified in *Publication No. 75/P – Environmental Tests of the Naval Ships Marine Equipment*.

2.1.4.2 Ship's electrical and electronic equipment is not to emit excessive electromagnetic, radiated and conducted interferences.

Testing parameters are specified in *Publication No. 75/P – Environmental Tests of the Naval Ships Equipment*.

2.1.4.3 For the purpose of protecting the radio receiving equipment from electrical interference, the requirements given in Chapter 5 of *Part X – Statutory Equipment and Requirements* are to be taken into account.

2.1.4.4 Screens of power cables, metal coating and armouring of cables are to be earthed as often as practicable at least at the points of their connections and at each end, connecting them to the metal enclosures of electrical equipment and to the ship's hull.

2.1.4.5 All signal, control and measurement cables are to be screened. Metallic screens of these cables are to be earthed appropriately to the number of screens. In the case of using double-screened cables and occurrence of high-frequency field interference, internal and external screens are to be earthed on both sides and connected to equipment earthing. Internal cable screens may be earthed on one side if low frequency interference occurs. The above-mentioned principles do not concern screened concentric cables.

2.1.4.6 In all cases, the electrical continuity of all cable sheaths is to be provided, i.e. in cable junction and connecting boxes, as well as at the point of cable penetration of bulkheads.

2.1.4.7 Conductors which earth cable screens may be directly connected to the earthing bus, if any, of switchboard or directly to ship's metallic hull.

2.1.4.8 To prevent contacts with the ship's hull, screens of signal and measurement conductors are to be covered with an insulated outer sheath.

2.1.4.9 The screens and enclosures of electrical equipment placed on the main command station/ navigation bridge are to be earthed.

The screens of cables and flexible cords are also to be earthed in accordance with 2.4.3.5.

The screens and enclosures of electrical equipment, which do not generate radio interference need not be earthed, provided the electrical equipment itself does not require protective earthing.

2.1.4.10 It is recommended to use screened cables with pair or multipair twisted wires, in order to increase their resistance to electromagnetic interference.

2.1.4.11 When installing electrical equipment and cables in the vicinity of magnetic compasses, the requirements given in Chapter 5 of *Part X – Statutory Equipment and Requirements* are to be complied with.

2.1.4.12 Telephone cables and cables of other internal communication systems, except for the cables connecting separate telephone sets, as well as cables of electrical medical equipment capable of generating radio interference, are to be screened.

2.1.4.13 In ships constructed of non-current-conducting materials where radio equipment installation is required, all cables installed within the radius of 9 m from antenna are to be screened or protected against interference by other means.

2.2 Materials

2.2.1 Construction Materials

2.2.1.1 The structural parts of electrical equipment are to be made of metal or at least of hardly combustible insulating materials, resistant to sea air and oil vapour effects, or they are to be reliably protected against such effects.

2.2.1.2 Screws, nuts, hinges and similar items designed to fasten enclosures of the electrical equipment to be installed on weather decks or in spaces with higher than normal humidity are to be made of corrosion-resistant materials or are to have effective corrosion-resistant coating.

2.2.1.3 All current-carrying parts of electrical equipment are to be made of copper, copper alloys or other materials of equivalent qualities, with the exception of:

.1 rheostat elements which are to be made of mechanically strong materials having high resistivity and capable of withstanding high temperature;

.2 rotor cages windings of asynchronous and synchronous motors, which can be made of aluminium or its alloys resistant to sea weather;

.3 carbon brushes and rings, cermet contacts and similar parts when the properties specified so require;

.4 parts of electrical equipment connected directly to the hull used as return conductor in one-wire system.

The use of other materials for current-carrying parts will be specially considered by PRS in each particular case.

2.2.2 Insulating Materials

2.2.2.1 Insulating materials of live parts are to have adequate dielectric and mechanical strength, resistance to creeping currents, moisture and oil vapour or else they are to be suitably protected against effect of these factors.

At the rated load, the temperature of the current-carrying parts and the points of their connections is not to be greater than the permissible temperature of the applied insulating material.

2.2.2.2 Uninsulated parts of electrical equipment are to be cooled by incombustible liquids and gases only.

2.2.2.3 The insulating materials to be used for winding insulation in machines, apparatus and other equipment for essential services are to be those specified in Table 3.1 of Appendix 2.

The use of insulating materials of at least Class E is recommendable.

2.2.2.4 Conductors used for internal connections in electrical devices are to have insulation made of materials rated at least as hardly combustible. For apparatus with increased heating, as well as those specified in Chapter 15 – of incombustible materials.

2.2.2.5 Insulating materials used for manufacturing cables are to comply with the requirements given in 16.3.

2.3 Design Requirements and Degrees of Enclosures Protection

2.3.1 General Requirements

2.3.1.1 Parts, which may require replacement while in service, are to be easily dismountable.

2.3.1.2 Where screw fastenings are employed, measures are to be taken to exclude self-loosening of screws and nuts or, where dismantling and opening are at frequent occurrence, loss of some.

2.3.1.3 Gaskets used in conjunction with electrical equipment components (such as doors, covers, sight holes, packing glands, etc.) are to be appropriate to the degree of enclosure protection of the equipment in service.

Gaskets are to be secured to the covers or casings.

2.3.1.4 Enclosures, shields and covers of electrical equipment installed in places accessible to unauthorised persons, protecting against access to live parts, are to be capable of being opened only with the use of tools.

2.3.1.5 Water drainage arrangements are to be provided in electrical equipment where condensation is likely to occur. Channels are to be fitted inside the equipment to ensure condensate drainage from all equipment components. Windings and live parts are to be so arranged or protected that they are not exposed to the effect of condensate which may accumulate inside the equipment.

2.3.1.6 When oil, steam or water are led to the measuring instruments used in the control desk or in the switchboard, it is necessary to undertake the preventive measures in order not to allow oil, steam or water to penetrate the live parts of the electrical equipment in case of damage of the measuring instruments or pipes.

2.3.2 Insulation Clearances

2.3.2.1 Clearances between live parts of different potentials, or between live parts and earthed metal parts or an outer enclosure, both in the air and across the insulant surface, are to be in accordance with the operating voltage and operating conditions of the installation, the properties of the insulating materials used being taken into account.

2.3.3 Internal Connections

2.3.3.1 Stranded conductors are to be used for all the internal wiring in electrical equipment. The use of single-wire conductors will be specially considered by PRS in each particular case.

2.3.3.2 The conductors to be used for the internal wiring switchboards, control and monitoring desks and other distribution and switching gear are to have the cross-sectional area of not less than 1 mm^2. For control, protection, measurement of parameters, signalling and internal communication circuits, conductors with cross-sectional area of not less than 0.5 mm^2 may be used.

For electric and electronic circuits transforming and transmitting low-current signals, conductors with cross-sectional area of less than 0.5 mm^2 may be used, which will be specially considered by PRS in each particular case.

2.3.3.3 Current-carrying parts are to be so attached as not to transmit any additional mechanical stresses; such parts are not to be attached by means of screws fitted directly into insulating materials.

2.3.3.4 Stranded cores, cables and conductors are to have their ends fitted out to suit the type of terminal used, or are to be provided with lugs.

2.3.3.5 The method used for insulated conductors attachment and arrangement should not lead to reduced insulation resistance and not to make them exposed to damage due to short-circuit electrodynamic loads or dynamic loads caused by vibrations or shocks.

2.3.3.6 The connection of insulated conductors to terminals and busbars is to be so effected that, under rated operating conditions, the insulation of conductors is not exposed to overheating.

2.3.4 Degrees of Enclosure Protection

2.3.4.1 Electrical equipment is to be provided with appropriate protective enclosures ensuring degree of protection conforming to *PN-EN 60529* Standard and depending on their location or other suitable measures are to be taken to protect the equipment from a harmful effect of the environment and to protect the personnel from electric shock hazards.

2.3.4.2 The minimum degree of enclosure protection of electrical equipment installed in rooms and spaces of the naval ship is to be chosen in accordance with Table 2.3.4.2.

Table 2.3.4.2

No.	Place of electrical equipment location (examples)	Conditions in equipment location	Design according to degree of protection
1	2	3	4
1 2 3 4 5 6	Ammonia plant rooms (refrigerating machinery) Accumulator battery rooms Paint storerooms Stores for welding-gas bottles Storerooms of other materials classified as explosion-hazardous Tunnels for pipes containing flammable liquid with a flash-point of 60°C or below	Danger of explosion	Certified safe-type (see 2.8)
7 8	Dry accommodation spaces Dry control rooms	Danger of touching live parts	IP20
9 10 11 12 13 14 15 16	Rooms on the bridge Engine and boiler rooms above floor Steering gear rooms Refrigerating machinery rooms (excluding ammonia plants) Emergency machinery rooms General store rooms Pantries Provision rooms	Danger of dripping liquid and/or moderate mechanical damage	IP22
17	Bathrooms and showers	Increased danger of liquid occurrence and/or mechanical damage	IP34
18 19 20 21 22 23	Engine and boiler rooms below floor Closed fuel oil separator rooms Closed lubricating oil separator rooms Ballast pump rooms Refrigerated rooms Galleys and laundries	Increased danger of liquid occurrence and mechanical damage	IP44

1	2	3	4
24 25	Shaft or pipe tunnels in double bottom Holds	Danger of liquid spraying. Presence of cargo dust Danger of serious mechanical damage Aggressive fumes	IP55
26	Open decks	Danger of occurrence of liquid in massive quantities	IP56

Notes:

1) Where the protection is not achieved by the equipment enclosure itself, other means or equipment location, shall ensure the degree of protection required in the Table.

2) For spaces other than defined in the Table, the required degree of protection is to be each time agreed with PRS.

2.4 Earthing of Non-current-carrying Metal Parts

Metal enclosures of electrical equipment designed for higher than the safety voltage, having no double or reinforced insulation, are to be fitted with an earth terminal marked with the symbol ⏚

Depending on the purpose of the electrical equipment, provision is to be made for its earthing from inside or from outside.

2.4.1 Parts Subject to Earthing

2.4.1.1 The metal parts of electrical equipment which are likely to be touched under service conditions and which may become live in the event of damage to the insulation (except those mentioned in 2.4.1.2), are to have a reliable electric contact with a component fitted with an earth terminal connected efficiently to the ship's hull (see also 2.4.3).

2.4.1.2 Protective earthing against electric shock hazard is not required for:

- **.1** electrical equipment supplied with current at safety voltage;
- **.2** electrical equipment provided with double or reinforced insulation;
- **.3** metal parts of electrical equipment fastened in an insulating material or passing through it and isolated from the earthed and live parts in such a manner that under normal operating conditions these parts cannot happen to be live or get in contact with the earthed parts;
- **.4** cages of specially insulated bearings;
- **.5** lamp bases, lamp holders and fasteners for luminescent lamps, lamp shades and reflectors, covers fastened to lamp holders or to lighting fixtures made of an insulating material or screwed into such a material;
- **.6** cable hangers and brackets;
- **.7** single sets of 250 V supplied by a separating transformer.

2.4.1.3 The screens and metal sheaths of cables are to be earthed.

2.4.1.4 The secondary windings of all measuring current and voltage transformers are to be earthed.

2.4.2 Earthing of Aluminium Superstructures in Steel Naval Ships

Superstructures made of aluminium alloys fastened to the ship's steel hull, but insulated from it, are to be earthed with a special conductor having a cross-section not less than 16 mm^2 which is to be corrosion-resistant and such that will not cause electrolytic corrosion at the point of contact of the superstructure with the hull. Such earthing connections are to be effected with at least two conductors provided at different locations situated opposite each other, accessible for inspection and suitably protected from damage.

2.4.3 Earthing Terminals and Earthing Wires

2.4.3.1 Bolts for fastening the earthing wire to the ship's structure are to have a diameter not less than 6 mm; only for fastening wires with a cross-section of up to 2.5 mm^2 and wires with cross-section of up to 4 mm^2, bolts of 4 mm and 5 mm in diameter, respectively, may be used.

These bolts are not to be used for other purposes than fastening the earthing wires. Bolts, which are screwed to a material, are to be made of brass or other corrosion-resistant material.

The surface of ship's structure to which the earthing wire is connected is to be metallically clean and adequately protected against corrosion.

2.4.3.2 Fixed electrical equipment is to be earthed by means of external earthing wires or an earthing conductor in the feeding cable.

If earthing is made by means of one of the cores of the feeding cable, the core is to be connected to the earthed part of the equipment inside its enclosure. Special earthing need not be provided if the fastening of equipment ensures reliable electrical contact between the equipment enclosure and the ship's hull under all operating conditions.

For the purpose of earthing effected with an external earthing wire, copper wire is to be used. Wire of any other corrosion-resistant metal may also be used, provided the resistance of this wire does not exceed that of the required copper wire.

The cross-section of copper earthing wire is not to be less than that specified in Table 2.4.3.2.

Table 2.4.3.2

Cross-section of cable connected to the appliance, mm^2	Minimal cross-section of external earthing conductor of fixed equipment, mm^2	
	Single-wire conductor	Multi-wire conductor
Up to 2.5	2.5	1.5
Over 2.5 to 120	Half the cross-section of a cable conductor connected, but not less than 4	
Over 120	70	

For the earthing effected with a special core in the feeding cable, the cross-section of this core is to be equal to the nominal section of the feeding cable core for cables up to 16 mm^2 and is to be equal to at least half the cross-section of the feeding cable core, but not less than 16 mm^2 for cables having a cross-section over 16 mm^2.

2.4.3.3 Earthing of the movable and portable appliances is to be effected through the earthed jack of a socket outlet or through other earthed connecting elements and the earthed copper core of the feeding cable.

Cross-section of the earthing core is not to be less than the nominal cross-section of the core in the flexible feeding cable for cables up to 16 mm^2 and at least half the cross-section of the core in the flexible feeding cable, but not less than 16 mm^2 for cables over 16 mm^2.

2.4.3.4 Earthing wires or earthing conductors of cables in fixed equipment are not to be disconnected.

2.4.3.5 Earthing of screens and metal sheaths of cables is to be effected by one of the following methods:

.1 by a copper earthing wire having a cross-section not less than 1.5 mm^2 for cables with a cross-section up to 25 mm^2 and not less than 4 mm^2 for cables with a cross-section over 25 mm^2;

.2 by a suitable fastening of the metal sheath or armour of cables to the metal hull of the ship;

.3 by means of rings in the cable glands, provided they are corrosion-resistant, well conducting and resilient.

The earthing is to be effected at both ends of a cable, except cables in final sub-circuits, which are permitted to be earthed on the supply end only. Where the methods specified above cause failures in the equipment operation, the screens, metal sheaths and armour of cables may be earthed by other approved means.

2.4.3.6 The external earthing wires are to be accessible for inspection and are to be protected against getting loose and against mechanical damage.

2.5 Lightning Protection

2.5.1 General Requirements

2.5.1.1 The ship is to be fitted with a lightning protection, the protection zone of which should comprise all arrangements that require protection against lightning.

When a ship is exposed to the risk of fire or explosion due to after-effects of lightnings, the earthing installation, which would preclude secondary sparking, is to be provided.

2.5.1.2 The lightning installation is to consist of a spike, lightning conductors and earthing. On metal masts, the lightning conductors need not be fitted if provision is made for a reliable electrical connection of the mast to the metal hull or to the earthing point.

2.5.2 Spike

2.5.2.1 In metal ships, such vertical structures as masts, superstructures, etc. are to be used as spikes if provision is made for their electrical connection to the ship's hull. Additional spikes may be used only in such cases in which the structural elements do not form the required protection zone.

2.5.2.2 If electrical equipment is installed on top of a metal mast, a lightning spike having a reliable connection with the mast is to be provided.

2.5.2.3 On each mast or topmast made of non-conducting material, a proper lightning installation is to be fitted.

2.5.2.4 Spikes are to be made of a rod of at least 12 mm in diameter. The rod may be of copper, copper alloys or steel suitably protected against corrosion; for aluminium masts, the spike may be made of an aluminium rod.

2.5.2.5 The spike is to be fitted to the mast in such a way as to project at least 300 mm above the top of the mast or above any equipment fitted on the top.

2.5.3 Lightning Conductor

2.5.3.1 The lightning conductor is to be made of a rod, flat bar or metal rope having a cross-section not less than 70 mm^2 for copper or its alloys and not less than 100 mm^2 for steel, the steel lightning conductors being suitably protected against corrosion.

2.5.3.2 Lightning conductors are to be run on the outer side of the mast and superstructures and as straight as possible with a minimum number of bends which should be smooth and have the largest possible radii.

2.5.3.3 Lightning conductors are not to pass through explosion-hazardous spaces.

2.5.4 Earthing

2.5.4.1 In composite naval ships, the metal stem or other metal structures immersed in water under all conditions of sailing may be used as earthing.

2.5.4.2 Provision is to be made for earthing the lightning conductors or the ship's steel hull to an efficient earth on shore when the naval ship is in a dry dock or on a slipway.

2.5.5 Connections in the Lightning Installation

2.5.5.1 Connections in the lightning installation are to be welded, clamped, riveted or bolted with clamps.

2.5.5.2 The contact area of connections is to be at least 1000 mm^2.

Clamps and bolts are to be made of copper alloys or steel suitably protected against corrosion.

2.5.6 Earthing Installation

2.5.6.1 Separate metal structures, fixed and movable joints, pipelines, screens of the cable network, as well as their inlets to the explosion-hazardous spaces are to be earthed.

2.5.6.2 Pipelines for crude oil products as well as other pipelines connected with the explosion-hazardous spaces and located on open decks or in spaces without electromagnetic shielding are to be earthed to the hull at distances not more than 10 m apart.

Pipelines located on the deck on which explosive gases may occur, but not connected with the explosion-hazardous spaces, may be earthed to the ship's hull every 30 m.

2.5.6.3 Metal parts located near the lightning conductors are to be earthed if they are not fixed on the earthed structures or if they are not metallically connected in any other way to the ship's hull.

Devices or metal parts located at a distance not more than 200 mm of the earthing conductors are to be connected to them in such a way as to preclude the possibility of secondary sparking.

2.5.6.4 All connections in the earthing installation are to be accessible for control and protected against mechanical damages.

2.6 Arrangement of Equipment

2.6.1 Electrical and automation equipment is to be installed in such a manner as to provide convenient access to control elements and to all parts that require maintenance, inspection and replacement.

2.6.2 The horizontal-shaft electric machines are to be so installed that the shaft is situated parallel to the fore-and-aft plane of the ship. Placing of such machines with the shaft situated in another direction is permitted only in those cases when the construction of the machine will ensure its normal operation under conditions specified in 2.1.2.2.

2.6.3 The air-cooled electrical equipment is to be so located that cooling air is not drawn in from bilges or other spaces in which the air may be contaminated with substances having a harmful effect on insulation as well as conducting and structural materials of the equipment.

2.6.4 The electrical equipment to be placed in locations subject to vibrations and shocks (heavier than those specified in 2.1.2.1) which are impossible to be eliminated, is to be so designed as to be capable of normal operation under such conditions or is to be mounted on shock absorbers.

2.6.5 The electrical equipment is to be fixed in position in such a manner that the fastening method does not reduce the strength or tightness of hull plating, deck or bulkhead.

2.6.6 The electrical equipment is not to be situated closer than 300 mm horizontally and 1200 mm vertically to non-protected combustible materials.

2.6.7 When installing electrical equipment having metal enclosures made of material other than that used for the ship's structures on which they are mounted, suitable means to prevent electrolytic corrosion are to be provided.

2.7 Special Electrical Spaces

2.7.1 The doors of special electrical spaces are to be locked with a key. These doors are to open outwards. Doors leading to corridors and passageways may open inwards, provided that suitable stops are fitted. Appropriate warning plate is to be placed on the doors. From the inside, the doors are to open without the use of a key.

2.7.2 Special electrical spaces are not to be adjacent to the tanks filled with flammable liquids. If this requirement is impracticable from the structural point of view, no fittings or pipeline connectors are to be fixed on the tanks within these spaces.

2.7.3 No exits, opened side-scuttles or other outlets are permissible from special electrical spaces into rooms and spaces subject to explosion hazard.

2.7.4 Handrails made of insulation material are to be installed in special electrical spaces, in passageways and servicing areas of open-type electrical equipment.

2.8 Electrical Equipment in Explosion Hazardous Rooms

2.8.1 The requirements of the present Section apply to electrical equipment installed on all ships where in enclosed and semi-enclosed rooms and spaces explosive mixtures of vapour, gases and dust with air may accumulate – specified in items 1 to 6 of Table 2.3.4.2.

2.8.2 In explosion hazardous spaces and rooms, only electrical equipment of explosion- proof construction according to space category, temperature class and the ignition group of mixture, may be installed.

The installation of electrical equipment in explosion hazardous spaces and spaces leading thereto is to comply with the requirements given in 2.8.3 to 2.8.5.

The installation of electrical equipment in accumulator battery rooms is to comply with the requirements given in 13.6.

The installation of echo depth sounder oscillators and their cables is to comply with the requirements given in Chapter 6 of *Part X – Statutory Equipment and Requirement.*

2.8.3 Electrical equipment may be installed in explosion hazardous stores and their ventilation ducts in such case only when it is essential for operational services. Only the following explosion-proof electrical equipment is allowed to be installed: intrinsically safe type (Exi), with flameproof enclosure (Exd), with pressurised enclosure (Exp), increased safety type (Exe), with special enclosure (Exs). This equipment is to be intended for the ignition group of mixtures of at least II B and temperature class of at least T3.

Switchgear, protective and control devices for electrical equipment installed in the above mentioned stores are to switch off all poles and phases. Such devices are recommended to be installed in non-hazardous spaces.

2.8.4 In spaces on open deck at the distance up to 1 m from input openings of explosion hazardous stores ventilation ducts or to 3 m from output openings of their mechanical ventilation, the following electrical equipment is allowed to be installed:
- electrical equipment of explosion-proof construction allowed for explosion-hazardous stores (see 2.8.3),
- equipment with enclosure Exn,
- equipment which does not generate arc during operation and whose surface does not reach unacceptably high temperature,
- equipment with simplified pressurised enclosure or enclosure resistant to vapour (degree of enclosure protection at least IP55) whose surface does not reach unacceptably high temperature,
- cables. [zmiana własna]

2.8.5 Adjacent spaces having exit to explosion hazardous stores may be considered as non-hazardous spaces on the condition that:
- doors to the stores are gas-tight, self-closing type without holders,
- in the stores an independent, natural ventilation system from non-hazardous space is provided,
- at the entrance to the paint stores a warning inscription is placed indicating that there may be readily flammable and dangerous materials in the store.

2.8.6 In rooms where dust or fibres may produce explosive mixtures with air, electrical equipment is allowed to be installed, provided it has an enclosure protection of at least IP65.

In spaces where dust or fibres may temporarily produce explosive mixtures with air only as a result of damage to an enclosure or untightness of technological equipment under operation, as well as in the case of interruptions in operation of a ventilation system, electrical equipment having an enclosure protection of IP55 may be installed.

Enclosure of electrical equipment installed in those rooms is to be so designed that the temperature of its upper horizontal surfaces or of those inclined at an angle not exceeding 60° to the horizontal is at least 75 °C below the smouldering point of the dust existing in these rooms under conditions of continuous operation (the smouldering point is to be determined for a layer of dust 5 mm thick).

2.8.7 Lighting fixtures of explosion-proof construction are to be installed in such a manner that, except the fastening points, a free space of at least 100 mm is left around.

2.8.8 All devices, except fire detection devices, installed in explosion hazardous rooms and spaces, are to be fitted with switches, protection devices or starters capable of switching off all poles or phases located outside explosion hazardous rooms and spaces.

2.8.9 Fastening of electrical equipment to the walls of tanks intended for flammable liquids is not permitted. The distance between electrical equipment and the tank walls is in no case to be less than 75 mm.

2.8.10 In enclosed and semi-enclosed rooms which do not contain vapours or gases that could cause an explosion, but which have openings into explosion hazardous rooms and spaces, as a rule, electrical equipment of explosion-proof construction is to be installed.

Electrical equipment of non-explosion-proof construction is allowed to be installed if the following conditions are met:

.1 interruption in operation of a ventilation system gives an alarm signal (audible and visual) and switches off the power supply to electrical equipment (with a time delay, if necessary);

.2 interlocking device is provided to ensure that electrical equipment cannot be switched on until the room is ventilated enough (air in the room is to be changed at least 10 times).

2.8.11 In cargo holds for the carriage of explosion hazardous cargoes in containers, electrical equipment and cables are not to be installed. If the installation of electrical equipment is necessary, it is to be of explosion-proof construction, i.e. of intrinsically safe type (Exi), ventilated type or with pressurised enclosures (Exp), with flameproof enclosures (Exd) or of increased safety type (Exe).

In cargo holds intended for the occasional carriage of the above-mentioned cargoes, electrical equipment of non-explosion-proof construction may be installed, provided it is possible to disconnect completely the equipment by removal of special links, other than fuses, for the duration of the carriage of cargoes subject to explosion hazard.

2.8.12 In explosion hazardous spaces and rooms, only cables intended for electrical equipment located in these spaces and rooms are to be installed.

Cables passing through the above-mentioned rooms and spaces may be installed, provided the requirements given in 2.8.13 to 2.8.17 are met.

2.8.13 Cables installed in explosion hazardous rooms and spaces are to be sheathed with one of the following:

.1 metal armour or braid with non-metallic covering; or

.2 lead sheath plus further mechanical protection; or
.3 copper or stainless steel sheath (for mineral insulated cables only).

2.8.14 Cables passing through explosion hazardous rooms and spaces are to be protected against mechanical damage.

2.8.15 All metal sheaths and armour of the power supply cables of electric motors and lighting circuits passing through explosion hazardous rooms and spaces, or supplying electrical equipment located in these rooms and spaces, are to be earthed at least at both ends.

2.8.16 Cables associated with intrinsically safe circuits are to be used for one device only and are to be separated from other cables.

2.8.17 No cables of portable electrical equipment are to pass through explosion hazardous rooms and spaces, except cables associated with intrinsically safe circuits.

3 MAIN SOURCE OF ELECTRIC POWER

3.1 General Requirements

3.1.1 Each naval ship is to be provided with main source of electric power of capacity sufficient to supply all essential services of the ship in conditions specified in 3.1.6. The main source of electric power is to consist of at least two generators with an independent prime mover.

In naval ships of gross tonnage up to 200 tons, accumulator battery may be used as main source of power.

3.1.2 The number and the capacity of the generating sets and power converters composing the main source of electric power are to be such that in the event of any one generating set or power converter being stopped, it will still be possible to:

- **.1** supply the essential services, in conditions mentioned in 3.1.6, maintaining the minimum comfortable habitation conditions;
- **.2** start the electric motor with maximum starting current under the most severe starting conditions, with no such drop in voltage or frequency that might cause a fall out of synchronism or a stop of the generator prime mover, or switching off the running machines and apparatus;
- **.3** supply the electrical services necessary to start the main propulsion plant.

3.1.3 The emergency source of electric power may be used for starting the engine-room machinery operation from a dead ship condition if its capability either alone or combined with that of any other source of electric power is sufficient to supply at the same time the services required in 9.3.1 ÷ 9.3.3 (see also 1.8.4 of *Part VI – Machinery Installations and Refrigerating Plants*).

3.1.4 If only electric power is used for starting the main propulsion plant operation from a dead ship condition and if emergency source of electric power cannot be used for this purpose, then the generating set used for starting the main propulsion plant from a dead ship condition is to be provided with starting arrangements at least equivalent to those required for starting the emergency generating set.

3.1.5 Shaft generator may be used instead of one of the generating sets mentioned in 3.1.1, provided it complies with the requirements of 3.2.3.1 and there is a possibility of starting the ship's main engine in the event of failure of any of the generating sets.

3.1.6 The composition and the capacity of the main source of electric power are to be determined with regard to the following operating conditions of the ship:

- **.1** running conditions;
- **.2** manoeuvring;
- **.3** the event of fire, piercing of the hull or other conditions having effect on the ship's safety;
- **.4** other – according to the ship's assignment.

3.1.7 Each hull of a catamaran is to be provided with at least one generating set.

3.1.8 If the main source of electric power are accumulator batteries, their capacity is to be sufficient to satisfy the requirements given in 3.1.2.1 for 8 hours without recharging.

3.1.9 In ships of restricted service III with a low-rated electrical installation, one generating set and/or accumulator batteries may be used as the main source of electric power.

3.2 Electric Generating Sets

3.2.1 General Requirements

3.2.1.1 Engines designed for use as generator prime movers are to comply with the requirements given in Chapter 2 of *Part VII – Machinery, Boilers and Pressure Vessels* and additionally with the requirements of the present sub-chapter.

3.2.1.2 Generating sets are to be designed for continuous duty, taking into account the power drop of the prime movers during the operation of the ship under the conditions specified in 2.1.1.1.

3.2.1.3 In the event of short-circuit in the ship's network, the generators are to be capable of maintaining the design short-circuit current of the value sufficient for the operation of protective devices.

3.2.1.4 Generators of the generating sets are to be provided with voltage regulation within the limits specified in 10.6 and 10.7, as well as with frequency regulation within the limits specified in 2.1.3.1.

3.2.1.5 For alternating current generators, the effective value of the 1st harmonic of voltage curve is not to exceed 5 percent of the effective value of the base component.

3.2.2 Load Sharing between Generating Sets running in Parallel

3.2.2.1 The speed governor characteristics of prime movers used to drive alternating-current generators intended to operate in parallel are to be such that within 20 to 100 per cent of rated load the active loads of the generators do not differ from the proportional outputs of the individual generators by more than 15 per cent of the active output of the largest generator operated in parallel or 25 per cent of the active output of the given generator, whichever is the smaller.

Alternating-current generating sets intended to operate in parallel are to be provided with a device for precise regulation of the load distribution within the range not exceeding 5 per cent of the rated power at the rated frequency.

3.2.2.2 Alternating-current generating sets intended to be run in parallel are to be provided with such a reactance drop compensating system that when the sets are run in parallel, the reactive load sharing between the generators does not differ from a value proportional to their output by more than 10 per cent of the rated reactive load of the largest generator, or 25 per cent of the smallest generator, whichever is the smaller.

3.2.2.3 Where alternating-current generators are run in parallel at 20 to 100 per cent of rated load, the admissible current variations are to be within ± 15 per cent of the rated current value of the largest generator.

3.2.2.4 The speed governor characteristics of prime movers used to drive direct-current generators are to be such that in parallel operation the load on individual generators is shared, as far as possible, in proportion to the rated output of each generator.

At loads within 20 to 100 per cent of the rated value, the load on individual generators is not to differ from the proportional output of a particular generator by more than 12 per cent of the output of the largest, or by more than 20 per cent of the smallest of the generators run in parallel. For generators of equal size, the load on any generator is not to differ from the value proportional to their rated output by more than 10 per cent.

3.2.3 Shaft Generators

3.2.3.1 Shaft generators used as main source of electric power for shipboard electrical network are to be provided with devices for voltage regulation within the limits specified in 10.6 and 10.7 and for frequency regulation within the limits specified in 2.1.3.1 at variable speeds of main engine or shaft.

In the event of the network frequency drop below the permissible value, provision is to be made for automatic switching on one or more generators with an independent drive, and actuation of alarm system in the engine room or central control station.

3.2.3.2 The use of shaft generators designed to supply individual consumers with voltage and frequency parameters different from those specified in 3.2.3.1 will be specially considered by PRS in each particular case.

3.2.3.3 Shaft generators with semiconductor converters directly supplying the shipboard network are to be so designed that they cannot be damaged in case of a short-circuit on the main switchboard busbars. The determined value of the short-circuit current is to be sufficient for actuation of automatic protective devices.

3.2.3.4 Shaft generators are to be designed for at least short-time operation in parallel with generating sets with an independent drive for the purpose of manual or automatic picking-up of load.

3.2.3.5 For alternating-current shaft generators, automatic devices preventing current overloads of elements of the generator excitation systems operating with a speed less than 95 per cent of the rated speed, are to be provided. It is permitted that the voltage of the shaft generator terminals be suitably reduced.

3.2.3.6 The main switchboard is to be provided with de-exciters assigned for each shaft generator as well as with measuring instruments according to 4.5.4.3 or 4.5.4.4.

3.2.3.7 When shaft generators are connected to the ship's power network, visual signalling is to automatically switch on warning on the main command station/ navigation bridge that a change of the rotational speed of the main propulsion may result in a change of the ship's network parameters exceeding the limits specified in 10.6, 10.7 and 2.1.3.1.

3.2.3.8 In shaft generators systems with semiconductor converters, generators with an independent drive may be used as reactive load compensators.

3.3 Number and Power of Transformers

In naval ships where lighting and other essential services are powered through transformers, provision is to be made for not less than two transformers of such capacity that in case of failure of the largest unit, the remaining transformers are capable of satisfying the complete demand for electric power under all operating conditions of the ship.

Where sectionalised busbars are used in the main switchboard, the transformers are to be connected to different sections of the busbars.

In ships of restricted service III and in ships of restricted service II with a low-rated electrical installation, only one transformer is required.

3.4 Power Supply from an External Source of Electric Power

3.4.1 A terminal for power supply from an external source of electric power is to be installed in each naval ship.

The external supply terminal is to be connected to the main switchboard by permanently fixed cables.

In ships with a low-rated electrical installation, it is permitted to connect the cable supplying the ship's network from an external source of electric power directly to the main switchboard.

3.4.2 The terminal for power supply from an external source of electric power is to be provided with:

.1 suitable clamps to connect flexible cables;

.2 switchgear and protective devices for connection and protection of the cable supplying the main switchboard;

.3 a voltmeter or signal lamps to show the presence of voltage on terminals;

.4 a device or a possibility for connecting a device for checking the polarity and the phase sequence;
.5 clamps for earthing the neutral run from the external source;
.6 a plate indicating voltage level, kind of current and frequency of shipboard network;
.7 at the external supply terminal or nearby, a device for mechanical fastening of the flexible cable led to the terminal is to be provided.

3.4.3 If provision has not been made for parallel operation between the shore electric power source and thhat fitted on board, the connection system is to be provided with interlocking to prevent the connection of these sources for parallel operation.

3.5 Connection of Supply Sources

3.5.1 Where the electric power supply sources are not adapted for a prolonged operation in parallel to feed common busbars, the system of connections is to be so arranged as to provide possibility of their parallel operation during the time necessary for load transfer from one generator to another.

3.5.2 Compound-wound generators designed for parallel operation are to have equalising connections.

3.5.3 Where alternating-current generators are intended to operate in parallel, a synchroniser is to be installed in the main switchboard. Where synchronising is arranged to operate automatically, a stand-by manual synchroniser is to be provided.

Lamps for manual synchronising are to be provided irrespective of whether or not synchronoscopes have been fitted for manual or automatic synchronising.

3.5.4 Where several direct-current generators are installed, a field-initiating device is to be installed in the main switchboard. Such a device is also to be used in the case of a.c. synchronous generators if it is necessary for field initiation.

3.5.5 Where the main source of electrical power is necessary for propulsion of the naval ship or where the total output of generators running in parallel is over 1000 kW (kVA), the main switchboard busbars are to be subdivided into at least two parts, which should normally be connected by circuit breakers, switches, isolating switches or easily removable links.

As far as practicable, generators and electrical power consumers which are duplicated are to be equally divided between the parts.

3.5.6 Sectionalisation of the main switchboard busbars for supplying the electrical equipment in each hull of the catamaran is to be provided.

3.6 Shipboard Generating Stations

3.6.1 One main generating station is to be situated in machinery compartment, between its extreme transverse watertight bulkheads. No other bulkhead situated between the extreme bulkheads is to separate the generating station equipment.

3.6.2 Where in a naval ship provision is made for more than one main generating station, they are to be located in separate watertight compartments.

3.6.3 As far as possible, particular generating stations are to have installed outputs equal or similar one to another.

3.6.4 Each generating station is to comply with the requirements of 3.1.2.

4 DISTRIBUTION OF ELECTRIC POWER

4.1 Distribution Systems

4.1.1 The following systems of electric power distribution may be used in shipboard installations:

.1 For voltages above 1000 V – in accordance with 18.2.1.1;

.2 For voltages up to 1000 V alternating current:

.2.1 three-phase, three-wire insulated system;

.3 In addition, for voltages up to 500 V alternating current:

.3.1 three-phase, four-wire system with neutral earthed but without hull return;

.3.2 single-phase, two-wire insulated system;

.4 for direct current:

.4.1 two-wire insulated system;

.4.2 single-wire system with hull return, for voltages of up to 30 V only, in restricted and locally earthed systems (e.g. in the starting system of internal combustion engines).

The use of other systems is subject to agreeing with PRS.

4.1.2 If there is a single main switchboard installed in the naval ship, its common busbars are to be divided into sections connected by circuit-breakers.

4.1.3 Where two or more main switchboards are installed in the naval ship, power exchange between them is to be ensured, with the switchboards connecting lines being dimensioned for the transfer of power equal to at least that of the connected power source having the greatest output.

4.2 Permissible Voltages and Frequencies

4.2.1 For voltages exceeding 1000 V – in accordance with 18.2.2.

4.2.2 The following permissible rated voltages and frequencies of alternating current across the terminals of the sources of electric power are recommended: 115/230/400/440/690 V (50/60 Hz), 115/440 V (400 Hz) depending on the applied power distribution system as given in 4.1.1.

4.2.3 The recommended direct current rated voltage across the terminals of the sources of electric power is 24/28 V.

4.2.4 The rated voltages across the terminals of alternating current-consuming appliances are not to exceed the values specified in Table 4.2.4.

Table 4.2.4

Item	Type of consumers	Permissible voltages [V]
1	Stationary power consumers, heating, cooking and space heating appliances permanently installed in spaces other than those specified in item 2	1000
2	Portable socket-outlet supplied power consumers, fixed permanently when used; control circuits, heating and space heating appliances in cabins and crew spaces (see 15.2.7)	500
3	Lighting, signalling and internal communication, socket-outlets for supplying portable equipment with reinforced or double insulation, or separated by means of selective transformer	230
4	Socket-outlets installed in spaces with increased humidity or in extra humid spaces intended for supplying equipment without reinforced or double insulation	50

Supplying consumers with voltage higher than 1000 V is subject to agreement with PRS.

4.2.5 The rated voltages across the terminals of direct current-consuming appliances are not to exceed 28 V.

4.3 Power Supply to Essential Services

4.3.1 The following essential consumers and their switchboards are to be supplied by separate feeders to the principles given in 4.3.2 or 4.3.3:

.1 steering gear electric drives (see also 5.5.2);
.2 windlass electric drives;
.3 fire pump electric drives;
.4 drainage and dewatering pump electric drives;
.5 fire-extinguishing equipment;
.6 electric drives of main propulsion plant excitation units;
.7 section switchboards of machinery ensuring the operation of the main propulsion;
.8 section switchboards of the main lighting;
.9 control system of controllable pitch propellers;
.10 switchboards of radio communication equipment;
.11 switchboards of navigational equipment;
.12 switchboards of navigation lanterns;
.13 armament and ammunition hoists,
.14 section switchboards of other essential services concentrated in accordance with similar functions performed;
.15 control and monitoring desks of naval ship command stations (see also 4.4);
.16 fire alarm system;
.17 switchboards supplying electric drives of watertight door drives and signalling;

.18 uninterruptible power supply (UPS) systems and chargers of starting batteries;
.19 armament command and control system;
.20 switchboards for lighting the air-sheds and those of the signalling lights for helicopter landing fields;
.21 air filtering equipment and the ship flushing equipment;
.22 other equipment essential for ship service and ship and crew safety;

The list of equipment supplied by separate circuits is subject to agreement with PRS.

4.3.2 Circuits supplying duplicated essential consumers, where one of the pair serves as a stand-by appliance, are to be connected to two different main switchboards or two different sections of main switchboard busbars, in naval ships with one main switchboard, or to main and emergency switchboards, if generating set serves as emergency source of electric power.

Supply of these consumers may be effected from two different section switchboards, supplied according to the above principles.

4.3.3 Essential consumers, except these specified in 4.3.2, are to be supplied by two independent circuits from two different main switchboards or from two different sections of the main switchboard busbars, in naval ships with one main switchboard, or from main and emergency switchboards, if generating set serves as emergency source of electric power.

These consumers may be supplied by single circuits from a section switchboard, supplied according to the above principles and when the below conditions are fulfilled:
– the section switchboard supplies only consumers of the same or similar purpose,
– the section switchboard is installed in the same fire zone as the consumers it supplies.

4.3.4 The section switchboards intended for supplying essential consumers are not to be used for supplying other consumers.

4.3.5 Supply of the integrated combat system is to be agreed with PRS.

4.3.6 Irrespective of the requirements specified in 4.3.2 and 4.3.3, the machinery essential for the naval ship serviceability is to be capable of being temporarily supplied from the stand-by power distribution system. This requirement does not apply to auxiliary naval ships with low-rated electrical system.

4.3.7 In naval ships provided with stand-by supply system for essential consumers, appropriate cable penetrations are to be made in bulkheads and decks, close to manholes or doors.

4.3.8 In naval ships provided with low-rated electric system and in other naval ships, when agreed with PRS, the windlass may be supplied from auxiliary switchboard supplying the mooring winch or from other switchboard if it is supplied in accordance with 4.3.3.

4.3.9 Final sub-circuits having a current rating in excess of 16 A are to supply no more than one consumer.

4.3.10 Power supply to automation systems is to comply with the requirements given in 20.3.

4.3.11 Where the main source of electrical power is necessary for propulsion and steering of the naval ship, the power distribution system is to be so arranged that the electrical power supply to the equipment necessary for propulsion and steering and to ensure safety of the ship will be continuously maintained or immediately restored in the case of loss of any one of the generators in service.

4.4 Power Supply to Ship's Navigation Control and Monitoring Consoles

4.4.1 When locating the electrical equipment, navigational equipment, radio equipment, electrical automatic and remote control equipment for the main and auxiliary machinery in the console, such equipment is to be supplied by separate feeders.

It is permitted to supply the equipment specified in 4.3.1 from the switchboards built into ship's navigation control and monitoring console, provided the requirements of paragraphs 4.4.2 ÷ 4.4.6 are met (see also 9.4.3).

4.4.2 The control and monitoring consoles are to be supplied from two different main switchboards or two different sections of the main switchboard busbars directly or through transformers by two different feeders – in naval ships with one main switchboard, or are to be supplied by one feeder from the main switchboard and one feeder from the emergency switchboard if the generating set is the emergency source of energy.

4.4.3 In addition, the control and monitoring consoles are to be independently supplied by a separate feeder from other source or sources of power, if necessary, basing on the requirements for the equipment fed from these switchboards or on any other technical reasons.

4.4.4 The console switchboard is to be provided with a change-over switch for feeders specified in 4.4.2 and 4.4.3. If an automatic change-over switch is used, manual switching of feeders is also to be ensured. In this case, provision is to be made for appropriate interlocking.

4.4.5 Each consumer specified in 4.3.1, supplied from the control and monitoring consoles, is to be supplied by a separate feeder (see also 9.4.3).

4.4.6 In each control and monitoring console, a visual signalling device indicating the presence of voltage is to be fitted.

4.5 Distribution Switchboards

4.5.1 Switchboard Constructions

4.5.1.1 The frames, front panels and casings of switchboards are to be made of metal or some other incombustible material. The generator panels of the main switchboards are to be separated by barriers made of incombustible materials.

4.5.1.2 Switchboards are to be of rigid construction capable of withstanding the mechanical stresses liable to occur under service conditions or as a result of short-circuits. The doors and opening panels of the switchboards are to be strengthened to restrict occurrence of excessive vibrations.

4.5.1.3 Frequency of free vibration of switchboard structure is to be greater than those of the ship, so that preclude occurrence of resonance vibration.

4.5.1.4 Switchboards are to be at least protected from drip. This protection is not required if the switchboards are to be located in spaces where the conditions are such that no vertically falling drops of liquid can get into the switchboard.

4.5.1.5 Switchboards intended to be installed in places accessible to unauthorised persons are to be provided with doors to be opened with the use of a special key, the same for all the switchboards in the ship.

4.5.1.6 The design of the switchboard doors is to be such that with the doors opened access is assured to all parts, which require maintenance; live parts installed on the doors are to be protected against accidental touch.

Opening panels and doors, on which electrical control devices and measuring instruments are located, are to be securely earthed with at least one flexible connection.

4.5.1.7 Main, emergency and section switchboards and control desks are to be provided with handrails fitted on their front side. Switchboards accessible from the rear are to be provided with horizontal handrails fitted at the back.

The handrails may be made of insulating material, wood or earthed metal covered with a suitable insulating material.

4.5.1.8 The generator panels of main switchboards are to be provided with lighting fittings supplied on the side of the generator, but before its main circuit-breaker or from two different sections of busbars through selector switch.

4.5.1.9 The lighting fittings on the front side of switchboard panels are to be so arranged as not to interfere with instrument observation or produce a blinding effect.

4.5.1.10 The design of wall switchboards is to be such as to provide access to parts, which require attendance. The switchboard doors are to be locked in the open position.

It is recommended that withdrawable blocks and panels with apparatus were provided with mechanical devices setting their position during operation, during testing (control circuit connected), as well as when disconnected (main circuits and control circuits disconnected). Drawing-out or drawing-in of block or panel from/to operating position is to be possible only when switching device is open.

4.5.2 Busbars and Bare Conductors

4.5.2.1 The permissible values of temperature rise due to rated loads and short-circuits for switchboard busbars and bare conductors, or those of permissible short-circuit load for copper busbars, are to be taken in accordance with the relevant standards.

4.5.2.2 Equaliser busbars are to be designed for at least half the rated current of the largest-size generator connected to the main switchboard.

4.5.2.3 Where the busbar is in contact with or close to insulated parts, its heat effect under operating or short-circuit conditions are not to cause a temperature rise in excess of that allowable for a given insulating material.

4.5.2.4 Busbars and bare conductors in switchboard are to have adequate electrodynamic and thermal strength to withstand the passage of short-circuit currents occurring at relevant points in the circuit.

Such electrodynamic loads as occur in busbars and bare conductors due to short-circuit are to be determined in accordance with the relevant standards.

4.5.2.5 Insulators and other insulating elements designed to support busbars and bare conductors are to be capable of withstanding the loads caused by short-circuits.

4.5.2.6 The natural frequency of copper busbars is to be outside the ranges of 40 to 60 Hz and 90 to 110 Hz when the rated frequency is 50 Hz and outside the ranges of 50 to 70 Hz and 110 to 130 Hz when the rated frequency is 60 Hz, as well as outside the ranges of 320 to 480 Hz and 720 to 880 Hz when the rated frequency is 400 Hz.

4.5.2.7 In direct current switchboards, busbars and bare conductors of different polarity are to be marked with the following distinguishing colours:

.1 red for the positive pole;

.2 blue for the negative pole;

.3 black or yellow and green transverse bands for earth connections;

.4 light-blue for the middle wire.

The equaliser connection is to be marked with white transverse bands in addition to the appropriate colour as given above.

4.5.2.8 Busbars and bare conductors in single-phase switchboards are to be marked with the following distinguishing colours:

.1 Brown for phase conductor;

.2 Light blue for neutral wire.

4.5.2.9 Busbars and bare conductors of different phases in three-phase switchboards are to be marked with the following distinguishing colours:

.1 yellow for phase 1;

.2 green for phase 2;

.3 violet for phase 3;

.4 light-blue for neutral wire;

.5 green-yellow transverse bands for earth connections.

4.5.2.10 Busbar connections are to be made in such a way as to preclude corrosion in places of connection.

4.5.3 Selection of Apparatus and Short-circuit Currents Calculation

4.5.3.1 Electrical apparatus are to be so selected that under normal service conditions their rated voltages, load and temperature rise limits are not exceeded. The apparatus are also to be capable of withstanding, without damage or reaching dangerous temperature, the prospective overloads and currents in transient conditions.

Short-circuit protective equipment is to conform to specific conditions of the naval ship's electrical network and in particular:

– power factor at short-circuit in alternating current networks,
– sub-transient and transient components of short-circuit current.

The following cases of the short-circuits are to be taken into consideration:

– on the generator side,
– on the busbars of the main switchboard,
– on the busbars of the emergency switchboard, if installed,
– on the consumers and switchboards supplied directly from the main switchboard.

Calculation of the minimal short-circuit current is to be carried out only if it is necessary for estimation of the system.

4.5.3.2 The rated breaking capacity of an electrical apparatus designed to break short-circuit currents is not to be less than the prospective short-circuit current at the point of its installation.

4.5.3.3 The rated making capacity of electrical apparatus designed to break short-circuit currents is not to be less than the prospective peak value of short-circuit current at the point of its installation.

4.5.3.4 The rated electrodynamic strength of an electrical apparatus not intended for breaking the short-circuit currents is not to be less than the prospective peak short-circuit current at the point of its installation.

4.5.3.5 The rated thermal strength of an apparatus is to be in accordance with the prospective short-circuit current at the point of its installation, as well as with the prospective duration of short-circuits based on the discriminative action of the protection.

4.5.3.6 Automatic circuit-breakers are to be used as overload protection in circuits with load currents exceeding 320 A. In circuits with load currents in excess of 200 A, the use of automatic circuit-breakers is recommended.

4.5.3.7 Switches in the circuit of compound generators designed for parallel operation are to have a pole in the equaliser connection so interlocked mechanically with the other circuit-breaker poles that it closes and opens after the other poles are connected to or disconnected from the busbars.

4.5.3.8 Calculation of short-circuit currents is to be carried out on the basis of standards or according to the calculation method approved by PRS.

4.5.3.9 When calculating the anticipated short-circuit current, the equivalent impedance of the arrangement on the damage side is to be taken into account. The source of current is to include all the generators, which may be connected in parallel, and all the motors running simultaneously. Currents induced by generators and motors are to be calculated according to the standard IEC 61363-1.

According to the above mentioned standard for alternating-current motors, the following effective values are to be taken:

– large capacity motors (power above 100KW):
  $I''_M = 6.25 I_{rM}$
  $I_{acM} = 4 I_{rM}, \quad t = \mathrm{T}/2$
  $i_{pM} = 10 I_{rM}$
– small motors:
  $I''_M = 5 I_{rM}$
  $I_{acM} = 3.2 I_{rM}, \quad t = \mathrm{T}/2$
  $i_{pM} = 8 I_{rM}$

where:

I''_M – initial value of symmetric short-circuit current;
I_{rM} – rated current value;
I_{acM} – effective value of symmetric short-circuit current;
i_{pM} – peak value of short-circuit current;
T – supply voltage period.

In the case of direct current, in order to determine the maximum value of the short-circuit current induced by electric motors, the current equal to six times the total value of rated currents of the electric motors running in parallel is to be taken.

Calculation is to be carried out for all cases of short-circuit necessary for obtaining the system characteristics.

4.5.4 Arrangement of Apparatus

4.5.4.1 Each circuit in a switchboard is to be provided with a non-manoeuvring switch capable of switching off all poles or phases.

Switches need not be installed in each circuit in switchboards provided with central switches and supplying the final lighting circuits, as well as in the circuits of instruments, interlocking devices, alarms and local lighting of switchboards protected by fuses.

4.5.4.2 Apparatus, measuring and indicating instruments used in conjunction with generators and essential services are to be fitted on the switchboard panels associated with the respective generator or services.

The above-mentioned requirements do not refer to the case when switchgear and measuring instruments for several generators are concentrated in the central control console of main switchboard or in the central control desk.

4.5.4.3 The apparatus in switchboard outgoing circuits is to be so arranged that connecting is possible without opening switchboard doors and covers. Design of switchboards is to preclude incidental switching on or off apparatus.

4.5.4.4 One ammeter and one voltmeter are to be provided for each direct-current generator on the main and emergency switchboards.

4.5.4.5 The following instruments are to be installed on the main switchboard for each alternator and on the emergency switchboard for the emergency set:

- **.1** an ammeter with a selector switch for current measurements in each phase;
- **.2** a voltmeter with a selector switch for measuring phase and line voltages;
- **.3** a frequency indicator (as regards generators operating in parallel, a twin frequency indicator with a selector switch for each generator may be used);
- **.4** a wattmeter (for outputs in excess of 50 kVA).

4.5.4.6 In ships with a low-rated electric installation, where provision has not been made for the parallel operation of generators, only one set of the measuring instruments specified in 4.5.4.3 and 4.5.4.4 may be installed on the main and emergency switchboards, provided the possibility of measurements on each installed generator is ensured.

4.5.4.7 Ammeters are to be installed in the circuit of essential consumer services with rated current of 20 A and more. These ammeters may be installed on the main switchboard or at the control stations.

It is permitted to install ammeters with switches but not more than one ammeter for six consumers.

4.5.4.8 On the main switchboard in the circuit supplied by an external electric power source, the following is to be provided:

- **.1** a switchgear and a protective device;
- **.2** a voltmeter or indicating lamps.

4.5.4.9 A change-over arrangement or a separate device for each network of isolated systems is to be installed on the main and emergency switchboards for measuring insulation resistance.

Earth current flowing to the ship's hull, induced by insulation resistance measuring device is not to exceed in any conditions 30 mA. Visual and audible alarms are to be provided to indicate an inadmissible insulation resistance drop in the ship's electrical network.

4.5.4.10 Measuring instruments are to have scales with a margin exceeding the rated values of quantities to be measured.

The upper scale limits of the instruments used are to be not less than:

.1 for voltmeters – 120 per cent of the rated voltage;

.2 for ammeters associated with generators not operated in parallel and with current consumers – 130 per cent of the rated current;

.3 for ammeters associated with parallel-operated generators – 130 per cent of the rated current for load-current scale and 15 per cent of the rated current for reverse-current scale (the last requirement applies to d.c. generators only);

.4 for wattmeters associated with generators not operated in parallel – 130 per cent of the rated output;

.5 for wattmeters associated with generators operated in parallel – 130 per cent for power scale and 15 per cent for reverse power scale;

.6 for frequency indicators – ± 10 per cent of the rated frequency.

The above given scale limits may be changed upon agreement with PRS.

4.5.4.11 The voltage, current and power ratings of electric propulsion plant and generator circuits are to be clearly indicated on the instrument scales.

4.5.4.12 Where possible, switchgear is to be installed and connected to busbars in such a way that none of the movable elements and the protection or control devices associated with the switchgear are energised in the open position.

4.5.4.13 Where switchboard outgoing circuits are provided with switches and fuses, the fuses are to be fitted between busbars and switches. Other pattern of fuse and switch installation will be specially considered by PRS in each particular case.

4.5.4.14 Fuses provided in switchboards installed on a foundation at the floor level are to be located not lower than 150 mm and not higher than 1800 mm from the floor level.

Open live parts of switchboards are to be located not lower than 150 mm from the floor level.

4.5.4.15 Fuses are to be so installed in switchboards as to be readily accessible and not to cause danger to the attending personnel when renewing the fuse elements.

4.5.4.16 Screwed-in fuses are to be so installed that the supply leads are connected to the lower terminal.

4.5.4.17 Fuses protecting the poles or phases of the same circuit are to be installed in a row, horizontally or vertically, depending on the fuse design.

The fuses in an a.c. circuit are to be positioned to follow the sequence of phases from left to right or from top to bottom. In a d.c. circuit, the positive-pole fuse is to be on the left side, on the top, or closer to be reached.

4.5.4.18 The manual actuators of voltage regulators installed in the main or emergency switchboards are to be positioned close to the measuring instruments associated with the respective generators.

4.5.4.19 The ammeters of compound-wound generators designed for operation in parallel are to be installed in the pole circuit, which is not connected to the equaliser.

4.5.4.20 Flexible stranded conductors are to be used for connection of instruments located on movable or drawn-out parts.

4.5.4.21 Apparatus, instruments, panels and outgoing circuits are to have their designations marked on the switchboards.

The position of switchgear is also to be indicated. Besides, markings are to be provided to indicate the rated current of the fuses, as well as the setting of the circuits-breakers, protection devices and relays.

4.5.5 Visual Signals

4.5.5.1 For visual signals, colours given in Table 4.5.5.1 are to be used.

4.5.5.2 The use of visual signals other than those specified in Table 4.5.5.1 (for example, letter codes) will be specially considered by PRS in each particular case.

Table 4.5.5.1

No.	Colour	Meaning	Type of signal	Equipment usage
1	Red	Danger	Blinking	Alarm in dangerous situations calling for immediate intervention
			Permanent	General alarm in dangerous situations, as well as in dangerous situations detected but not yet eliminated
2	Yellow	Attention	Blinking	Abnormal situations, but not requiring immediate intervention
			Permanent	Situations intermediate between abnormal and safe. Abnormal situations detected, but not yet eliminated
3	Green	Safety	Blinking	Indication that a stand-by unit is put into service
			Permanent	Normal operating conditions, normal functioning
4	Blue	Instructions and information	Permanent	Units and devices ready to be started. Circuit energised. All in order
5	White	General information	Permanent	Signals used when required. Notations relating to automatic action. Other additional signals

4.5.6 Arrangement of Switchboards

4.5.6.1 The main switchboard is to be located as close as practicable to the power source, within the same machinery space and the same A 60 fire boundaries.

4.5.6.2 Where services essential for naval ship safety, operation of armament, and for steering and propulsion are supplied from section boards, these and any transformers, converters and similar appliances constituting an auxiliary part of electrical supply system are to be situated in the same watertight compartment as the consumers supplied by these switchboards (see also 4.3.3).

The above requirement does not apply to drives of drainage pumps, which are to be supplied from the switchboard installed in other watertight compartment than that of the pump.

4.5.6.3 The main switchboards and section boards having open live parts on the rear side, installed along the ship's side below the load waterline, are to be protected from water by means agreed with PRS.

4.5.6.4 The switchboards are to be placed in locations where concentration of gases, steam, dust and acid evaporations is not possible.

4.5.6.5 If a switchboard with the degree of protection IP10 and lower is located in a special space, cabinet or recess, such spaces are to be made of incombustible material or are to have a lining of such material.

4.5.6.6 The arrangement of pipelines near the electrical equipment is to conform to the requirements given in 1.16.11.11, 1.16.11.14, 1.16.11.16 and 1.16.11.17 of *Part VI – Machinery Installations and Refrigerating Plants.*

4.5.6.7 The navigation lantern switchboard is to be located on the main command station/navigation bridge where it is readily accessible and visible for the personnel on watch.

4.5.6.8 In catamarans, the main switchboard is to be installed in each hull.

It is permitted to install only one main switchboard provided that it is situated above bulkhead deck.

4.5.7 Access to Switchboards

4.5.7.1 In front of the switchboard, a passageway is to be provided not less than 800 mm wide for switchboards up to 3 m long and not less than 1000 mm wide for longer switchboards.

In naval ships of 200 tons gross tonnage or less, the width of the passageway may be reduced to 600 mm.

4.5.7.2 Behind the free standing switchboards, it is necessary to provide a passageway not less than 600 mm wide for switchboards up to 3 m in length and not less than 800 mm wide – for longer switchboards.

The width of passageways between the free standing switchboards with open live parts is not to be less than 1000 mm.

4.5.7.3 The space behind the free-standing switchboards with open live parts is to be enclosed and fitted with doors in accordance with 2.7.1.

4.5.7.4 The space behind the free standing switchboards specified in 4.5.7.3 of more than 3 m in length, is to have at least two exits located at the opposite ends of the switchboards and leading to the space where the switchboard is installed. One of the doors may lead to the adjacent space provided with at least one more exit.

4.5.7.5 The passageways specified in 4.5.7.1 and 4.5.7.2 are to be measured from the most protruding parts of the switchgear and the switchboard construction to the protruding parts of equipment or hull structures.

5 ELECTRIC DRIVES FOR MACHINERY AND EQUIPMENT

5.1 General Requirements

5.1.1 The control stations and automatic systems of the drives are to comply with the relevant requirements given in 20.1, while the power supply of electrical automation systems is to meet the requirements given in 20.3.

5.1.2 Electrically driven machinery is to be provided with visual signal indicating that the device is in ”on” position.

5.1.3 The equipment provided with automatic, remote and manual control is to be designed in such a manner that the automatic or remote control is switched off when changing over to the manual control. Manual control is to be independent of automatic or remote control.

5.2 Interlocking of Machinery Operation

5.2.1 The machinery provided with electric and manual drives is to be fitted with interlocking devices that will prevent the possible simultaneous operation of the drives.

5.2.2 If mutual dependence of machinery operation or machinery operation in a certain sequence is required, the appropriate interlocking device is to be used.

5.2.3 A device may be installed that will switch off the interlocking on condition that this device is protected from accidental switching off the interlocking. An informative inscription is to be placed in close proximity to this device to indicate its application and to prohibit its use by unauthorised personnel. Such device is not to be used for machinery specified in 5.2.1.

5.2.4 Starting of the machinery whose electric motors or switchgear require additional ventilation in normal operating conditions is to be possible only with ventilation in action.

5.3 Safety Switches

5.3.1 The control systems of electric drives, whose operation under certain conditions may endanger the human or naval ship safety, are to be provided with safety switches that will ensure the disconnecting of the power supply from the electric drive.

The safety switches are to be painted red. An inscription indicating their purpose is to be placed near the switches.

These safety switches are to be protected from accidental, unintended use.

5.3.2 Safety switches are to be located in the control stations and/ or in other places to ensure safe operation conditions.

5.3.3 Electric drives of the machinery and devices for which, in order to avoid damage or break-down, movement limits are required, are to be provided with limit switches that would ensure effective disconnecting of the electric motor.

5.4 Switchgear and Machine Control Gear

5.4.1 The switchgear which is not designed to break short-circuit currents is to withstand such maximal prospective short-circuit current that may flow at the point of its installation during the time required for operation of protection devices.

5.4.2 The machine control gear employed is to enable starting an electric motor only from the stop position.

5.4.3 Machine control gear is to be provided with an appropriate discharge protection device that would permit the disconnection of the shunt-field windings.

5.4.4 Only such alternating-current electric motors that meet the requirements of 3.1.2.2 and 16.8.3.3 may be directly connected to the network.

5.4.5 For each electric motor rated at 0.5 kW and more and its control gear, an appropriate device to disconnect the power supply is to be provided. If the control gear is mounted on the main switchboard or on any other switchboard in the same compartment and can be seen from the place of installation of the electric motor, then for this purpose it is permitted to use a non-manoeuvring switches mounted on the switchboard.

If the requirements concerning the location of machine control gear stated above are not met, the following is to be provided:

.1 a device interlocking the switch on the switchboard in the ”off” position; or

.2 an additional disconnecting switch near the electric motor; or

.3 fuses in each pole or phase arranged in such a manner that they can be readily removed or replaced by the personnel.

5.5 Electric Drives for Steering Gear

5.5.1 In addition to the requirements given in sub-chapter 6.2 of *Part VII – Machinery, Boilers and Pressure Vessels* and in sub-chapter 2.6 of *Part III – Hull Equipment*, steering gear is to meet the requirements of the present sub-chapter.

5.5.2 Each electric or electrohydraulic drive of the main steering gear comprising one or more power units is to be supplied directly from the main switchboard by two separate circuits laid on separate routes (see also 16.8.4.13).

Where sectionalised busbars are used in the main switchboard, each circuit is to be connected to a different section of the busbars. It is recommended that one of the circuits be supplied through the emergency switchboard.

Electric or electrohydraulic drive of the auxiliary steering gear required by sub-chapter 2.6 of *Part III – Hull Equipment* may be supplied from one of the circuits supplying the main steering gear.

5.5.3 Each circuit is to have sufficient loads for supplying all the electric motors, which are normally connected to it and may run simultaneously.

5.5.4 If a change-over arrangement is provided to supply any electric motor or a combination of motors from one or the other feeder, such feeders are to be designed for operation under the most severe loads and the change-over arrangement is to be installed in the steering gear compartment.

5.5.5 In case of failure in the steering gear power unit operation, the other unit required by sub-chapter 2.6 of *Part III – Hull Equipment* is to be capable of being started automatically or by manual means located on the main command station/ navigation bridge.

5.5.6 In all ships provided with steering gears in accordance with sub-chapter 2.6 of *Part III – Hull Equipment* when the main source of power supplying the steering gear drive is out of service, the supply from the emergency source of power or any other independent one located in the steering gear compartment and designed only for this purpose, is to be switched on automatically within 45 seconds.

This source of power is to have a capacity sufficient for at least half an hour of continuous operation of the steering gear drive, as well as its associated control system and the rudder angle indicator. For small naval ships and the naval ships of restricted service III, PRS may permit restriction of the source of power capacity to be sufficient for at least 10 min of continuous operation of the steering gear drive, as well as its associated control system and the rudder angle indicator.

5.5.7 The operating conditions of the electric drive of active means of steering the naval ship are to conform to the operating conditions of the whole system and the electric motors are to be calculated at least for a short-time duty of 30 minutes.

5.5.8 The electric and electrohydraulic drive for the steering gear is to ensure:

.1 putting the rudder over from one side to the other side within the time and angle stated in sub-chapter 6.2.1 of *Part VII – Machinery, Boilers and Pressure Vessels;*

.2 continuous putting the rudder over from one side to the other side during 30 minutes for each set with the rudder blade fully immersed and at maximum ahead speed corresponding to such draught;

.3 continuous operation during one hour at the maximum service speed ahead with putting the rudder over through an angle so as to ensure 350 such operations per an hour;

.4 possible stalling of the electric motor in ”on” position at the rated supply for one minute from hot state (only for rudders fitted with the direct electric drive);

.5 sufficient strength of electric drive in the presence of mechanical forces created at maximum speed astern; it is recommended to provide a possibility of putting the rudder over at the average speed astern.

5.5.9 Starting and stopping of the steering gear electric motors other than the electric motors of rudders with direct electric drive are to be effected from the steering gear room and from the main command station/ navigation bridge.

5.5.10 The starting devices are to ensure automatic restarting of electric motor as soon as the voltage is restored after interruption in power supply.

5.5.11 Visual and audible signals are to be provided on the main command station/navigation bridge and at the main engine control station to indicate:

.1 the loss of voltage, the absence of phase and the overload in the supply circuit of each energetic set;

.2 the loss of voltage in the control system supply circuit;

.3 the low level of oil in a service fuel tank.

Moreover, an indicator is to be provided to indicate that the electric motors of the steering gear power units are running.

5.5.12 The control systems of the steering gear electric drive, required by sub-chapter 2.6 of *Part III – Hull Equipment*, are to be supplied from the steering gear power circuit in the steering gear compartment or directly from the main switchboard busbars.

5.5.13 Means are to be provided in the steering gear compartment for disconnecting from the steering gear any control system operable from the main command station/ navigation bridge.

5.5.14 Each remote control system, specified in sub-chapter 2.6 of *Part III – Hull Equipment* is to be equipped with its own independent circuit transmitting the steering signals to the rudder steering mechanism.

5.5.15 It is permitted to use a steering wheel, a handle or push-buttons as manual controlling means on the control desk. The direction of rotation of the rudder wheel or the direction of the movement of the control gear handle is to be in accordance with the direction of putting the rudder over. In the push-button control system, the push-buttons are to be arranged in such a manner that the push-button located on the right side causes the rudder blade to move rightward, while the button on the left side – leftward.

5.5.16 It is permitted to install in naval ships automatic pilots controlling the ship's steering gear by means of their own transmission gear or by means of the ordinary manual control system.

5.5.17 Automatic pilot is to be capable of keeping the ship on a predetermined course with accuracy ± 1°, at the ship's speed not less than 6 knots.

Maximum amplitude of yawing from the predetermined course is not to exceed:

.1 ± 1° at sea state up to 3 degrees,

.2 ± 4° at sea state up to 5 degrees and the wave direction not exceeding ± 45° from ship's course.

5.5.18 If automatic pilot is connected to two independent sources of information on actual course, a visual signalling is to be provided to indicate the exceeding of the limit difference between the course values.

5.5.19 A device is to be provided for manual adjustment of the rudder putting-over sensitivity of the automatic pilot depending on voyage conditions, as well as a possibility of automatic pilot adjustment according to the ship's manoeuvring characteristics.

5.5.20 Automatic pilot is to be fitted with a device capable of restricting the putting-over of the rudder within the limits not exceeding 35° to each side.

5.5.21 Indicators are to be provided to inform on determining or obtaining maximum rudder putting under automatic control.

5.5.22 Adequate visual signalling system indicating power supply "on" in the circuit and the kind of control is to be provided. Simultaneous audible and visual signals are to be also fitted to indicate overload in the steering gear electric motors.

It is recommended to provide audible signalling system indicating the ship's inadmissible serving from the predetermined course under automatic control.

5.5.23 Automatic pilot control system is to be of a completely self-synchronised type and it is not to require any regulation during switching over from one kind of operation to another.

5.5.24 The control desk of the automatic pilot is to be provided with a device for manual control of the steering gear.

5.5.25 Manual control of the steering gear is to be simple and reliable and is to be capable of efficient operating, without complex elements used in automatic control systems.

5.5.26 Switching over from automatic control to manual control is to be effected by one manipulation only in not more than 3 seconds, irrespective of the rudder position.

5.5.27 The arrangement and construction of the automatic pilot are to ensure the possibility for manual control of the rudder from any of the steering stations available on board the naval ship in the event of any damage to the automatic control system.

5.5.28 The following instruments and devices are to be mounted on the control desk of the automatic pilot: repeater of gyrocompass or repeater of magnetic compass, true and intended rudder position display, devices switching on the power supply to the whole system of control and electric motors of the steering gear, change-over switches of sensitivity and various kinds of control, signal lamps as required in 5.5.18, 5.5.21 and 5.5.22 and other means of operational control and adjustment.

5.5.29 Repeater, true and intended rudder position display, switching and operation control means of electric motors of the steering gear need not be installed on the control desk, provided the executive mechanism of the automatic pilot is built in the control desk or is installed as a separate device directly connected to the ordinary manual steering gear control station.

5.5.30 The automatic pilot control desk is to be provided with fuses or circuit-breakers capable of protecting all essential circuits against short-circuit.

5.5.31 The control desk is to be provided with the light regulation of the repeater of the compass rose and steering gear position indicator.

5.5.32 The automatic pilot is to be provided with a device capable of changing the predetermined ship's course to any other course by manual operation within the limits of at least ±15°, under automatic control, without switching over to manual control.

5.5.33 It is recommended to provide the set of the automatic pilot with two additional remote control stations for manual control capable of ensuring rapid manual changing of the ship's course when proceeding under automatic control.

The value of the rapid change of the ship's course should be possible up to the complete circulation. The remote control stations intended for manual control are to be so arranged as to ensure the return of the ship to the predetermined course and further functioning of the automatic control system after the control handle (push-button) of the station is set in neutral position.

5.5.34 Adaptive automatic pilot is to meet the following requirements:

.1 to ensure, without the services of a helmsman, optimum operation of the rudder in various ship's navigation conditions and under the change in the distribution of cargo, ship's speed and trimming;

.2 to enable simultaneous and parallel operation of two steering gear motors in difficult navigation and weather conditions.

5.6 Electric Drives for Anchor and Mooring Machinery

5.6.1 In addition to the requirements given in sub-chapters 6.3 and 6.4 of *Part VII – Machinery, Boilers and Pressure Vessels*, the drives of windlasses, anchor and mooring capstans and mooring winches are to meet the requirements of the present sub-chapter.

5.6.2 The alternating-current squirrel-cage electric motors for driving the windlasses and mooring winches are to withstand, after 30-minute operation at the rated load, the stalling in ”on” position at the rated voltage for at least 30 seconds for windlasses and at least 15 seconds for mooring winches. For motors with a change-over of the number of poles, this requirement is to be complied with for operating with winding developing the largest starting torque.

The direct-current electric motors and the alternating-current wound-rotor electric motors are to withstand the above stalling conditions but at the torque twice that of the rated value; the voltage, in this case, may be reduced below the rated value.

After stalling conditions, the temperature rise is not to be over 130 per cent of the permissible value for the insulation used.

5.6.3 In anchor and mooring winch at the speed steps intended for mooring operations, not intended for anchor lifting, provision is to be made for appropriate overload protection of electric motor.

5.6.4 The power supply of windlass electric drives is to meet the requirements of 4.3.1 and 4.3.3.

5.7 Electric Drives for Pumps

5.7.1 The electric motors of fuel and lubricating oil transfer pumps as well as of oil separators are to be provided with three remote switching devices, one of which is to be located outside the spaces in which these pumps/separators are located and outside the machinery casing, but in direct vicinity of the exits from these spaces. The two other positions are to be in central control station and in the main control station/navigation bridge.

5.7.2 The electric motors of the pumps transferring the liquids outboard through the drain holes above the lightest waterline at locations where lifeboats or liferafts are lowered, are to be provided with non-manoeuvring switching devices located near the control stations of the driving machinery for lowering the relevant boats or rafts.

5.7.3 The electric motors of submersible bilge pumps and emergency fire pumps are to be provided with a remote-starting device located above the bulkhead deck. The remote starting device is to be provided with the visual signal to indicate that the electric drive is switched on.

5.7.4 The remote switching devices mentioned in 5.7.1 and 5.7.2 are to be located in conspicuous places under transparent, easily breakable covers and are to be provided with informative notices.

In catamarans, these devices are to be grouped separately for each hull.

5.7.5 The local starting of fire and bilge pumps is to be possible even in case of failure in their remote control circuits.

5.8 Electric Drives for Fans

5.8.1 The electric motors for ventilation fans in machinery spaces are to be provided with at least three remote switching devices, one of which is to be located outside these spaces and their casings but in direct vicinity to the entries to these spaces. It is recommended to install such switching devices in one place together with the switching devices mentioned in 5.7.1. The two other positions are to be in central control station and in the navigation bridge.

5.8.2 The electric motors for ventilation fans serving store-rooms and galley fans are to be provided with switching devices at locations readily accessible from the main deck, but outside the machinery casings.

Electric motors of exhaust fans from the space above galley ranges are to be provided with additional switching devices located inside the galley room.

5.8.3 The electric motors for general shipboard ventilation are to have at least three devices for their remote switching off from the navigation bridge/main command station, central control station and from the watchman special compartment (when the ship is not underway). Where provision has not been made for a watchman compartment, the third switching-off device is to be fitted in a place easily accessible from the main deck.

In ships with a low-rated electrical installation, one remote disconnecting switch may be used, located on the navigation bridge/main command station or in a place easily accessible from the main deck.

5.8.4 The supply and exhaust ventilation in spaces protected by a smothering system is to stop automatically when such a system is being put into operation.

5.8.5 The remote switching devices of electric motors for ventilation fans specified in 5.8.1 ÷ 5.8.3 are to be grouped on board the ship so that all the electric motors may be remotely switched off from not more than three places.

In catamarans these devices are to be grouped separately for each hull.

5.9 Electric Drives for Boat Winches

5.9.1 The electric drives of boat winches are to comply with the requirements given in *Part X – Statutory Equipment and Requirements*, Chapter 4.

5.9.2 The controls of the boat winch electric drives are to be provided with self-return to the ”Stop” position.

5.9.3 A switch in the main current of the winch electric motor is to be installed near the boat winch control station.

5.10 Electric Drives for Watertight and Fire Doors

5.10.1 The electric drives of watertight doors are to meet the requirements of sub-chapter 7.9 of *Part III – Hull Equipment* and the requirements of this sub-chapter.

5.10.2 Power supply of electric drives and of signals indicating the position and closing of watertight doors is to be effected from the main, emergency and transitional source of power, in accordance with the requirements given in 4.3.1.20.

5.10.3 The electric drives of the devices keeping the fire doors in the open position are to comply with the following:

- **.1** they are to be supplied by main and emergency sources of electric power;
- **.2** they are to be provided with signals indicating loss of voltage supply;
- **.3** they are to be provided with remote control from the navigation bridge/ central control station ensuring the release of each of the doors separately, in groups or all of them at the same time;
- **.4** they are to release automatically all the fire doors at the same time in the event of loss of voltage supply;
- **.5** they are to be so designed that any failure of the release mechanism of a particular door does not stop the operation and control of other doors.

6 LIGHTING

6.1 General Requirements

6.1.1 In all rooms, spaces and locations of the naval ship where lighting is necessary to ensure the safety of navigation, operating of machinery and equipment, as well as accommodation and evacuation of crew, stationary fixtures of the main lighting supplied from the main source of electric power are to be installed.

The list of rooms, spaces and locations in which, in addition to the main lighting, fixtures of emergency lighting are to be installed, is given in 9.3.1.1.

6.1.2 The main lighting installation is to be so designed that lighting of all the places mentioned in 6.1.1 is to be ensured, the maximum resistance of the installation to mechanical damage, including damage in operation conditions, being maintained.

6.1.3 Lighting fixtures installed in rooms, locations and spaces where mechanical damage is possible to the hoods are to be provided with protection gratings or hoods made of material resistant to mechanical shocks.

6.1.4 Lighting fixtures are to be installed in such a manner as to prevent heating of cables and adjacent materials up to a temperature exceeding the permissible level.

6.1.5 In rooms and places illuminated with luminescent lamps where visible rotating parts of machinery are located, all measures are to be taken to prevent stroboscopic effect.

6.1.6 External lighting fixtures are to be installed in such a manner as not to dazzle the crew present at operational positions and in the ship command positions.

6.1.7 In rooms, locations and spaces lighted with discharge lamps, which do not ensure the continuity of lighting at the voltage variations specified in 2.1.3.1, lighting fixtures with incandescent lamps, are to be provided.

6.1.8 Battery compartments and other explosion-hazardous spaces are to be illuminated with lighting fixtures located in adjacent safe spaces through gas-tight windows or with explosion-proof lighting fixtures installed inside such spaces (see also 2.8).

6.1.9 In ammunition stores, lighting fixtures of at least IP65 protection degree of the casing are to be used.

6.1.10 In places where local vibrations occur of linear acceleration exceeding $20 m/s^2$, the lighting fixtures are to be fitted on shock absorbers.

6.2 Supply to the Lighting Circuits

6.2.1 The main lighting section switchboards are to be supplied by separate feeders solely intended for that purpose:
- from two different sections of the main switchboard busbars – in naval ships with one main switchboard,
- from two different main switchboards – in naval ships with two or more main switchboards.

The above requirement does not apply to naval ships with low-rated electrical installation.

6.2.2 Lighting of ship command stations, armament control stations, corridors and stairways, machinery spaces, propeller shaft tunnels, boiler water-level indicators is to be supplied from not less than two independent feeders. The feeders are to be supplied by different section switchboards. The lighting fixtures are to be arranged in such a manner that in the event of failure of either feeder uniformity of lighting will be ensured.

In ships with a low-rated electrical installation, one feeder may supply the lighting circuits in the above-mentioned spaces, except machinery spaces, from the section switchboard or directly from the main switchboard.

6.2.3 If the ship is divided into main fire zones, lighting of each zone is to be supplied by two feeders which are separated from the feeders supplying the lighting circuits in other fire zones.

As far as possible, the lighting feeders are to be installed in such a manner that a fire in one zone cannot damage the feeders supplying the lighting circuits in other zones.

Such feeders are to be connected to different section switchboards.

6.2.4 Where the lighting in any of main fire zones is supplied from two or more switchboards located in this zone, these switchboards are to be located, as far away each other as possible.

6.2.5 In addition to the lighting final sub-circuits, the main lighting switchboards may supply the electric drives of non-essential services rated up to 0.25 kW and individual space heaters rated up to 10 A.

6.2.6 The protections of the lighting final circuits of individual spaces are to be designed for the rated current not exceeding 16 A and the total circuit current is not to exceed 80 per cent of the rated current of the applied protection.

The number of lighting fixtures supplied from the lighting final circuits is not to exceed that specified in Table 6.2.6.

Table 6.2.6

Item	Voltage	Maximum number of lighting fixtures
1	Up to 50 V	10
2	from 51 to 120 V	14
3	from 121 to 250 V	24

The cabin fans and other minor consumers may be supplied from the lighting final circuits.

6.2.7 Local lighting fixtures in crew spaces, as well as socket-outlets are to take power from the lighting switchboard by a separate feeder other than that intended for supplying the common lighting fixtures.

6.2.8 The main lighting system is to be so designed that a fire or other failure in the spaces containing the main source of electric power and/or the main lighting transformers does not cause the disconnection of the emergency lighting.

6.3 Emergency Lighting

6.3.1 Emergency lighting is to be installed onboard each naval ship. This requirement does not apply to small port and roadstead craft with lighting system supplied from accumulator batteries, constituting the main source of power.

6.3.2 The intensity of emergency lighting in the respective spaces, locations and areas, mentioned in 9.3.1.1, is to be equal to at least 10 per cent of the general lighting intensity (see 6.7).

Emergency lighting intensity in the engine room may be lower if socket outlets, supplied from the emergency lighting system, are provided in this space, but it is to equal to at least 5 per cent of the general lighting intensity.

This lighting is to ensure easy identification of the escape routes.

6.3.3 For the purpose of achieving the intensity of lighting required by 6.3.2, incandescent lamps, together with gas discharge lamps, may be applied (see also 6.1.7).

6.3.4 The main lighting lamps may be used as the lamps of the emergency lighting, provided that they are supplied from the emergency source of electric power.

6.3.5 The emergency lighting system is to be so designed that a fire in the spaces containing the emergency source of electric power and/or emergency lighting transformers will not disconnect the main lighting.

6.3.6 Permanently fixed, independent, automatically switched on lamps with built-in accumulator batteries and automatically recharged from the main lighting circuits may be used for the emergency lighting.

6.3.7 Each emergency lighting fixture is to be painted red. This requirement concerns also lighting fixtures mentioned in 6.3.4.

6.4 Switches in Lighting Circuits

6.4.1 Two-pole switches are to be used in lighting circuits. In dry crew and service spaces except main command station/navigation bridge, single-pole switches may be used in circuits of individual and group lighting fixtures with a total power consumption of not more than 6 A, as well as in safety-voltage lighting fixtures.

6.4.2 In the emergency lighting circuits, as a rule, no switches are to generally be fitted for the local disconnecting of fixtures. These switches may be used only in such circuits of the emergency lighting lamps, which, under normal conditions, are the lamps of the main lighting.

Emergency lighting lamps of places near lifeboats and liferafts, as well as outboard spaces, which in normal conditions are main lighting lamps, are to switch on automatically at the voltage decay. It is permitted to switch them on by central switches located on the main command station/navigation bridge, provided that these lamps switch on automatically after repeated voltage decay.

The emergency lighting circuits of the main command station/navigation bridge are to be provided with switches.

6.4.3 Permanently installed ship's external lighting fixtures are to be provided with central switches located on the main command station/navigation bridge or in any other permanently attended place.

6.4.4 The switches of lighting circuits of the fire extinguishing stations storage spaces for ammunition and of the battery room are to be located outside these spaces.

6.4.5 The lighting switches behind free-standing switchboards are to be installed near each entry behind the switchboard.

6.5 Fluorescent and Gas Discharge Lamps

6.5.1 Reactors, capacitors and other ancillary gear of gas discharge lamps are to be protected by securely earthed metal enclosures.

6.5.2 Capacitors of 0.5 μF and above are to be fitted with discharging devices. The discharging device is to be so designed that the voltage of the capacitor does not exceed 50 V 1 minute after disconnection from the supply.

6.5.3 Reactors and transformers having a high reactance are to be installed as close as possible to the lighting lamp they serve.

6.5.4 Gas discharge lamps supplied by a voltage exceeding 250 V are to be provided with warning notices stating the voltage rating.

6.6 Socket Outlets and Plugs

6.6.1 Socket outlets for portable lighting fixtures are to be installed at least:

- **.1** on deck near the windlass,
- **.2** in the steering gear compartment,
- **.3** in the machinery spaces,
- **.4** in the naval ship command post,
- **.5** behind the main switchboards,
- **.6** in special enclosed electrical spaces,
- **.7** in the emergency generator set compartment,
- **.8** in the propeller shaft tunnel,
- **.9** in the vicinity of the log trunk and echo sounder,
- **.10** in the gyrocompass room,
- **.11** in spaces where centralised ventilation and air conditioning installations are located.

6.6.2 Socket outlets installed in circuits with different voltages are to be so designed as to prevent insertion of a plug intended for one voltage into a socket intended for another voltage.

6.6.3 Socket outlets of portable lighting and other electric appliances, installed on weather decks, are to be adapted for insertion of the plug from the underside.

6.6.4 Socket outlets cannot be installed in machinery spaces below the floor, in the enclosed spaces of fuel or lubricating oil separators or in places where the explosion-proof type equipment is required.

6.7 Illumination Intensity

6.7.1 The intensity of illumination of rooms and spaces is not to be below that specified in Table 6.7.1. These requirements are not applicable to ships provided with lighting circuits supplied at a voltage below 30 V.

The general illumination standards, stated in Table 6.7.1, refer to the level of 800 mm above the compartment floor, while the general illumination standards, plus local ones, refer to the level of the working areas.

Table 6.7.1

Lp.	Spaces and surfaces		Illumination intensity, lux			
			Lighting other than incandescent		Incandescent lighting	
			general + local	general	general + local	general
1	2	3	4	5	6	7
1	Chart room	at level of 0.8 m above floor	–	100	–	50
		chart tables	150	–	150	–
2	MCS/navigation bridge	at level of 0.8 m above floor	–	75	–	50
3	Armament control station, hydrolocation and internal communication rooms. Armament equipment spaces	Work tables	150	–	150	–
		at level of 0.8 m above floor	–	75	–	50
4	Engine rooms, spaces for switchboards, manoeuvring and control stations, spaces for automation facilities and gyrocompasses	at level of 0.8 m above floor	–	75	–	75
		surfaces of switchboards and control and monitoring desks	200	100	150	75
		main engine controls stand	150	100	150	75
		passageways between boilers, machinery, engines, stairs	–	75	–	30
		in front of boilers	100	75	75	75
5	Propellers shaft tunnels, log and echo sounder trunks, chain lockers	at level of 0.8 m above floor	–	50	–	20
		surfaces of shaft bearings and connection flanges, etc.	75	–	50	–
6	Weapon store-rooms, ammunition chambers	at level of 0.8 m above deck	–	75	–	50
7	Battery compartments	at level of 0.8 m above floor	–	75	–	50
8	Passageways on decks, gangway bridges and lifeboat and liferaft positions	at level of 0.8 m above deck	–	50	–	20
9	Overside spaces in way of lifeboat and liferaft lowering	near the load waterline	–	–	–	5

6.8 Navigation Lanterns

6.8.1 The navigation lantern switchboard is to supply, by separate feeders, the masthead lights, side lights and the stern light, and also permanently mounted lights specified in *Part X – Statutory Equipment and Requirements*, as well as lights for special equipment of the naval ship.

6.8.2 The navigation lantern switchboard is to be supplied by two feeders:

.1 one feeder from the main switchboard through the emergency switchboard;

.2 the second feeder from the section switchboard which is not supplied by the emergency switchboard.

The navigation lantern switchboard installed in the ship control and monitoring console may be supplied directly from the console, provided it is supplied in compliance with 4.4.2.

In ships with low-rated electrical system where the main source of electric power is an accumulator battery and the main switchboard is located on the main command station/navigation bridge, the navigation lanterns may be supplied directly from the switchboard.

6.8.3 Navigation lanterns are to be connected to the network by flexible cables and plug connectors.

6.8.4 Each feeding circuit of navigation lanterns is to be of two-wire type with a double-pole switch installed in the navigation lantern switchboard.

6.8.5 Each navigation lantern feeding circuit is to be provided with short-circuit protection in both wires and with optical signal of proper functioning of each navigation lantern.

The visual indicator is to be designed and installed in such a manner that its damage does not cause the disconnection of the navigation lantern. A voltage drop on the supply switchboard of navigation lanterns, including the signalling system of functioning of the lantern, is not to exceed 5 per cent at the rated voltage up to 30 V and 3 per cent at the voltage over 30 V.

6.8.6 Irrespective of the signals required in 6.8.5, provision is to be made for visual and audible signals functioning in the case of failure of any navigation lantern with the switch in the ”on” position.

The power supply of signals is to be taken:

– from a circuit or a source other than that used for the power supply of navigation lantern switchboard, or
– from an own accumulator battery.

6.8.7 The lamp holders and lamps used in navigation lanterns are to meet the requirements of the COLREG Convention.

6.9 Lighting of Helicopter Landing Zones

6.9.1 The lighting system of the helicopter landing zones is to comply with the *NO-07-A025:2000 Standard – Wspólne działania okrętów i statków powietrznych.*

7 SIGNALLING

7.1 General Requirements

7.1.1 It is recommended that signalling and internal communication systems are to meet applicable requirements of this Chapter as well as with the provisions of the Code on Alarms and Indicators, 1995, adopted by IMO.

7.2 Electric Engine Room Telegraphs

7.2.1 In addition to the requirements of the present sub-chapter, the electric engine-room telegraphs are to meet the requirements given in 1.14.1 of *Part VI – Machinery Installations and Refrigerating Plants.*

7.2.2 The engine-room telegraphs are to be provided with a visual signal of the presence of voltage in the power supply circuit supplying the engine-room telegraphs and the sound signalling of power decay.

7.2.3 The engine-rooms telegraphs installed in the wheelhouse are to be provided with scale lighting permitting adjustment of illumination intensity.

7.2.4 The engine-room telegraphs are to take their power supply from the main switchboard or from the navigation equipment switchboard. If the ship is provided with a ship's navigation control and monitoring console (main command station), the engine-room telegraph may take its power supply from this control console.

7.2.5 The engine-room telegraph transmitter in the wheelhouse is to be installed in such a way that in the case of transmitting commands concerning the running of the naval ship, the handle or pushbuttons of the transmitter are set in accordance with the direction of the ship's running. The vertical position of the handle or the middle pushbutton is to correspond to the command "Stop".

7.2.6 When the engine-room telegraph, as well as remote controls of the main engines and controllable pitch propellers are installed on an inclined panel of the control desk, the handle in the "STOP" position is to be vertical to the desk and is to remain exactly in this position.

7.2.7 Where two and more engine-room telegraphs are located in close proximity to one another (on one deck), they are to ensure the transmission of commands from any telegraph and the reception of reply by all of them simultaneously, without any additional switching.

The change-over to telegraphs located on another deck or in another part of the naval ship is to be performed by switches fitted in the wheelhouse.

7.2.8 Each engine-room telegraph is to be provided with an audible signal, on the navigation bridge and in the machinery space, operating at communicating orders and switching off after receiving a correct response. When the response is incorrect, the audible signal should remain operating.

7.3 Alarm System

7.3.1 Every naval ship is to be provided with an alarm system. The system is to be capable of sounding the alarm signal by a whistle or siren, or other sounds, as well as displaying red light visual signal. In spaces where the sound signal may interfere with work, only visual signals may be used.

The minimum sound pressure levels for the alarm tone in open and closed spaces is to be 80 dB(A) and at least 10 dB(A) above ambient noise levels. In cabins, loudspeaker system is to be used for transmitting sound signals and in cabins without the loudspeaker installation, a buzzer or a similar sound device is to be installed.

Detailed requirements for each type of signal system are to be agreed with PRS in each particular case.

7.3.2 Signalling devices are to be installed in the following places:

.1 in machinery spaces;
.2 in public spaces;
.3 in accommodation spaces;
.4 in corridors;
.5 on open decks near manoeuvring posts;
.6 in other spaces agreed with PRS.

7.3.3 The alarm system is to be supplied from the ship's network and from the emergency switchboard busbars.

The general alarm system may be supplied from the ship's network and from own accumulator battery, provided that automatic switch-over of supply circuit to accumulator battery is ensured. In such case, supply from emergency and transitional source of electric power is not required.

The general alarm system is to be power supplied continuously, irrespective of the accumulator battery being set in position for charging or discharging.

7.3.4 When general alarm system is provided with its own accumulator battery, this battery may also be used for supplying other internal communication appliances, provided the battery capacity is sufficient for simultaneous supply of electric power to all connected appliances for at least 3 hours and the system is so designed that a damage to any circuit does not interfere with operation of other circuits and the prospective period of supplying the appliances is not long.

7.3.5 Power supply circuits of alarm system are to be provided only with short-circuit protection. Protection devices are to be fitted in all wires of supply circuit, as well as in circuits of each signalling device, if the system is not of self-controlled type.

7.3.6 Sound devices of alarm system are to be so located that a signal is clearly heard against the noise in the given space. Sound devices installed in spaces with high intensity of noise are to be also fitted with visual signals.

7.3.7 The sound of the general alarm system is to be different from the sounds of all other signalling systems.

7.3.8 The alarm signal is to be activated from the wheelhouse and, except for the ship's whistle, also from central fire-fighting station and from the compartment intended for the watch when the ship is in a port. The alarm should continue to operate until it is manually turned off or overridden by the public address system broadcast. The switching device activating the alarm system is to automatically return to starting position after the activating load is withdrawn.

7.3.9 No switching devices are to be incorporated into the circuits of the alarm system other than the switches activating the alarm. However, if it is necessary to install switches in the alarm system switchboards, they are to be protected from accidental activation. Intermediate contactors connected by means of a switch may be used; however, not more than one contactor in each branch is to be fitted.

7.3.10 Signalling devices, switches and distribution boxes of the alarm system are to be provided with readily visible distinctive marking.

7.3.11 Audible devices of the alarm system are to have at least two circuits connected by one switch and so located that in large spaces (machinery spaces, boiler spaces and other spaces) audible devices supplied from different circuits are installed.

7.3.12 Activation of general alarm system is to override all music channels of all broadcasting systems.

7.4 Fire Detection System

7.4.1 General Requirements

7.4.1.1 In addition to the requirements of the present sub-chapter, fire detection system is to meet the requirements given in Chapter 4 of *Part V – Fire Protection.*

7.4.1.2 Except the activation of fire alarm, fire detection system may be used for the alarm system and control of:

- **.1** public address system;
- **.2** stopping fans;
- **.3** closing fire doors;
- **.4** closing fire dampers;
- **.5** sprinkler system;
- **.6** smoke extraction system;
- **.7** additional low-location lighting.

7.4.1.3 Fire detection control panels are to be located in the wheelhouse and/or in the main fire control station and/or another accessible place, where the fire detection alarm will result in undertaking proper action by the crew.

7.4.1.4 Fire detection system is to be of self-controlled type and is to give visual and audible alarm signal in an emergency e.g. switching over to emergency power supply or power decay. Signalling of the system emergency conditions is to be different than fire alarm signal.

7.4.1.5 Detection of raised temperature, smoke or other combustion products is to actuate visual and audible alarm in the fire detection control panels and in the wheelhouse.

7.4.1.6 Informative plates identifying section number and spaces or regions covered by the detection system are to be located in fire detection control panels or close to them.

7.4.1.7 Cables and conductors of fire detection system are not to run through galleys, machinery spaces of category A and other high fire risk spaces, except supply cables and fire detectors installed in these spaces.

7.4.2 Fire Detection System in Compartments and Engine-Rooms

7.4.2.1 Fire detection system is to be installed in accommodation, public spaces, service spaces, command stations and in the machinery spaces of naval ships.

7.4.2.2 Fire detection system is to be supplied by separate feeders from two independent electric power sources.

Where the main source of power supply is the main source of electric power, the second (stand-by) source of power supply is to be the emergency source of electric power or an accumulator battery. Where the main source of electric power supply is an accumulator battery, the second (stand-by) battery is to be provided. Each of the batteries is to meet the requirements of 9.3 or 22.1.2 in respect of its capacity and location.

Change-over to the stand-by source of power supply is to be effected automatically with a simultaneous operation of alarm signal specified in 7.4.1.4.

7.4.2.3 Detectors and manually operated call points are to be connected into loops corresponding to sections specified in Chapter 4 of *Part V – Fire Protection*. Activation of a detector or a manually operated call point is to result in operation of audible and visual alarm in the fire detection control panel or in the alarm indicating unit, giving the number of activated loop (section of detectors).

7.4.2.4 In the case of fire in machinery spaces, the alarm should be immediately audible within accommodation spaces of the responsible engine-room crew.

7.4.2.5 If the alarm signals given in 7.4.2.3 and 7.4.2.4 have not received attention within 2 minutes at the fire detection control panel, the audible alarm is to be automatically sounded at command posts, in service spaces and crew accommodation. This alarm sounder system in the above-specified spaces need not be an integral part of the fire detection system.

7.4.2.6 Indicating units are to identify at least number of loop (section), where a detector or manually operated call point has been activated.

At least one indicating unit is to be continuously easily accessible at sea and in port to responsible crew members.

One indicating unit is to be located in the wheelhouse if fire detection control panel is located in the main fire control station or in other location (see 7.4.1.3.).

7.4.2.7 An informative plate specified in 7.4.1.6 is to be provided near each indicating unit.

7.4.2.8 Fire detection system is to ensure remote detector identification and is to meet the following requirements:

.1 Loop configuration is to preclude damage in more than one place, which means that data highway is not to run through protected zone more than once, and where it is not possible e.g. in large general purpose compartments, the loop parts running through again are to be installed as far away one of another as practicable;

.2 Any fault occurring in the loop e.g. power decay, short-circuit, earth, is not to cause the whole loop ineffective, but only a part of it, of the size equal to the size of fire detection system loop;

.3 Arrangements are to be provided to ensure restoration of the initial configuration of the system after the repair/elimination of failure;

.4 The first indicated fire alarm would not prevent any other detector from initiating further fire alarms.

7.4.2.9 Detectors are to be operated by heat, smoke or other combustion products, flame or any combination of these factors. Flame detectors may only be used in addition to smoke or heat detectors. Installation of other detectors will be separately considered by PRS in each particular case, provided that they are as sensitive to the initial stage of fire as the detectors specified above.

7.4.2.10 Heat detectors are to be certified to operate before the temperature exceeds 78 °C, but not until the temperature exceeds 54 °C, when the temperature rises to these limits at a rate less than 1 °C per minute. Sensitivity limits of heat detectors for other temperature rises will be separately considered by PRS in each particular case.

7.4.2.11 Smoke detectors to be installed in stairways, corridors and escape routes within accommodation spaces are to be certified to operate before the smoke density exceeds 12,5% obscuration per cubic metre, but not until the smoke density exceeds 2% obscuration per cubic metre. Sensitivity limits for smoke detectors intended for other spaces will be separately considered by PRS in each particular case.
Smoke density according to EN-54 Standard Part VII – reduction in luminous intensity of the light passing through the smoke, equal to the logarithm of the ratio of the initial luminous intensity to the light intensity after it passes through the smoke volume specified for defined testing conditions.

7.4.2.12 In spaces of a normal high ambient temperature, the permissible operation temperature of heat detectors may be increased to 30 °C above the maximum deckhead temperature. Operation temperature of heat detectors in drying rooms and similar spaces may be up to 130 °C, and up to 140 °C in saunas.

7.4.2.13 All detectors are to be of such design that they can be tested for correct operation and restored to normal surveillance without the necessity of the renewal of any component.

7.4.2.14 Where fire detectors are provided with the means to adjust their sensitivity, necessary arrangements are to be ensured to fix and identify the set point.

7.4.2.15 Where there is a possibility of temporary switching off a particular loop or detector, it is to be clearly indicated at a fire detection control panel and reactivation is to be performed automatically after the preset time.

7.4.2.16 It is recommended to provide each detector with visual indicator to enable confirmation of its operation.

7.4.2.17 The installation of detectors of the fire detection system in explosion-hazardous spaces or located in the stream of air sucked from these spaces is to comply with the requirements of 2.8 and 22.4.4.

7.4.3 Sample Extraction Smoke Detection System in Holds

7.4.3.1 Sample extraction smoke detection system in holds, operating on the principle of the analysis of the air coming from the protected spaces to the analysing unit, is to be supplied, together with the fans, from the main and other independent stand-by source of electric power. Change-over of power supply to stand-by source of electric power is to be performed automatically with simultaneous activation of alarm signal specified in 7.4.1.4.

7.4.3.2 The system is to be capable of continuous operation for the whole service period. Exception is the system operating on sequential scanning principle, in which interval between scanning the same position twice is to depend on number of sampling points and overall response time of the fans.

The interval is to be calculated from the below formula:

$$I = 1.2 \text{ x } T \text{ x } N, \text{ [s]} \qquad (7.4.3.2)$$

where:
T – response time of air sample extraction, [s];
N – number of air sampling points.

However, maximum permissible interval between two air sample extractions is not to exceed 120 s.

7.4.3.3 The system is to be so designed, constructed and installed as to prevent:

.1 penetration of hold atmosphere into accommodation, service spaces, machinery spaces and command posts;

.2 ignition of flammable mixtures of gas and air.

7.4.3.4 The system is to ensure:

.1 testing correct operation and restoring to normal surveillance without the renewal of any component;

.2 observation of air in each sampling pipe;

.3 extracting, as far as practicable, equal quantity of air through each smoke accumulator.

7.4.3.5 Sample extraction fans are to be duplicated and have sufficient capacity to suck air from the farthest spaces with the mechanical ventilation in these spaces switched on.

The complete time of air sample extraction is not to be longer than 15 s.

7.4.3.6 The sensing unit is to be certified to operate before the smoke density within the sensing chamber exceeds 6.65% obscuration per cubic metre.

7.5 Warning Signalisation of Fire Extinguishing Systems Operation

7.5.1 In addition to the requirements of the present sub-chapter, warning signalling systems indicating that a fire extinguishing system is put into action, is to meet also the requirements given in Chapter 4 of *Part V – Fire Protection*.

7.5.2 Warning signalling system is to be supplied from the naval ship's main source of electric power and from accumulator battery of the capacity sufficient to provide power supply for 30 minutes. An automatic change-over of its supply to an accumulator battery in the case of voltage decay in the ship's network is to be provided.

7.5.3 Warning signal is to be:

.1 activated automatically e.g. by opening doors of control boxes of manual and remote mechanism activating fire-fighting system;

.2 activated ahead of activation of fire-fighting system operation – see 3.6.4.5 of *Part V – Fire Protection*;

.3 audible in spaces with fire-fighting system in usual noise conditions;
.4 different than any other audible signal;
.5 provided with additional visual signal in spaces of excessive noise.

7.6 Indication of Closing Watertight and Fire Doors

7.6.1 The indication of closing watertight doors is to meet the requirements of 7.4.8.4 to 7.4.8.8 and 7.5.6.4 to 7.5.6.8 of *Part III – Hull Equipment*, and the indication of the fire doors position is to meet the requirements of 6.1.8.4, *Part V – Fire Protection*.

7.6.2 PRS shall define in each particular case doors to the spaces, which are to be provided with local opening indication.

7.7 Indication of Opening and Recording of Access to Special, Cryptographic Communication and Registered Information Office

7.7.1 The alarm signal devices are to be located in the wheelhouse and in the watch crew rooms. The access recording equipment is to be protected from loss of data and access of unauthorised persons.

7.7.2 The requirements for the installation and supply of the signal system specified in 7.7 are to be agreed with PRS in each particular case.

7.8 Alarm System in Protected Spaces for the Storage of Hand Weapon, Armament Equipment, Artillery and Rocket Ammunition as well as Explosives

7.8.1 The alarm signal devices are to be located in the wheelhouse and in the watch crew rooms.

7.8.2 Type, amount and arrangement of detectors are to depend on type of ammunition or explosives and are to be agreed with PRS in each particular case.

7.8.3 The warning signal system is to be supplied from the naval ship's main source of electric power and from accumulator battery having capacity sufficient to provide power supply for 30 minutes. An automatic change-over of supply to an accumulator battery in the case of voltage decay in the ship's network is to be provided.

8 PROTECTIVE DEVICES

8.1 General Requirements

8.1.1 Except the case specified in 8.3.3, 8.3.5, 8.4.1 and 8.9.1, outgoing circuits of switchboards are to be protected against short-circuits and overloads by means of suitable devices installed at the beginning of each circuit.

Where circuit overload is not likely to occur, the circuit may be protected against short-circuits only.

8.1.2 Protective devices are to be so matched with the characteristics of the equipment under protection as to operate at all inadmissible overloads.

8.1.3 The protection system is to be discriminative both with regard to the whole range overload currents and to the prospective short-circuit currents.

Protection devices are to be so adjusted that the damage of non-essential consumers or their circuits does not affect harmfully the operation reliability of naval ship's generating plant and the continuity of supplying essential services. Overload and short-circuits protection is not to operate under the effect of starting currents of the protected devices.

8.1.4 Overload protection is to be provided in:

.1 not less than one phase or positive pole in a two-wire system;

.2 not less than two phases in an insulated three-wire three-phase alternating- current system;

.3 all phases in a three-phase four-wire alternating-current system.

8.1.5 High voltage fuses are not to be used as the overload protection devices.

8.1.6 Short-circuit protection is to be fitted in each insulated pole of a direct-current system and in each phase of an alternating-current system.

Short-circuit current protective devices are to be set to operate at not less than 200 per cent of the rated current. Operation may be instantaneous or after a time-lag to allow for the proper discrimination.

Switches or fuses are to be applied as short-circuit protection devices.

To protect feeder cables and consumers against short-circuits, the same protective devices may be used.

8.1.7 Cables connecting switchboards, capable of carrying current in both directions are to be protected against short-circuits at both ends.

8.1.8 Feeders need not have overload protection if:

– consumers or groups of supplied consumers have individual overload protection, and
– continuous current overload of a feeder supplying these consumers have been selected for maximum load.

8.1.9 Where, in any part of supply circuits, the cable cross-section is reduced, additional protection is to be provided unless the previous protective device is capable of protecting the cable of the reduced cross-section.

8.2 Protection of Generators

8.2.1 Generators not intended for parallel operation are to be provided with means of protection against overload and short-circuits and are to have under-voltage protective devices acting simultaneously at all isolated poles or phases. Multi-pole fuses may be used as protective devices for generators rated under 50 kW (kVA).

8.2.2 Generators intended for parallel operation are to be at least provided with the following means of protection:

.1 against overloads;
.2 against short-circuits;
.3 against reverse current or reverse power;
.4 against under-voltage.

Generator protection system against overload is to be provided with visual and audible signals of overload operating with a time-lag of up to 15 minutes at overloads from 100 to 110 per cent of the rated current and be capable of disconnecting the generator after a time-lag corresponding to the generator thermal time constant at overloads within 110 to 150 per cent of the rated current of the generator.

For a setting of the protection to operate at 150 per cent of the rated current of generator, the time-lag should not exceed 2 minutes for a.c. generator and 15 seconds for d.c. generator. At overloads exceeding 150 per cent of the rated current, the disconnection of the generator under such overload is to be instantaneous.

Overload protection setting and time delay values are to be selected to correspond to the overload characteristics of the generator prime mover so that the prime mover is capable of developing the output necessary for the generator to generate the current sufficient for operation of the protecting devices within the time delay period adopted.

The protective devices used for generator overload protection are not to prevent the possibility of re-starting the generator immediately.

8.2.3 Means are to be provided to automatically and selectively disconnect the less essential services in the event of the generator being overloaded.

This load shedding may be carried out in one or several stages, depending on the overload capacity of generators operating in combined system.

In the case the naval ship power plant has not the required power reserve, interlocking arrangements are to be provided precluding automatic start of engines and other high capacity consumers.

These requirements don’t apply to naval ships provided with low-rated electrical system.

8.2.4 Reverse-power protection for generators intended to operate in parallel are to be selected to correspond to the prime mover characteristics. The respective protection settings are to be in accordance with those specified in Table 8.2.4.

Table 8.2.4

Kind of current	Limits of reverse-power protection settings related to generator prime mover	
	Turbine	Internal combustion engine
Alternating current	2–6 per cent of rated output of generator (kW)	8–15 per cent of rated output of generator (kW)
Direct current	2–6 per cent of rated current of generator (A)	8–15 per cent of rated current of generator (A)

Reverse-power and reverse-current protection for direct-current generators is to be installed in the pole opposite to that in which the equalizer is connected. Reverse power or reverse-current protection is still to be capable of operation when the voltage applied is reduced by 50 per cent although reverse current or reverse power may have altered values.

8.2.5 The under-voltage protection is to provide the possibility of connecting the generators to busbars at a voltage equal to 85 per cent or over of the rated value and to preclude their connecting to busbars at a voltage lower than 35 per cent of the rated value, as well as to disconnect generators when the voltage drops at their terminals to a value from 70 per cent to 35 per cent of the rated voltage.

The under-voltage protection is to operate with a time-lag necessary for disconnecting the generators from the busbars in the case of voltage drop and is to operate immediately during the attempt of connecting to busbars a generator, whose voltage has not reached the above-mentioned value.

8.2.6 Protection against damage to connections between the generator and the circuit-breaker, causing de-energizing and immediate switching off the generator, is recommended for generators of rating 1500 kVA and above; additional thermal protection against the internal faults in generator windings is recommended.

8.2.7 If a turbine-driven d.c. generator is intended for operation in parallel with other generator, a device is to be provided to trip the automatic circuit-breaker of this generator when the emergency governor of the turbine operates.

8.2.8 The short-circuit trips with a time-lag are to be so selected that in each case the expected short-circuit current in a protected circuit, after the elapse of the time-lag, is greater than the minimum return current of the trip.

8.2.9 Fuses may be applied as protection of semiconductors in the generator excitation circuits. Overload protection is to be in accordance with thermal characteristics of semiconductors.

8.2.10 Electronic or computerised protection devices for generators and consumers with load current higher than 30% of the smallest generator rated current are to be provided with arrangements to identify the final settings.

8.3 Protection of Electric Motors

8.3.1 Outgoing feeders from switchboards supplying electric motors rated at over 0.5 kW are to be provided with means of protection against short-circuit currents and overloads, as well as with no-voltage protection if motors need not be automatically re-started.

It is admissible for overload and no-voltage protective devices to be installed in the motor starting apparatus.

8.3.2 The overload protective devices for continuously-loaded motors are to be set to disconnect the motor under protection in a range of 105 to 125 per cent of the rated current.

8.3.3 It is admissible for overload protective devices of a set of two independent electric motors driving essential consumers, each having capacity sufficient for driving the consumer to be replaced by audible and visual signals.

8.3.4 Multi-run motors of windlasses, capstans, loading and other appliances, which may be overloaded during operation, are to be provided with thermal protection operating at excessive rise of winding temperature.

8.3.5 The feeders of the electric drives of fire pumps are not to be fitted with overload protection operating on the thermal relay basis. Overload protection may be substituted with visual and audible signals.

8.3.6 For motors protected by fuses, burnout of one phase of the fuse is to result in disconnecting of motor.

8.4 Protection of Steering Gear Motors

8.4.1 Only short-circuit current protection is to be provided for electric motors and control systems of electric and electro-hydraulic steering gear.

Visual and audible alarms warning of motor overload and voltage failure in any of the phases are to be provided.

8.4.2 Short-circuit protection of the circuit-breakers of the d.c. motors of the electric and electro-hydraulic steering gears are to be set for instantaneous release at current not lower than 300 per cent and not higher than 400 per cent of the rated current of the motor under protection, while those used in conjunction with alternating-current motors are to be set for instantaneous release at current exceeding by about 25 per cent the peak starting current of the motor under protection.

Where fuses are used for protection of steering gear motors, the rated current of the fuse elements is to be chosen by one degree higher than that resulting from the choice made on the basis of the starting current of the electric motor.

8.4.3 The electric motors of active means of steering the naval ship are to have short-circuit and overload protection. Overload protection is to give audible and visual signals and is to cause the disconnection of the electric motor within the range required by 8.3.2.

Short-circuit protection is to comply with the requirements of 8.4.2.

8.5 Protection of Transformers

8.5.1 Short-circuit and overload protective devices are to be installed on the supply feeders of transformer primaries.

Transformers rated up to 6.3 kVA may be protected with fuses only.

Overload protection or alarms need not be provided for voltage transformers and transformers supplying control circuits.

8.5.2 Transformers intended for parallel operation are to be provided with switches to disconnect their primary and secondary windings, but not necessarily at the same time.

If these transformers are supplied from different sections of the main switchboard, which may be disconnected during exploitation, interlocking device is to be provided in order to prevent their parallel operation when one of the sections, from which they are supplied, is disconnected.

8.5.3 The connection of current transformers is to be so arranged as to prevent the possibility of their secondary windings being opened during the switching of circuits.

8.6 Protection of Storage Batteries

8.6.1 Means of protection against short-circuit currents are to be provided for storage batteries other than those which are designed to start up internal combustion engines.

8.6.2 Each battery charging system is to be provided with a suitable protection against battery discharge due to a drop or loss of voltage at the outlet from the charger.

8.7 Protection of Pilot Lamps, Voltmeters, Capacitors and Voltage Coils of Apparatus

8.7.1 Pilot lamps, as well as measuring and recording instruments are to be provided with short-circuit protection or elements limiting short-circuit current.

Pilot lamps need not have such protective devices or limiting elements of their own, provided that:

.1 the lamps are supplied through circuits inside the enclosure of the device;
.2 the protection of the device circuit is not exceeding 25 A;
.3 a fault in the lamp circuit is not liable to cause an interruption in the operation of an essential service.

Short-circuit protection and current limiting devices are to be located as close as practicable to the terminals on the supply side.

8.7.2 Radio interference suppression capacitors installed in the circuits of main and emergency switchboards, generators, and essential electrical installations, are to be protected against short-circuit currents.

8.7.3 The voltage coils of apparatus and control or protective devices are to be protected against short-circuit current, but they need not have protection of their own, provided that:

.1 the coils are in the common enclosure of the device, they have common protective devices and they refer to the control system of one device;
.2 the coils are supplied through circuit of the device with protection not exceeding 25 A.

8.8 Protection of Power-Electronic Equipment

8.8.1 Power-electronic semiconductor equipment is to be protected against internal and external overvoltage.

8.8.2 Blocks of semiconductor elements are to be protected against short-circuit. The protection of diodes and thyristors is to be independent of the load circuits protection.

8.8.3 If only one consumer is to be supplied by power-electronic equipment, the blocks of diodes and thyristors as well as the consumer may have a common protection.

8.9 Protection of Emergency Circuits

8.9.1 The emergency sources of electric power are to be provided with a short-circuit protection only. Where the emergency source is a generator with an independent drive, visual and audible signals indicating the generator overload are to be fitted in the central control station and in the emergency switchboard.

8.9.2 Protection devices preventing immediate switching-on after operation of protection are not to be used in supply circuits of the emergency switchboard and emergency consumers.

9 EMERGENCY SOURCE OF ELECTRIC POWER AND DISTRIBUTION OF POWER FROM EMERGENCY SOURCES

9.1 General Requirements

9.1.1 The installation of the emergency source of power in naval ships will be considered by PRS in each particular case. The emergency source of electric power, if provided, shall comply with the requirements of the present chapter.

9.1.2 Generators with an independent drive or accumulator batteries may be used as the emergency source of electric power.

9.1.3 The capacity of the emergency source of electrical power is to be sufficient to supply power to all consumers, whose simultaneous operation is necessary to ensure naval ship safety in case of emergency.

Where electrical power is necessary to restore propulsion from a dead ship condition, the emergency source of electrical power is to have such capacity that the necessary propulsion starting energy is available within 30 min of blackout. Emergency generating set stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and other essential auxiliaries (excluding emergency generating set).

The dead ship condition is understood to mean a condition under which the main propulsion plant, together with generating sets are not in operation and devices intended for starting the main and auxiliary engines such as starting air receivers or starting batteries are discharged. Emergency generating set is not in operation but it is ready for use.

For steam naval ships, the 30 min. time limit is to be considered as time from blackout/dead ship condition to light-off of the first boiler.

9.1.4 Means are to be provided to enable the inspection of all emergency electrical installations, including the automatic starting arrangement.

9.1.5 The central control station or the main switchboard are to be provided with a device indicating the discharge of an accumulator battery serving as the emergency or the transitional emergency source of power.

9.2 Spaces of Emergency Sources of Electric Power

9.2.1 The spaces of emergency sources of electric power, associated transforming equipment (if any), the transitional emergency sources of electric power, the emergency switchboard and the emergency lighting switchboard are to be situated above the highest continuous deck, outside machinery casings and aback the collision bulkhead.

The exits from these spaces are to be easy accessible and are to lead directly on the open deck.

9.2.2 The location of the emergency sources of electric power, associated transforming equipment (if any), the transitional emergency sources of electric power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electric power, associated transforming equipment, and the main switchboard is to be such as to ensure that fire or other casualty in the space containing the main source of electric power, associated transforming equipment, the main switchboard or in any machinery space of Category A will not interfere with the supply, control and distribution of emergency electric power.

9.2.3 The spaces of emergency sources of electric power, associated transforming equipment, the transitional sources of power, the emergency switchboard and the emergency lighting switchboard are not to be adjoining, as far as practicable, to machinery and boiler compartments of Category A or spaces containing the main source of electric power, associated transforming equipment and the main switchboard.

Where such an arrangement is impracticable, decks and bulkheads separating the spaces are to comply with the requirements concerning command posts, given in *Part V – Fire Protection*.

9.2.4 The emergency switchboard is to be installed as near as practicable to the emergency source of electric power.

9.2.5 Where the emergency source of electric power is a generator with an independent drive, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard is thereby impaired.

This space is to contain also all the starting, charging and energy storing devices intended for starting the emergency set.

9.2.6 The space of the emergency generating set is to be provided with heating arrangements to ensure appropriate temperature for ready starting of the set. The space is to be also ventilated in compliance with requirements of para. 11.3.3 of *Part VI – Machinery Installations and Refrigerating Plants.*

9.2.7 An accumulator battery which constitutes the emergency or transitional emergency source of electric power as well as the emergency switchboard are to be installed in separated spaces. The accumulator battery space is to meet the requirements of 13.2.

9.3 Emergency Sources of Electric Power

9.3.1 The emergency sources of electric power in naval ships of 200 tons gross tonnage and upwards of unrestricted service and the restricted service I are to have adequate capacity to supply simultaneously, for a period of 18 hours, electric power to the following consumers:

.1 emergency lighting:
- **.1** of all corridors, stairways and exits leading from accommodation and service spaces, personnel lift cars and their trunks;
- **.2** of the machinery and generating sets spaces;
- **.3** of all control stations, the main and the emergency switchboards;
- **.4** of emergency generating set space;
- **.5** of the main command station;
- **.6** of chart room and radio room;
- **.7** of the stowage positions for emergency and fire equipment, as well as the location of the manually operated call points;
- **.8** of the steering gear compartment;
- **.9** of position at the fire pump, the emergency bilge pump, the sprinkler pump and at the starting positions of their motors;
- **.10** of air-sheds and helicopter landing zones;
- **.11** of gyrocompass rooms;
- **.12** of medical rooms;

.2 navigation lanterns, ”not under command” lanterns and other lanterns required by the *International Regulations for Preventing Collisions at Sea (the COLREG Convention)*;

.3 internal communication equipment, command broadcast apparatus and general alarm system;

.4 navigation and radio equipment;

.5 fire detection system;

.6 the daylight signalling lamp, audible devices (whistles, gongs, etc.), the calling signalisation and all internal signalling systems required in an emergency;

.7 sufficient number of fire pumps supplied from emergency power source and electrical equipment for foam generators mentioned in chapter 3 of *Part V – Fire Protection*;

.8 sufficient number of bilge pumps supplied from the emergency power source;

.9 other consumers, whose operation will be regarded by PRS necessary to ensure the safety of the naval ship and of the people on board.

The consumers specified in 9.3.1.3 to 9.3.1.6 may be supplied by their own accumulator batteries installed in accordance with 9.2 and having sufficient capacity to supply the services during 18 hours.

For naval ships of restricted service II and III of 200 tons gross tonnage and upwards, upon consent of PRS the required period of 18 hours may be reduced to 12 hours.

For naval ships of less than 200 tons gross tonnage of unrestricted service and the restricted service I, upon consent of PRS the required period of 18 hours may be reduced to 6 hours while in respect of naval ships of restricted service II and III – to 3 hours.

9.3.2 The emergency source of electric power is to supply, for the period of 3 hours, the emergency lighting of places by lifeboats and liferafts, as well as the outboard spaces where the lifeboats and liferafts are brought down on water.

9.3.3 The emergency sources of electric power are to ensure supply to the steering gear.

9.3.4 Where the emergency source of electric power is a generator with an independent prime mover, it is to be:

.1 driven by internal combustion engine (see 2.1 of *Part VII – Machinery, Boilers, Pressure Vessels*);

.2 capable of automatic starting in case of the loss of voltage in the main network and automatic connecting to the emergency switchboard busbars; the services required in 9.3.7 are to be automatically supplied from the emergency generator. The total time of starting and taking over the required load by the generator cannot exceed 45 seconds;

.3 provided with a transitional emergency source of electric power if the time of the generator automatic starting and taking over the load, as required in .2, exceeds 45 seconds.

9.3.5 Where the emergency source of electric power is an accumulator battery, it is to:

.1 operate without recharging and with the voltage changes at its terminals within limits ± 12 per cent of the rated value throughout the discharge period;

.2 be capable of automatic connecting to the emergency switchboard busbars in the case of the loss of voltage in the main network and capable of immediately supplying at least those services mentioned in 9.3.7.

9.3.6 The accumulator battery is to be used as a transitional emergency source of electric power required in 9.3.4.3. The capacity of the battery is to be sufficient to provide power supply without recharging and at the voltage changes at its terminals in limits ± 12 per cent of the rated value throughout the discharge period.

9.3.7 The capacity of the battery used as a transitional emergency source of electric power is to be such as to ensure, for 30 minutes, power supply to the following consumers:

.1 lighting mentioned in 9.3.1.1 and 9.3.1.2 and navigation lanterns in accordance with 9.3.2;

.2 all internal communication equipment and signals required in an emergency;

.3 fire detection and general alarm systems;

.4 the daylight signalling lamp, audible signals (whistles, gongs, etc.).

The consumers specified in .2, .3 and .4 are not required to be supplied by a transitional source of electric power, provided they have their own accumulator batteries of sufficient capacity for the required period of time.

9.3.8 At switching over from the main source of electric power to an emergency source, the continuously supplied consumers are to be supplied from continuous supply installation.

9.4 Distribution of Electric Power from Emergency Sources

9.4.1 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be protected at the main switchboard against overload and short-circuit and which is to be disconnected automatically at the emergency switchboard in case of the loss of voltage in the main source of electric power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short-circuit.

9.4.2 While the naval ship is at sea, the emergency generating set may be used for short periods only, to supply consumers other than those specified in 9.3.1, 9.3.2 and 9.3.3 in the following conditions:

.1 blackout condition;
.2 dead ship condition;
.3 routine use for testing;
.4 short-term parallel operation with the main source of electrical power for the purpose of load transfer.

9.4.3 The emergency generating set may be used, exceptionally and for short periods, during the naval ship lay time in port, for the supply of the consumers not mentioned in 9.3.1, 9.3.2 and 9.3.3, provided the following requirements are complied with:

.1 to prevent the generator or its prime mover from becoming overloaded, arrangements are to be provided to shed appropriate non-emergency loads to ensure continued supply of emergency consumers;
.2 the prime mover is to be fitted with installations ensuring its proper operation, including fuel oil and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation intended for unattended operation;
.3 the fuel oil supply tank is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the period of time required in 9.3.1;
.4 the prime mover is to be designed and built for continuous operation and should be subjected to a planned maintenance scheme ensuring that it is always available and capable of fulfilling its role in the event of an emergency at sea;
.5 fire detectors are to be installed in the locations containing emergency generating set and the emergency switchboard;
.6 means are to be provided to readily change over to emergency operation;

.7 supply, control and alarm circuits are to be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services.

When necessary for safe operation, switches to isolate the circuits are to be fitted between the emergency and main switchboards.

9.4.4 Instructions are to be provided on board the naval ship to ensure that when the ship is under way, all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generating set and emergency switchboard.

These instructions are also to contain information on the required fuel oil tank level, position of harbour/sea mode switch, if fitted, ventilation openings, etc.

9.4.5 The consumers specified in 9.3.1.1 are to be supplied with electric power by separate circuits directly from the busbars of the emergency switchboard fitted with suitable protection devices and switches. The consumers, mentioned in 9.3.1.2 to 9.3.1.6, may be supplied from the naval ship's navigation control and monitoring console located in the main command station and supplied in accordance with 4.4.2.

9.4.6 Where a transitional emergency source of electric power is fitted, the consumers mentioned in 9.3.7 are to be supplied through a special switchboard. The circuits of the switchboard are not to be fitted with switches.

9.4.7 Cables supplying the emergency consumers are to be so run as to ensure the electric power supply to the remaining emergency consumers in case the emergency consumers located below the bulkhead deck are flooded.

9.4.8 The switchboards of the emergency consumers are to be located above the bulkhead deck, behind the collision bulkhead.

9.5 Starting Arrangements of Emergency Generating Sets

9.5.1 The following devices with a continuously stored energy may be used as the starting arrangements of emergency generating sets:

.1 electrical starting system with its own accumulator battery and the charging system supplied from the emergency switchboard;

.2 hydraulic starting system supplied from the emergency switchboard;

.3 compressed air starting system supplied from the main or auxiliary air receivers through a non-return valve or by emergency air compressor supplied from the emergency switchboard.

9.5.2 Each emergency generating set arranged to be automatically started is to be equipped with a starting device of a PRS-approved type having the energy reserve sufficient for performing at least three consecutive starts. Besides, a second source of energy for additional three starts within 30 minutes or a manual starting device is to be provided.

9.5.3 Where automatic starting of the emergency generating set is not required, manual starting initiated by manual cranking, inertial starter, manually charged hydraulic accumulators, powder charge cartridges may be applied, provided it can be demonstrated as being effective.

Where manual starting is not practicable, the starting devices are to comply with the requirements of 9.5.1 and 9.5.2, manual initiation of starting being permitted.

9.5.4 Where the emergency generating set is arranged to be started by means of electric starting system with its own accumulator battery only, a second accumulator battery serving as a reserve source of power with stored energy meeting the requirements of 9.5.2 is to be provided.

9.5.5 Emergency generating sets are to be capable of being readily started in their cold condition down to the temperature of 0 °C. If this is impracticable or if lower temperatures are likely to occur, heating arrangements are to be provided so that ready starting of the generating sets is ensured.

10 ELECTRIC MACHINES

10.1 General Requirements

10.1.1 Electric main propulsion generators and motors or, where justified, also machines of other designation, are to have heating arrangements to maintain their temperature at least 3 °C above the ambient air temperature.

10.1.2 Shaft generators are to have a possibility for the stator to be axially shifted in relation to the rotor to ensure an access to the winding. If such shifting is impossible, a split stator and split bearing discs are to be provided.

Such shaft generators are to have an air-gap precluding the possibility of mechanical contact of the stator with the rotor in the most unfavourable service conditions.

10.1.3 Rotors of alternating and direct-current machines are to be capable of withstanding, for 2 minutes, without damage and permanent deformations, the following increased speed of rotation:

.1 generators, converters, electric couplings and brakes: 120 per cent of the rated speed, but not less than by 3 per cent more than the maximum number of revolutions in transient conditions;

.2 series-wound motors: 120 per cent of the permissible speed as indicated on the rating plate, but not less than 150 per cent of the rated speed;

.3 all motors other than those mentioned above: 120 per cent of the maximum no-load speed.

10.1.4 Where a machine is so designed that at the point of installation on board its lower part is situated below the floor level, ventilating air intake is not to be effected through the bottom part of the machine.

10.1.5 The requirements concerning electric machines testing are given in *Publication No. 42/P – Testing of Electric Machines*.

10.2 Rings, Commutators and Brushes

10.2.1 Direct-current machines for driving the propulsion plants and direct-current machines rated at 200 kW and over are to be provided with sight holes to permit observation of the commutator and brushes without removing the lids.

10.2.2 The permissible amount of wear of commutator segments or slip rings is to be indicated on their face side. It is to be taken equal to at least 20 per cent of the commutator segment or slip ring height.

10.2.3 For rotor of a mass of more than 1000 kg, possibility of reconditioning the commutator/slip rings without removing the rotor from the machine is to be provided.

10.2.4 A flexible copper line is to be used for drawing current from brushes, as well as supply of current to brushes. Brush holder springs are not to be used for this purpose.

10.2.5 The position of brushes in direct-current machines is to be clearly and indelibly marked.

Direct-current machines are to be so constructed as to be capable of working with fixed brush setting under all conditions.

10.2.6 Commutator and ring type machines are to be capable of operating practically without sparking at any load from zero to the rated value.

At the specified overloads, reversals or starts no sparking causing damage to brushes or commutators is to be possible.

10.3 Bearings

10.3.1 Bearings are to be so designed as to avoid the possibility of oil splashing or leaking along the shaft and coming into contact with the machine windings or live parts.

10.3.2 Sliding bearings are to be fitted with overflow holes enabling outflow of oil excess and an oil level inspection lid. Oil level indicators are to be provided on machines rated at 100 kW (kVA) or more.

10.3.3 Pressure lubrication systems are to incorporate pressure indicators for oil supplied to a bearing.

10.3.4 Measures are to be taken to prevent flow of shaft stray currents through machinery bearings.

10.3.5 The bearings of generators driven by the main propulsion plant by means of belts or chains are to be designed with the transverse pull forces taken into account.

10.4 Temperature Sensors

10.4.1 Stators of alternating-current machines rated at over 5000 kVA, or having an axial iron core length of more than 1000 mm, are to be provided with temperature sensors installed in places where the highest temperatures may be expected.

10.4.2 Embedded temperature sensors are recommended for short-time-rated and intermittent-rated electric motors.

10.4.3 It is recommended that embedded temperature sensors be used for the windlass drive electric motors. The sensors are to be so selected that the protection system disconnects the motor when the temperature rise limit for the insulation employed is exceeded by more than 30 per cent.

The terminals of sensors leads are to be so located as to be easily accessible.

10.5 Overcurrent

10.5.1 Generators are to be so designed that after reaching the steady-state temperature corresponding to the rated load they are capable of sustaining overcurrent such as specified in Table 10.5.1.

Table 10.5.1

No.	Type of generator	Overcurrent, per cent	Duration of overcurrent, s
1	a.c. generator	50	120
2	d.c. generator	50	15

10.5.2 Electric motors are to be so designed as to be capable of developing, without stopping or sudden speed changes, increased torque such as specified in Table 10.5.2.

Table 10.5.2

No.	Type of motor	Overload by torque, per cent	Duration of overload, s	Testing conditions
1	Multi-phase synchronous motors, as well as squirrel-cage motors with starting current less than 4.5 times the rated current	50	15	Frequency, voltage and excitation to be maintained at rated levels
2	Multi-phase induction motors for continuous and intermittent duties	60	15	Frequency and voltage to be maintained at rated levels
3	Motors as specified in 2, but for short-time and continuous duty with varying load	100	15	As above
4	Direct-current motors	50	15	Voltage to be maintained at rated level

10.6 Alternating-Current Generators

10.6.1 General Requirements

10.6.1.1 Each alternating-current generator is to have a separate independent system for automatic voltage regulation.

10.6.1.2 Damage to automatic voltage regulation of generators is not to result in inadmissible high voltages at the generator terminals.

10.6.1.3 Alternating-current generators are to have excitation margin sufficient to maintain for 2 minutes the rated voltage with a tolerance up to 10 per cent, with generator’s overload equal to 150 per cent of the rated current and power factor equal to 0.6.

10.6.1.4 Alternating-current generators rated at 50 kW (kVA) and over, together with their excitation and voltage regulation systems are to be so designed as to be capable of withstanding, at short-circuits, the effects of the three-fold rated current within 2 s.

10.6.1.5 Peak value of the three-phase short-circuit current of synchronous generators during operation at rated value is not to exceed fifteen-fold peak value of rated current.

10.6.2 Voltage Regulation

10.6.2.1 Alternating-current generators are to have voltage regulation system so adjusted to the regulation characteristics of the prime movers that the rated voltage is maintained within ± 2.5 per cent (up to ± 3.5 per cent for emergency sets) at load changes from no-load to the rated load at rated power factor.

Main generators may have their voltage maintained within ± 3.5 per cent of the rated value at all power factor values from 0.6 to 0.9 except for the rated power factor.

The above requirement applies to a set operating at the rated speed and load of the generator.

10.6.2.2 A sudden change in the balanced load of a generator running at rated speed and rated voltage, under given current and power factor conditions, is not to cause a fall of voltage below 85 per cent of the rated value nor a rise above 120 per cent.

Following such a change, the generator voltage is to be restored within not more than 1.5 seconds to the rated value with a tolerance of ± 3 per cent. For emergency sets, these values may be increased, respectively, to 5 seconds and ± 4 per cent of rated voltage.

Where no precise data are available on peak values of sudden load that may be connected additionally to the existing generator load, this may be taken equal to a sudden load of 60 per cent of the rated current at a leading power factor of 0.4 or less, which is connected at idle speed and then disconnected.

10.7 Direct-Current Generators

10.7.1 General Requirements

Shunt-wound direct-current generators may be used only when equipped with automatic voltage regulators.

10.7.2 Voltage Regulation

10.7.2.1 Voltage regulators of compound-wound generators are to provide for reduction of no-load voltage, with the generator cold, by not less than 10 per cent of the rated generator voltage, with due account taken of the increased revolutions of the prime mover running at no-load.

10.7.2.2 Manual voltage regulators are to be so designed that the voltage increases when their setting knobs are rotated clockwise.

10.7.2.3 Voltage regulators of shunt-wound generators are to be so designed that before the field current is switched off, field winding is shorted.

10.7.2.4 Compound-wound generators are to have independent devices for voltage regulation with an accuracy of ± 1 per cent for generators rated at up to 100 kW, or with an accuracy of ± 0.5 per cent for generators of rating exceeding 100 kW. The said regulation limits are to be maintained with both the generator cold and hot and at any load within the operating load range of the generator.

10.7.2.5 Direct-current sets comprising compound-wound generators are to have such external characteristics that voltage of a hot generator adjusted to the rated value with an accuracy of ± 1 per cent at 20 per cent load does not vary, at full load, by more than ± 1.5 per cent for generators rated at 50 kW or over, and by more than ± 2.5 per cent for generators of the lower output.

Voltage variations in a compound-wound generator running at 20 to 100 per cent of the rated load is not to exceed the following limits:

.1 ± 3% for generators rated at 50 kW or more;

.2 ± 4% for generators rated at over 15 kW but not higher than 50 kW;

.3 ± 5% for generators rated at 15 kW or less.

10.7.2.6 Direct-current sets comprising shunt-wound generators are to have such external generator characteristics and such automatic voltage regulators that voltage is maintained within ± 2.5 per cent of the rated value at all load variations from zero to the rated load.

10.8 Electromagnetic Brakes

10.8.1 The brake is to operate when the brake-operating coil becomes de-energized.

10.8.2 A 30 per cent voltage fall below the rated value is not to cause a hot brake to operate.

10.8.3 Electromagnetic brakes are to allow a manual release.

10.8.4 Electromagnetic brakes are to be fitted with at least two pressure springs.

10.8.5 The shunt windings of a compound-wound electromagnetic brake are to be capable of holding off the brake even when no current flows through the series winding.

10.8.6 The shunt windings of electromagnetic brakes are to be so constructed or protected that they can be safe from damage at overvoltages such as occur when they are disconnected.

11 TRANSFORMERS

11.1 General Requirements

11.1.1 The requirements of the present sub-chapter apply to power and lighting transformers mentioned in 3.3.

11.1.2 Dry transformers cooled by air are to be used in naval ships. The use of transformers of other design (e.g. liquid-cooled) will be considered by PRS separately.

11.1.3 Transformers are to have electrically separated windings for primary and secondary voltages.

11.2 Overloads, Voltage Variations and Parallel Operation

11.2.1 Transformers are to be capable of withstanding 10 per cent overloads for 1 hour and 50 per cent overloads for at least 5 minutes.

11.2.2 Voltage variations at an active load between zero and rated load are not to exceed 5 per cent for transformers rated at up to 6.3 kVA and 2.5 per cent for transformers of higher rating.

11.2.3 Parallel-operating transformers are to have compatible vector groups, the same transformation ratios and their short-circuit voltages are to be such that the load on any transformer, at full load, does not depart from the rated current by more than 10 per cent.

Where transformers are arranged to operate in parallel, the rated power output of the smallest transformer is not to be less than half the rated power output of the largest transformer.

12 POWER-ELECTRONIC EQUIPMENT

12.1 General Requirements

12.1.1 Power-electronic equipment is to be provided with silicone semi-conductor elements. The use of other types of elements will be specially considered by PRS.

12.1.2 Power-electronic equipment in which the power loss exceeds 500 W is to be provided with heating appliances to maintain the temperature of at least 3 °C higher than the ambient temperature.

12.1.3 Power-electronic equipment is to be provided with air-cooling (natural or forced).

The application of liquid-cooling will be separately considered by PRS.

12.1.4 In power-electronic equipment with forced ventilation, a protective device is to be provided to ensure reducing or switching off the load when the ventilation is switched off, as well as the actuating of the visual and audible signals when maximal permissible temperature inside the equipment is exceeded.

12.1.5 Power-electronic equipment is to be provided with appropriate measuring instruments.

The maximum permissible values of parameters are to be marked on the scales of the measuring instruments. On the scales of the cooling air thermometers, in the case of forced air cooling, the maximum permissible temperature of the cooling air is to be clearly indicated.

12.2 Permissible Parameters of the Voltage Distortions

12.2.1 The voltage distortion factor, K, of the naval ship's network, caused by the operation of the power-electronic equipment is not to be greater than 10 per cent.

The distortion factor is to be derived from the following formula:

$$K = \frac{1}{U_n} \cdot \sqrt{\sum_{\nu=2}^{n} U_\nu^2} \cdot 100, \quad [\%] \tag{12.2.1}$$

where:

U_n – effective value of the network voltage, [V]

U_ν – effective value of voltage of ν-number harmonic, [V]

ν – number of higher harmonic.

12.2.2 The factor u_w determining the maximum relative deviation of the voltage instantaneous value from the first harmonic, is not to exceed 30 per cent.

The factor is to be derived from the following formula:

$$u_W = \frac{\Delta U_m}{\sqrt{2} U_1} \cdot 100, \quad [\%] \tag{12.2.2}$$

where:
ΔU_m – the maximum value of the distorted voltage,
U_1 – the first harmonic effective value of voltage.

12.2.3 The application of the power-electronic equipment causing the voltage distortions, exceeding the above given tolerance range, will be specially considered by PRS.

12.3 Control and Signalling Systems

12.3.1 Power-electronic equipment is to be provided with visual signals indicating the ”on” and “off” position of the power and control circuits.

12.3.2 The power circuits are to be electrically separated from the control circuit.

12.3.3 The prolonged difference between currents in parallel branches is not to be more than 10 per cent of the mean current value.

12.3.4 Failure of any of the rectifier valves is not to affect the operation of power-electronic equipment. An automatic control of load is to be provided to avoid exceeding the permissible loads for each of the rectifier valves. Failure of each of the rectifier valves is to be signalled by visual and audible alarms.

12.3.5 The asymmetry of control pulses of the converter control system ($\Delta\alpha$) is to be determined by the formula:

$$\Delta\alpha = \delta_k - \frac{360}{n} \qquad (12.3.5)$$

where:
$\Delta\alpha$ is not to exceed ± 3 electric degree;
δ_k – distance between pulses of the adjacent ducts, in electric degrees;
n – number of control channels.

$\Delta\alpha$ is not to exceed ± 3 electric degrees at any point of the control range.

12.4 Testing and measurements

12.4.1 The power-electronic system, after being installed onboard a naval ship, is to be subjected to tests according to test programme agreed with PRS.

12.4.2 Additionally to functional tests carried out with respect to the system purpose, measurements of power network parameters, including the network voltage curve distortions due to the system operation at different loads are to be carried out during sea trials.

12.4.3 During the naval ship operation, at intervals not longer than 5 years, measurements are to be performed of power energy parameters (including distortions) of the naval ship's power network, where the rated power of the largest power-electronic system, if installed, exceeds 50 per cent of the rated power of the generating set supplying the system or where the combined capacity of all installed power-electronic systems exceeds 30 per cent of the rated power of naval ship power plant, taking the lower value. Similar tests are to be carried out when the naval ship power network is supplied by the power-electronic converter, whatever is its capacity.

13 STORAGE BATTERIES

13.1 General Requirements

13.1.1 Storage batteries are to be so constructed that the loss of capacity of a fully charged battery due to self-discharge after 28 days out of operation at a temperature of 25 ± 5 °C does not exceed 30 per cent of the rated capacity for acid batteries and 25 per cent for alkaline batteries.

13.1.2 Battery containers and closures for holes are to be so constructed and secured as to prevent spilling or splashing of the electrolyte when the container is inclined on any side to an angle of 40° from the vertical.

Closures are to be made of a durable material resistant to electrolyte. The closure design is to be such as to avoid the building up of excess gas pressure inside the battery.

13.1.3 The mastics used are not to change their properties or deteriorate at the ambient temperature changes within – 30 °C to +60 °C.

13.1.4 Materials used for fabrication of crates to house battery cells are to be resistant to electrolyte.

13.1.5 Individual cells arranged within the crates are to be so secured as to preclude their relative movement.

13.1.6 The use of non-service accumulators will be specialy considered by PRS.

13.2 Arrangement of Accumulator Batteries

13.2.1 Batteries having voltage exceeding the safety voltage, as well as batteries having a capacity of over 2 kW (computed from the maximum charging current and the rated voltage) are to be located in special battery compartments accessible from the deck or in appropriate boxes installed on the open deck. These spaces are to be special electrical spaces. Batteries having capacity of 0.2 kW up to 2 kW may be installed in boxes or cabinets located inside the naval ship’s hull.

Accumulator batteries intended for starting up internal combustion engines, except emergency sources of power, may be located in the engine room in special boxes or cabinets with suitable ventilation.

Batteries having a capacity of less than 0.2 kW are generally allowed to be installed in any space other than accommodation spaces, provided they are protected from the action of water and mechanical damage, and do not harmfully affect the surrounding equipment.

PRS may agree to location of batteries in accommodation spaces, provided the batteries are hermetically sealed.

13.2.2 The acid and alkaline batteries are not to be placed in one compartment or in one box.

The vessels and instruments intended for the batteries with different electrolytes are to be placed separately.

13.2.3 The inside part of battery compartment or box, as well as structural parts, which may be subjected to harmful effect of electrolyte or gas, are to be suitably protected.

13.2.4 The accumulator batteries, as well as the individual accumulator cells are to be properly secured in position. When they are placed on a stillage, the distance between the deck and the plugs of the upper tier of cells is not to exceed 1500 mm.

13.2.5 When installing the accumulator batteries or the individual accumulator cells, linings and distance pieces between them are to be provided to ensure a clearance for circulation of air of not less than 15 mm.

13.2.6 Warning notices indicating the danger of explosion are to be provided on the doors leading to the battery compartment or near thereto, as well as on the boxes containing accumulators.

13.3 Heating

13.3.1 The battery compartments in which temperature during operation may fall down below + 5 °C, with the exception of battery boxes or cabinets installed on deck, are to be heated. The heating is allowed to be effected by the heat produced in adjacent spaces, as well as with water or steam radiators located inside the battery rooms.

13.3.2 The heating system valves are to be located outside the battery compartments.

13.3.3 The shipboard air conditioning system is not to be used for heating the battery compartments.

13.4 Ventilation

13.4.1 The battery compartments and boxes are to have sufficient ventilation that will prevent possible formation and accumulation of explosive mixtures.

The ventilation system is to meet the requirements given in sub-chapter 11.8 of *Part VI – Machinery Installations and Refrigerating Plants*.

13.4.2 Arrangements for charging batteries placed in battery compartments equipped with mechanical ventilation are to ensure that charging is effected only when ventilation operates. The charging cycle is to be automatically discontinued if the ventilators stop. Ventilators are to have explosion-proof design: Exi, Exp, Exd or Exe (see 2.8).

13.5 Charging the Accumulator Batteries

13.5.1 Charging facilities are to be provided for charging accumulator batteries supplying essential services. These facilities are to be capable of charging a battery within a period of time not exceeding 8 hours. If an additional battery, which replaces the battery being charged, is available, the charging time may exceed 8 hours.

13.5.2 The charging facilities are to have means for measuring the voltage across battery terminals and charging current, and for emergency sources of electric power also discharging current.

13.5.3 In naval ships which are fitted with portable accumulator lanterns or which are fitted with spare accumulator-fed navigation lanterns, facilities for charging the accumulators of these lanterns are to be provided.

13.6 Installation of Electrical Equipment in Battery Compartments

Except for explosion-proof lighting fixtures and cables led to accumulators and lighting fixtures, no other electrical equipment is to be installed in battery compartments.

Cables leading to accumulators and lighting fixtures may be run without covers, provided that they have a metal armour or braid covered by non-metallic sheath, and that the armour or the braid are effectively earthed on both ends.

13.7 Electric Starters for Internal Combustion Engines

13.7.1 Number of Starter Batteries

13.7.1.1 In a naval ship equipped with electrically-started internal combustion engines, irrespective of the number of such engines, not less than two starter batteries are to be installed for starting the main and the auxiliary engines, or not less than two common batteries for starting all engines.

Permanent switching system is to be provided to ensure the possibility of using any battery for starting any of the engines in the group serviced by this battery. The arrangement is to be such that the batteries cannot be connected in parallel.

13.7.1.2 The starting batteries are to be used for starting and supply of the engine's own monitoring systems only. Arrangements are to be provided to maintain continuously the stored energy at all times.

13.7.1.3 In naval ships with the low-rated electrical installation, only one starter battery is allowed, provided it is capable of starting any diesel engine.

13.7.2 Battery Characteristics

13.7.2.1 Each starter battery is to be designed to withstand the discharging current during starting that will correspond to the maximum current through the most powerful starting electric motor.

13.7.2.2 The capacity of each battery is to be sufficient for at least six starts of the engine in the ready-for-start condition; in the case of two or more engines – for not less than three starts of each engine.

For main engines, such number of starts is to be ensured within 30 minutes without charging as is required in the case of the starting compressed air system (see sub-chapter 16.1 of *Part VI – Machinery Installations and Refrigerating Plants*).

13.7.2.3 When calculating starter battery capacity, the duration of each start is to be assumed to be at least 5 s.

13.7.3 Charging Facilities

13.7.3.1 A starter battery charging facility is to be supplied by a separate feeder from the main switchboard even if battery charging is possible by a generator located on internal combustion engine.

13.7.3.2 In naval ships with the low-rated electrical installation, the starter batteries may be charged only from the generator mounted on the diesel engine.

13.7.3.3 In naval ships where batteries are the main source of electrical power, their charging during naval ship's stay in a port from a shore supplied charging device is to be ensured.

14 ELECTRICAL APPARATUS AND ACCESSORIES

14.1 Electrical Apparatus

14.1.1 General Requirements

14.1.1.1 Electrical apparatus is to comply with applicable requirements of national and international standards on the switchgear and protection devices, including PN-EN 60269, 60947 series standards or equivalent, taking into account operation conditions defined in Chapter 2.

Additionally, the apparatus is to meet the requirements of this sub-chapter.

14.1.1.2 Electrical apparatus designed for the naval ship special equipment is to comply with the requirements of respective military standards.

14.1.1.3 The design of switchgear with renewable contacts is to be such that renewal of contacts is possible with the use of standard tools, without dismantling the switchgear or its basic components.

14.1.1.4 All non-manoeuvring switches, except for cabin switches, are to be provided with mechanical or electrical contact position indicators.

14.1.1.5 Controllers and master controllers are to be provided with drums fixing the particular position of controls; location in the zero position is to be more perceptible than elsewhere. Controller and master controller drums are to be fitted with a scale and a position indicator.

14.1.1.6 Machine control gear, except that used for continuous regulation, is to be so constructed that the end and intermediate fixed positions are easy to feel at various control stages, while movement beyond the end positions is impossible.

14.1.2 Manually Operated Apparatus

14.1.2.1 The direction of movement of manual operating controls of switchgear or machine control gear is to be such that clockwise rotation of a handle (handwheel) or upward/forward shifting of a handle (lever) corresponds to closing of an apparatus, start-up of a motor, increased speed, increased voltage, and so forth.

When controlling the lifting or lowering arrangements, clockwise rotation of a handle (handwheel) or shifting of a handle (lever) towards the operator is to correspond to lifting movement, and counter-clockwise rotation or shifting away from the operator – to lowering movement.

14.1.2.2 Switchgear push buttons are to be so designed that they cannot be actuated accidentally.

14.1.3 Motor-Operated or Electromagnetic Apparatus

14.1.3.1 Actuators of motor-operated or electromagnetic non-manoeuvring switches are to be so designed that in the event of loss of supply to the actuating motor the switch contacts remain in closed or in open position only.

14.1.3.2 Electric motor or electromagnetic actuators are to ensure correct closing of switchgear at control voltage varying within 85 to 110 per cent of the rated value and at rated frequency, in the case of alternating current.

14.1.3.3 Actuator operation at 110 per cent of the rated control voltage is not to cause mechanical damage to the switchgear or excessive rebounding of contact liable to affect the switching capacity (due to arcing or welding of contacts). As regards electromagnetic contactors, the above requirement is applicable to contactor operation at an ambient temperature of – 10 °C and with the coil winding cold.

14.1.3.4 At 85 per cent of the rated control voltage, the actuator is to be capable of correctly closing the switchgear at rated making current, at an ambient temperature of + 45 °C and with the actuator winding heated to the rated temperature.

14.1.3.5 A fall of control voltage down to 70 per cent of the rated value is not to cause opening or pressure decrease of movable elements below the required minimum, at an ambient temperature of + 45 °C and with the actuator winding hot.

14.1.3.6 Motor-actuated or electromagnetic non-manoeuvring switchgear is to be provided with a device for manual operation.

14.1.4 Coils

14.1.4.1 A conductor or damp is to be so attached to a coil winding as to avoid the weight or pressure of the connection affecting the coil turns. The tappings of voltage coils are to be made of a flexible stranded conductor, except when the contact terminals are secured directly to the coil frame.

14.1.4.2 The coils of electromagnetic apparatus are to bear notations giving particulars of their characteristics.

14.1.5 Resistance Elements

14.1.5.1 Resistance elements are to be easily replaceable in sections or as a whole.

14.1.5.2 Resistors are to be so located and ventilated that they do not heat other devices beyond the permissible limits.

14.1.5.3 The joints between resistor elements or between the resistor elements and terminals are to be made by welding or by mechanical press-fitting where there is no need to dismantle them. Soldering is allowed where there is no risk of temperature rise at the point of junction above the specified limits for the solder.

14.1.6 Fuses

14.1.6.1 Fuse elements are to be of a totally enclosed type and allow neither arc ejection to the outside, sparking, nor any other harmful effect upon the adjacent parts in the case the fuse blows.

14.1.6.2 Fuse elements housing is to be made of incombustible and non-hygroscopic insulating material.

14.1.6.3 Fuse sockets in multi-pole design are to have partitions of insulating material, separating the poles. The sockets of design such that accidental short-circuit during fuse replacement is precluded, need not have partitions.

14.2 Installation Fittings

14.2.1 General Requirements

14.2.1.1 Enclosures of accessories and fittings are to be constructed of corrosion-resistant or suitably protected from corrosion and at least low flame-spread materials of adequate mechanical strength. The enclosures of accessories and fittings designed for installation on weather decks or other humid areas are to be made of brass, bronze or equivalent materials, or of plastics of suitable quality.

If steel or aluminium alloys are used, adequate anticorrosive protection is to be provided.

Threaded and fitted joints are not to be made in aluminium alloys.

14.2.1.2 Insulating parts, to which current-carrying components are fixed, are to be made of materials that do not evolve gases that would ignite from an electric spark at a temperature up to 500°C inclusive.

14.2.1.3 The installation fittings intended to be mounted on or close to combustible materials are to be so constructed as not to get heated over 90 °C.

14.2.2 Lampholders

14.2.2.1 The design of lampholders, fitted with screw caps, is to be such as to effectively prevent the lamps from getting loose in service.

14.2.2.2 No switches are allowed to be fitted in lampholders.

14.2.2.3 Each lampholder is to be marked to indicate the rated voltage, as well as the permissible current or the lamp power.

14.2.3 Plug and Socket Connectors

14.2.3.1 The pin jacks of socket outlets are to be so constructed as to ensure permanent pressure in contact with the plug pins.

14.2.3.2 Plugs with slotted pins are not allowed for use. The pins of plugs designed for currents in excess of 10 A are to be cylindrically or rectangulary shaped, solid or hollow, as the case may be.

14.2.3.3 Socket outlets and plugs for voltage higher than the safety value are to have contacts for connecting the earth conductors of enclosures of the connected consumers.

14.2.3.4 Socket outlets having enclosures are to be so constructed that the required degree of protection is ensured, regardless of whether the plug is in or out of the socket outlet.

14.2.3.5 All the socket outlets rated at over 16 A are to be provided with built-in switches. Such socket outlets are to be interlocked to prevent the possibility of inserting or withdrawing the plug when the socket switch is in the ”closed” position.

14.2.3.6 Where socket outlets are not interlocked, the clearances between contacts in the air or across the insulation surface are to be such that no short-circuit is possible due to arcing over when the plug is withdrawn while carrying a load 50 per cent above the rated current at rated voltage.

14.2.3.7 Socket outlets and plugs are to be so designed that it is not possible to insert only one live contact pin into the socket outlet, or insert a live contact pin into the earthing contact. Besides, the design of the outlets intended for connecting the motors (or gear), the direction of rotation (or operation) of which depends on the change of the sequence of phases or poles connected, is to exclude the possibility of this change.

When the plug is inserted into the socket outlet, the earthing part of the plug is to make contact with the earthing part of the socket outlet before connecting the live pins.

14.2.3.8 No fuses are to be fitted in socket outlets, plugs or tapping boxes.

15 HEATING APPLIANCES

15.1 General Requirements

15.1.1 Only heating appliances of stationary type are to be used.

15.1.2 Heating appliances are to be supplied from the main switchboard or section switchboard adopted for this purpose, or from the lighting switchboard, with due regard paid to the requirements of 6.2.1.

15.1.3 The supporting structural parts of heating appliances, as well as the internal surfaces of enclosures, are to be made entirely of incombustible materials.

15.1.4 The permissible leakage current for hot heating appliances is not to be more than 1 mA per 1 kW rated input of any separately connected heating element, and not more than 10 mA for the appliance taken as a whole.

15.1.5 Heating appliances are to be so designed that the temperature of their components which are to be handled by the personnel or which can be touched accidentally does not exceed the values indicated in Table 15.1.5.

Table 15.1.5

No.	Item		Permissible temperatures, °C
1	Control handles and other service parts	metallic	55
		non-metallic	65
2	Handles or holders touched for short time	metallic	60
		non-metallic	70
3	Enclosures of electric space heating appliances at 20 °C ambient temperature		80
4	Air coming out from space heaters		110

15.2 Space Heating Appliances

15.2.1 Electric heaters intended for space heating are to be of stationary type. The electric heaters are to be provided with a suitable system to disconnect the supply source when the temperature rise exceeds the permissible limits for the heater enclosures.

15.2.2 The space heaters are to be installed in compliance with the requirements of 7.10 of *Part V – Fire Protection*.

15.2.3 If built-in switches are not provided in the heating appliances, such switches are to be installed in the rooms in which these appliances are located. Switches are to disconnect power supply at all poles or phases.

15.2.4 In each position of the switch governing the heating appliance power supply, uniform load distribution on supply phases is to be ensured.

15.2.5 Design of space heating appliances is to ensure required level of enclosure protection depending on the place of the appliance installation, in accordance with Table 2.3.4.2.

15.2.6 The enclosures of space electric heaters are to be so constructed as to prevent the possibility of placing any objects on them.

15.2.7 Stationary space heating appliances rated at 380 V and over and admitted for use in accordance with Table 4.2.2 are to be protected against access to live parts except with the aid of special tools. The enclosures are to have notices giving the voltage value.

15.3 Cooking Appliances

15.3.1 Heating appliances forming part of galley equipment are to be so constructed as to avoid the possibility of bringing cooking utensils or bare hand into contact with live parts, and to prevent short-circuits or damage to insulation due to liquid spilling or leakage.

15.4 Oil and Fuel Heating Appliances

15.4.1 The electrical heating appliances may be used for heating oil and fuel having a flash point of vapour above 60 °C, provided that the requirements of 15.4.2 and 15.4.3 are complied with.

15.4.2 The heating appliances of the oil and fuel pipelines are to be provided with temperature control devices, visual signal of operation conditions, as well as visual and acoustic alarms indicating a failure in the system or that the permissible temperature values have been exceeded.

15.4.3 In accordance with the requirements of sub-chapter 12.3 of *Part VI – Machinery Installations and Refrigerating Plants,* the heating appliances for oil and fuel tanks are to be provided with temperature control devices for the heated medium, temperature indicators for surfaces of heating elements, minimum level sensors, as well as with means for the disconnection of power supply to the heating devices when the maximum permissible temperature or the heating medium minimum level have been reached.

Such appliances are to be provided with visual signal on operation conditions and with audible and visual signals indicating a failure in the system.

15.4.4 The oil and fuel heating appliances are to be fitted with a device controlling the temperature of the heated agent. Irrespective of this, a safety cut-out switch with manual re-set is to be provided for disconnecting the supply voltage when the temperature of the heating medium reaches 220 °C.

16 CABLES AND CONDUCTORS

16.1 General Requirements

16.1.1 Cables and conductors allowed for use in naval ships are to be incombustible or flame-retardant type, water and oil resistant, marine cables and conductors – meeting the requirements of the present Chapter of the *Rule*s or the relevant national and international standards within the scope agreed with PRS, including PN-IEC 60092-350, PN-IEC 60092-351, IEC 60092-376.

16.1.2 Where use of fireproof cables is required, they are to additionally comply with the requirements of Publication IEC 60331.

16.1.3 The use of other types of cables and conductors is subject to special consideration by PRS in each particular case.

16.1.4 The requirements of the present Chapter do not apply to concentric, telephone cables and also power cables for the voltage over 1000 V.

16.2 Conductors

16.2.1 Cable conductors are to be of multi-wire type. The number of wires per conductor is to be not less than that specified in Table 16.2.1.

Table 16.2.1

No.	Nominal cross-sectional area of conductor, mm^2	Minimum number of wires per conductor	
		Circular non-compacted conductors	Compacted circular and shaped conductors
1	0.5 – 6	7	–
2	10 – 16	7	6
3	25 – 35	19	6
4	50 – 70	19	15
5	95	37	15
6	120 – 185	37	30
7	240 – 300	61	30

Note:

The ratio of nominal diameters of the thickest and the thinnest wire of mechanically compacted conductors is not to exceed the value of 1.3 and that of shaped non-compacted conductors – 1.8.

16.2.2 Wires of rubber-insulated copper conductors are to be tinned or coated with a suitable alloy. Tinning or other anticorrosive coating of external wiring or of all wires may be dispensed with if the manufacturer takes measures to guarantee that the rubber insulation does not affect adversely the metal of the conductor.

16.3 Insulating Materials

16.3.1 The types of insulation that may be used for insulating current-carrying conductors in cables are listed in Table 16.3.1. The use of other types of insulation will be specially considered by PRS in each particular case.

Table 16.3.1

Types of insulating materials	Designation	Maximum temperature of cable conductor[1], [°C]	
		Operational conditions normal	Operational conditions short-circuit
a) Thermoplastics			
– Polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC/A	60	150
b) Elastomers or thermosetting materials			
– of ethylene – propylene rubber or similar (EPM or EPDM)	EPR	85	250
– of cross-linked polyethylene	XLPE	85	250
– of silicone rubber	S 95	95	350[2]
– of halogen free ethylene-propylene rubber (EPM or EPDM)	HF EPR	85	250
– of halogen free cross-linked polyethylene	HF XLPE	85	250
– of halogen free silicone rubber			
– of halogen free cross-linked polyolefin	HF S 95	95	350[2]
	HF 85	85	250

[1] Temperature of the conductor assumed for the calculation of current rating in continuous service of cables.

[2] This temperature is not appropriate for tinned conductors.

16.4 Cable Sheaths

16.4.1 Cable and conductor sheaths may be made of materials given in Table 16.4.1. The use of other materials for cable sheaths will be specially considered by PRS in each particular case.

Table 16.4.1

Types of sheath materials	Designation	Maximum temperature of cable conductor, [°C]
a) Thermoplastics		
– polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	ST 1	60
	ST 2	85
– halogen free materials	SHF 1	85
b) Elastomers or thermosetting materials		
– of polychloroprene rubber,	SE 1	85
– of chlorosulfonized polyethylene or chlorinated polyethylene rubber,	SH	85
– halogen free materials	SHF 2	85

16.4.2 Sheaths are to be of uniform thickness, within permissible limits, throughout the manufacturing length of cable, and are to envelope the cable cores concentrically. The sheaths are to form an impervious cover adhering to the protected cores.

16.5 Protective Coverings

16.5.1 Metal screening braid is to be made of tinned copper wire. If plain copper wire is used, it is to be protected by suitable sheaths. Non-screening braids may be of galvanised steel wires. The braid is to be uniform and its density is to be such that its weight is at least equal to 90 per cent of the weight of the tube of an equal diameter, made of the same material, and with a wall thickness equal to the braiding wire diameter.

16.5.2 Metal armour is to be made of annealed steel wire or tape, galvanised and wound helically, with a suitable pitch, over a bedding in such a way that a continuous cylindrical layer is formed to assure adequate protection and flexibility of the finished cable. On special demand, the armour may be made of non-magnetic metals, using the techniques described above.

16.5.3 Cable armour or braid made of steel tape or wire are to be painted for corrosion prevention.

16.5.4 Armour bedding is to be made of moisture resistant materials.

16.6 Marking

16.6.1 Cable conductors are to be marked in a way that would ensure the permanence of marking. In multi-core cables, the cores of which are arranged in several concentric layers, at least two adjacent cores in each layer are to be marked with different colours.

16.6.2 Cables are to be provided with cable tags specifying cable number and cross-section in accordance with documentation. Cable tags are to be placed at least at both ends of each cable section.

16.7 Wiring

16.7.1 Insulated single-core conductors are to be used for internal wiring of switchboards and electrical devices (see also 2.3.3).

16.7.2 Non-insulated wires and busbars are permitted for use only for internal wiring of electrical devices. The external wiring with non-insulated wires or busbars is not allowed unless they are reliably guarded.

16.8 Cabling

16.8.1 General Requirements

16.8.1.1 Cables and conductors having multi-wire cores are to be used with the cross-sectional area not less than:

.1 1.5 mm^2 – for circuits supplying the essential equipment,

.2 1.0 mm^2 – for lighting, monitoring, control and signalling circuits supplying essential equipment and for power circuits supplying other equipment;

.3 0.75 mm^2 – for control, monitoring and signalling circuits supplying non-essential equipment and the circuits serving internal communication.

16.8.1.2 Supplying naval ships from the shore network or transmitting electric power to other unit is to be effected by means of conductors of wire cross-section not less than 4 mm^2.

16.8.1.3 Maximum permissible temperature for the insulating material of the cable cores or conductors is to be at least 10 °C higher than the ambient temperature likely to exist in the space where the cable is installed.

16.8.1.4 In locations affected by the action of crude oil products and other aggressive media, the cables having a sheathing that will withstand the action of a given medium are to be used. Cables of other types may be installed in such locations, provided they are laid in metallic pipes (see 16.8.8).

16.8.1.5 Cables laid in places where they are liable to be mechanically damaged are to have appropriate armour, whereas cables of other types are to be, in such places, protected by special sheathing or laid in pipes (see 16.8.8). PRS shall in each particular case specify necessity and extent of laying cables in pipes or channels, with respect to naval ship survivability as regards flooding, penetration of a shock wave after possible explosion inside the hull, penetration of smoke and fire and other hazards consequent upon the naval ship operation.

16.8.1.6 Cables running through the casings of the machinery space of category A, galleys, drying rooms, boiler rooms and other similar fire-hazardous spaces, unless they serve the equipment installed in these spaces, which supply and control the systems the operation of which is to be maintained also during fire (such as general alarm system, fire alarm system, fire-extinguishing system, fire doors system including the doors position signalling system, watertight doors system including the door position signalling system, emergency lighting system, command broadcast system, low-location lighting system, emergency fire pump) are to be fire-resistant. If it is possible, running cables through these spaces is to be avoided.

The above requirement need not be complied with if the given system is safe in case of damage or it is duplicated and the cables are separated apart as far as possible.

On the outer side of the walls of such compartments, the cables are to be run at a distance of not less than specified in 16.8.4.1.

In naval ships in which, due to their dimensions, the above requirement cannot be satisfied, measures are to be taken to ensure effective protection of cables running through fire-hazardous spaces.

16.8.2 Selection of Cables and Conductors for Loads Required

16.8.2.1 Where the manufacturer has not specified the load required for the used cable types, permissible continuous loads on single-core cables and on conductors insulated by various materials are to comply with the values given in Table 16.8.2.1 (see also 16.8.2.6). The values of loads given in the Table refer to the following cases of cable installation:

.1 not more than 6 cables installed in one bunch or one layer, adhering to one another;

.2 in two layers, irrespective of the number of cables in the layer, provided that there exists clearance for free circulation of the cooling air between the group or bunch of six cables.

The values of the permissible current ratings for the relevant cross-sectional areas specified in the Table are to be reduced by 15% (factor 0.85) in the case where more than 6 cables installed in one bunch may be simultaneously loaded by the rated current or where there is lack of clearance for the cooling air circulation.

Table 16.8.2.1
Permissible current ratings in continuous service of single-core cables and conductors with various insulation at the ambient temperature of 45 °C

Nominal cross-sectional area of conductor, mm^2	Permissible current rating in continuous service, A		
	Polyvinyl chloride or vinyl chloride-vinyl acetate copolymer	Ethylene-propylene rubber, cross-linked polyethylene	Silicon rubber
	$+60^X$	$+85^X$	$+95^X$
1	2	3	4
1	8	16	20
1.5	12	20	24
2.5	17	28	32
4	22	38	42
6	29	48	55
10	40	67	75
16	54	90	100
25	71	120	135
35	87	145	165

1	2	3	4
50	105	180	200
70	135	225	255
95	165	275	310
120	190	320	360
150	220	365	410
185	250	415	470
240	290	490	570
300	335	560	660

[X] Maximum permissible working temperature of conductor, °C.

16.8.2.2 The values of permissible current ratings, *I,* for the cross-sectional areas specified in Table 16.8.2.1, as well as for any other cross-sectional areas are to be calculated from the formula:

$$I = \alpha S^{0.625}, \quad [\text{A}] \tag{16.8.2.2}$$

where:

α – factor depending on the maximum permissible operating temperature of the conductor determined from Table 16.8.2.2;

S – nominal cross-section of conductor, [mm^2].

Table 16.8.2.2

Maximum temperature of conductor, °C		60	65	70	75	80	85	90
Values of factor α for the nominal cross-sectional area of conductor, *S*	≥ 2.5 mm^2	9.5	11	12	13.5	15	18	18
	< 2.5 mm^2	8	10	11.5	13	15	18	20

16.8.2.3 Permissible current ratings for two-, three- or four-core cables are to be reduced in relation to the values given in Table 16.8.2.1, using the following correction factors:

0.85 – for two-core cables,

0.70 – for three- and four-core cables.

16.8.2.4 Permissible current ratings for cables and conductors, installed in circuits with intermittent or short-time service, are to be determined by multiplying the value of current rating in continuous service of these cables, calculated in accordance with Table 16.8.2.1 or according to 16.8.2.3, by the correction factor taken from Table 16.8.2.4.

Table 16.8.2.4
Values of correction factors in relation to load

Nominal cross-sectional area of conductor, mm^2	Intermittent service, 40%		Short-time service, 30 min.		Short-time service, 60 min.	
	Cables and conductors					
	with metal coverings	without metal coverings	with metal coverings	without metal coverings	with metal coverings	without metal coverings
1	1.24	1.09	1.06	1.06	1.06	1.06
1.5	1.26	1.09	1.06	1.06	1.06	1.06
2.5	1.27	1.10	1.06	1.06	1.06	1.06
4	1.30	1.14	1.06	1.06	1.06	1.06
6	1.33	1.17	1.06	1.06	1.06	1.06
10	1.36	1.21	1.08	1.06	1.06	1.06
16	1.40	1.26	1.09	1.06	1.06	1.06
25	1.42	1.30	1.12	1.07	1.06	1.06
35	1.44	1.33	1.14	1.07	1.07	1.06
50	1.46	1.37	1.17	1.08	1.08	1.06
70	1.47	1.40	1.21	1.09	1.09	1.06
95	1.49	1.42	1.25	1.12	1.11	1.07
120	1.50	1.44	1.28	1.14	1.12	1.07
150	1.51	1.45	1.32	1.17	1.14	1.08
185	–	–	1.36	1.20	1.16	1.09
240	–	–	1.41	1.24	1.18	1.10
300	–	–	1,46	1.28	1.20	1.12

16.8.2.5 Permissible current ratings specified in Table 16.8.2.1 refer to the ambient temperature of + 45°C. The values of permissible current ratings in continuous service for other ambient temperatures are to be calculated by multiplying the values given in Table 16.8.2.1 by correction factors specified in Table 16.8.2.5.

Table 16.8.2.5
Values of correction factors in relation to the ambient temperature

Maximum permissible temperature of conductor °C	Ambient temperature, [°C]										
	35	40	45	50	55	60	65	70	75	80	85
60	1.2	1.15	1.00	0.82	–	–	–	–	–	–	–
85	9	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.50	–	–
95	1.1	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

16.8.2.6 Instead of execution of calculations resulting from 16.8.2.1 ÷ 16.8.2.5, permissible current ratings for cables and conductors in relation to different maximum insulation temperature and different ambient temperatures in continuous, short-time and intermittent services, may be selected according to *Publication No. 15/P – Current Rating Tables for Cables, Wires and Busbars in Marine Installations*.

16.8.2.7 When choosing cables for the final branch circuits of lighting or the heating appliances, neither correction nor demand factors are to be used.

16.8.2.8 Cables are to be so selected as to withstand the maximum short-circuit current. When choosing the cables, time-current characteristics of the applied protections, as well as the peak value of the anticipated short-circuit current in the first alternation, are to be also taken into account.

16.8.2.9 Cables installed in parallel for the same polarity or phase are to be of the same type, are to be run as close as possible to each other and are to have the same cross-sectional area of at least 10 mm^2 and the same length.

16.8.3 Selection of Cable Cross-Sectional Areas for Permissible Voltage Drop

16.8.3.1 The voltage drop on the cables connecting the generators to the main switchboard or the emergency switchboard is not to exceed 1 per cent.

16.8.3.2 In normal operating conditions, the voltage drop on the cables between the busbars of the main or emergency switchboard and any electric consumers is not to exceed 6 per cent of the rated voltage. For the consumers supplied from accumulator batteries of the voltage not exceeding 50 V, the value may be increased to 10 per cent.

For navigation and signal lantern circuits, the permissible voltage drop may be limited to smaller values so as to ensure the required lighting characteristics.

At short-time service, e.g. at starting the electric motors, a greater voltage drop is permissible, provided it does not adversely affect the work of the remaining electric consumers.

16.8.3.3 Cables used for supplying the directly-started alternating-current electric motors are to be so calculated that the total drop of voltage on motor terminals at starting does not exceed 25 per cent of the rated voltage.

The possibility of increasing the specified above voltage drop will be subject to special consideration by PRS in each particular case.

16.8.4 Installation of Cables

16.8.4.1 Cable runs are to be, as far as possible, straight and accessible, located as far away as possible of the side plating and are to pass through locations where cables are not affected by oil, fuel, water and excessive temperature. Cable runs for equipment and installations essential for the naval ship survivability are to be sufficiently protected (sheathed) from the effects of armament operation.

16.8.4.2 Cable runs are to be installed not closer than 100 Cable runs in spaces, which may be flooded, are to be led as high as possible.

16.8.4.3 Cables are not to be run in double bottom, except the demagnetisation winding cables, and, when necessary, cables of the hull protection electrochemical system and cables supplying the armament and command means. Running these cables is to be agreed with PRS in each particular case.

16.8.4.4 No cables are to be installed at a distance less than 50 mm from the double bottom, from the liquid fuel and lubrication oil tanks and from the fuel pipings. The distance of cables from the shell plating, as well as from fire-resistant, watertight and gastight bulkheads and decks is not to be less than 20 mm.

16.8.4.5 Cables installed in bunches are to be in accordance with the requirements of IEC Publication 332-3 regarding resistance of cable bunches to the spread of flame or the following means preventing the spread of flame are to be provided:

.1 fire stops, at least of B-0 class (see sub-chapter 1.2 of *Part V – Fire Protection*) are to be fitted on the cable bunches at the inlet to the main switchboard, emergency switchboard, switchboard supplying essential auxiliaries, monitoring and control panels and desks for control of machinery and the naval ship, as well as at each end of totally enclosed cable runs;

.2 in enclosed and semi-enclosed compartments and spaces, cable bunches installed in semi-enclosed and open cable runs are to be provided with:

– fire protection coating applied to the entire length of vertical runs and to the length of 1 m at every 14 m for horizontal runs, or

– fire stops of the B-0 class, at least at every second deck or every 6 m for vertical runs and every 14 m for horizontal runs;

.3 cable bunches installed in holds are to be protected using fire stops of B-0 class at the boundaries of the holds.

16.8.4.6 Cables are not to be painted.

16.8.4.7 Cables having external metallic sheathing may be installed on structures of light alloys or be fastened in position with holders of such alloys only in cases where reliable anti-corrosive protection is provided.

16.8.4.8 In enclosed spaces intended for the carriage of explosive and dangerous cargoes, as a rule, no through runs of cables are to be installed. Admissibility and methods of installation of cables in such spaces are subject to special consideration by PRS in each particular case.mm to the sources of heat.

16.8.4.9 No cables are recommended to be installed under the flooring of machinery spaces. If such an installation is required, cables are to be installed in metallic pipes or in closed ducts (see 16.8.8).

16.8.4.10 Cables are not to be laid in tanks nor in holds intended for the carriage of flammable liquids, except when they are run in doubled, watertight pipes or tunnels.

16.8.4.11 Where the cable run passes through spaces filled with water, cables are to be led in a watertight pipe or tunnel.

16.8.4.12 Cables installed across expansion joints in the hull structure are to be provided with expansion loops. The inside diameter of a loop is not to be less than 12 times outside diameter of the cable.

16.8.4.13 Cables led to equipment shock absorbed and movable under effect of mechanical impact are to be provided with appropriate expansion loops.

16.8.4.14 Installation of cables having insulation intended to withstand different permissible temperatures in the common cable runs is to be effected in such a manner that the cables are not heated above their permissible temperature.

16.8.4.15 Cables with different protective coverings, the less resistant of which may be subjected to damage, are not to be installed in one common pipe, one common duct or in other runs of unsupported common laying.

16.8.4.16 The current cables of the main electric propulsion machinery are to be installed separately from the cables intended for other purposes.

16.8.4.17 Cables of electro-acoustic equipment, which carry high value current or voltage pulses, are to be laid separately of other cables at their whole length, in metallic, efficiently earthed pipes.

16.8.4.18 Conductors in multi-core cables are not to be used for supplying power and control the circuits of essential services not associated with one another.

Multi-core cable is not to be used for both the safe voltage circuits and working voltage circuits greater than the safe voltage.

16.8.4.19 When equipment is supplied by two separate feeders, these feeders are to be installed in different runs at different naval ship sides as far apart as possible from one another, both in horizontal and in vertical direction.

16.8.4.20 Cables supplying emergency equipment are to be led close to the naval ship symmetry plane.

16.8.4.21 Cables are not to be led in ducts or other structures made of combustible materials.

16.8.4.22 Cables are not to be embedded in thermal or acoustic insulation if it is made of combustible materials. From such an insulation, cables are to be separated with plating of incombustible material.

Where cables are installed in thermal or acoustic insulation made of incombustible materials, the cables are to be selected taking into account their additional heating.

16.8.4.23 Running cables on weather deck is to be avoided, unless it is necessary.

16.8.4.24 In warfare naval ships, cables supplying essential consumers, led on weather deck, are to be placed in metallic pipes or protected by metallic sheaths, unless the naval ship is so designed that appropriate protection of the cables from external mechanical damages is ensured.

16.8.4.25 Cables installed in refrigerated spaces are to be provided with protective metallic protective coat or sheathing of neoprene or of any other material resistant to the action of the refrigerant. If cables are provided with an armour, this armour is to be suitably protected against corrosion.

16.8.4.26 Cables in refrigerated spaces are to be installed on perforated panels or holders and are to be fastened in position in such a manner that a free space is reserved between the cables and the walls of the room.

Panels, bridges and cable clips are to be protected against corrosion.

If cables are to pass through the thermal insulation of a refrigerated space, they are to run at right angles to the insulation surface in an appropriate gland packed on both ends.

16.8.4.27 The minimum internal bending radii of the cables are not to be less than those specified in Table 16.8.4.27.

Table 16.8.4.27

Kind of cable		External diameter of cable *d*, mm	Minimum bending radius
Kind of insulation	Kind of protective covering		
Thermoplastic and elastomeric materials	Metal tape or braid of metal wires	any	10 *d*
	Lead alloy or braid of metal wires	any	6 *d*
	Other sheathing	up to 9.5	3 *d*
		9.5 to 25.4	4 d
		over 25.4	6 *d*

16.8.4.28 Cables and earthing conductors of equipment mounted on shock absorbers are to be installed in such a manner that they cannot be damaged in service.

16.8.5 Fastening of Cables

16.8.5.1 Cables are to be suitably fastened in position by means of clips, holders, hangers, etc. made of metal protected against corrosion or other incombustible or low flame spread material.
The fastener surface is to be sufficiently wide and is to have no sharp edges.

The fasteners are to be selected in such a manner that the cables are fastened in position securely but without damage to their protective coverings.

16.8.5.2 Distances between the cable fastening points in the case of horizontal installation are not to exceed the values given in Table 16.8.5.2. For vertical runs of cables, these distances may be increased by 25 per cent. Number of fastening elements may be increased for locations particularly liable to impact and vibration due to the naval ship operation.

Table 16.8.5.2

External diameter of cable, mm		Distance between fastening points for cables, mm	
Over	Up to	Without armour	With armour
–	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	–	400	450

16.8.5.3 Cables are to be fastened in such a manner that mechanical strains in cables are not transmitted to their inlet connections.

16.8.5.4 Cable runs and cables installed parallel to the shell plating are to be fastened to the hull structural members and not to the shell plating.

On watertight bulkheads and masts, cables are to be fastened by means of suitable structures, such as perforated tray plates, holders or panels.

16.8.5.5 Cables running parallel to bulkheads subject to sweating are to be installed on bridges or on perforated panels in such a manner that a free space is reserved between cables and bulkheads.

16.8.5.6 Cable runs are to be installed with a minimum number of crossings. Bridges are to be used at places where cables cross each other. An air gap of not less than 5 mm is to be left between a bridge and the cable run crossing it over.

16.8.5.7 For naval ships made of non-metallic materials, including plastics, the requirements concerning running, fastening and sealing cable penetrations and cable runs, changed in respect of the requirements contained in *the Rules* for steel naval ships, may be simultaneously applied depending on manufacturing technology of non-metallic hulls, used materials, etc.

16.8.6 Cables Penetrating Decks, Bulkheads and Elements of Naval Ship Structure

16.8.6.1 Penetration of watertight, gastight and fire-resisting bulkheads and decks is to be made tight.

Packing where cables penetrate the mentioned bulkheads and decks is not to reduce their tightness or resistance; no force resulting from elastic deformations of the naval ship's hull is to be transmitted to the cables.

16.8.6.2 When installing the cables through non-watertight bulkheads or elements of the naval ship's structure less than 6 mm thick, lining or bushings that will prevent damage to cables are to be provided in cable penetration openings.

Where bulkheads or the naval ship's structures are more than 6 mm thick, no lining or bushings are required, but the edges of the holes are to be rounded off.

16.8.6.3 Cables passing through decks are to be protected from mechanical damage up to a suitable height above the deck, and in locations where mechanical damage is less probable, up to a height of at least 200 mm. Cable penetrations are to be filled with cable compound or other equivalent packing. For single cables, the use of glands is permitted instead of filling with compound.

16.8.7 Cable Compounds and Packing

16.8.7.1 To fill the cable boxes in watertight bulkheads and decks, the use is to be made of packing compounds having good adhesion to the inside surfaces of cable boxes and cable sheathing, that will withstand the action of water and oil products, will not shrink and lose its tightness in continuous service under conditions specified in 2.1.1 and 2.1.2.

16.8.7.2 Packing of cable penetrations through fire-resisting bulkheads is to be so made as to withstand standard fire test required for the given type of bulkhead, specified in sub-chapter 1.2 of *Part V – Fire Protection*.

16.8.8 Installation of Cables in Pipes and Conduits

16.8.8.1 Pipes and conduits in which cables are installed are to be metallic and protected from corrosion on the inside and outside surface. The inside surface of pipes and conduits is to be even and smooth. Ends of pipes are to be machined or protected in such a manner that no damage is caused to the cables when they are being pulled in. Cables with lead sheaths not having any additional protective coating are not to be drawn into pipes.

16.8.8.2 Use of pipes and conduits made of plastics is to be subject to special consideration by PRS in each particular case.

16.8.8.3 Pipe and conduit bending radius is not to be smaller than the permissible radius for cable of the largest diameter installed in this pipe (see 16.8.4.26).

16.8.8.4 The sum of the cross-sectional areas of all cables as measured on their outside diameters is not to exceed 40 per cent of the inside cross-sectional area of the pipe or conduit.

16.8.8.5 The pipes and conduits are to be mechanically and electrically continuous and are to be securely earthed if the method of their installation does not present in itself a reliable earthing.

16.8.8.6 The pipes and conduits are to be installed in such a manner that no water can accumulate in them. When required, ventilation holes are to be provided in the pipes and conduits, in the highest and lowest points possible, to ensure circulation of air and to prevent steam condensation. Holes in pipes are permissible only in places where they will not increase the danger of explosion or fire.

16.8.8.7 Cable pipes and conduits installed alongside the naval ship's hull, which can be damaged by deformation of the naval ship's hull, are to be provided with appropriate compensation devices.

16.8.8.8 Cables running in vertical pipes and conduits are to be protected in such a way as not to be damaged due to tension caused by their own mass.

16.8.9 Special Requirements for Installation of Single-Core Alternating-Current Cables

16.8.9.1 Single-core cables are not recommended for alternating-current installation. If installation of such cables is unavoidable, the cables rated in excess of 20 A are to meet the following requirements:

.1 cables are not to have coverings of magnetic material;

.2 cables which belong to one common circuit are to be installed in one run or in one pipe; installation of such cables in different pipes is permitted only when pipes of non-magnetic materials are used;

.3 cable fasteners other than those made of non-magnetic materials are to embrace all single-core cables in one circuit;

.4 distance between cables is not to be over one cable diameter.

16.8.9.2 When single-core cables are passed through bulkheads or decks, there is to be no magnetic material between the cables which belong to one common circuit. Distance between such cables and magnetic material is not to be less than 75 mm.

16.8.9.3 If single-core cables rated in excess of 250 A are installed parallel to steel structures, the distance between cables and these structures is not to be less than 50 mm.

16.8.9.4 When installing single-core cables with cross-sectional areas of over 185 mm^2, cables are to inter-cross not less than every 15 m. No cable inter-crossing is required in the case of cable length up to 30 m.

16.8.9.5 Multi-core cables with parallel connected cores are to be installed in the same way as single-core cables. For these cables, all requirements for single-core cables are applicable.

16.8.10 Connecting and Tapping of Cables

16.8.10.1 Ends of rubber-insulated cables, mineral-insulated cables and cables with metallic coating are to be packed in a manner that would prevent the entry of moisture inside the cable.

16.8.10.2 Ends of cable conductors are to be protected from unfastening of single wires by soldering or putting on cable terminals.

16.8.10.3 Protective covering of a cable led into a device from below should enter inside the device to not less than 10 mm above the inlet hole.

16.8.10.4 Connection of cables at places of tapping is to be effected in junction boxes by means of clamps.

16.8.10.5 If, during installation of cables, it is found necessary to make additional connections, they are to be effected in suitable junction boxes provided with clamps. The joint as a whole is to be protected from the influence of environmental conditions. Permission for the use of cable joining and application of cable joining method other than that mentioned above will be specially considered by PRS.

16.8.10.6 Where in a closed space, separated by watertight bulkhead, junction boxes have been installed for through cables supplying essential consumers located outside the space, these boxes are to have an enclosure protection degree of IPX8.

17 ELECTRIC PROPULSION PLANT

17.1 General Requirements

17.1.1 Unless specified otherwise in this Chapter, the electrical equipment forming part of the electric propulsion plant is to comply with the requirements of other Chapters of the present Part of the *Rules*.

17.1.2 The electric propulsion plant is to ensure sufficient redundancy through the use of one of the below arrangements:

.1 Two electric motors driving one common gear through the coupling;
.2 Two separate motors, each driving its own shaft;
.3 Single shaft with two motors arranged in a series;
.4 Single motor with two individual, electrically separated windings driving single shaft;
.5 Two rudder propellers;
.6 Two electric azimuth propellers;
.7 Other equivalent arrangement agreed with PRS in each particular case.

17.1.3 Propulsion generators may be used for supplying other shipboard electric systems, provided voltage and frequency stability can be assured under all running conditions, including those of manoeuvring, in accordance with the requirements of 2.1.3.

17.1.4 It is recommended that electrical heating be provided in the spaces accommodating electric machinery, switchboards and control desks.

17.1.5 Stationary lighting is to be provided underneath the propulsion electric motors and main generators.

17.1.6 The parts of the electric propulsion plant machines (generators and electric motors), installed below the floor, are to be constructed with the degree of protection not less than IPX4.

The degree of protection IPX2 may be allowed if they are installed in a dry space or are protected against ingress of water by a watertight foundation and if, in addition, there is signalling operating in case of water entering this space.

17.2 Permissible Supply-Voltage Levels

The voltage levels in the electrical systems of the propulsion plant are not to exceed values given in 4.2 or 18.2.2.

17.3 Electric Machines

17.3.1 Cooling and Ventilation

17.3.1.1 Generators and motors of the electric propulsion plant with closed-circuit ventilation are to be provided with thermometers to measure air and water temperature.

17.3.1.2 It is recommended that closed-circuit ventilating system be provided with air humidity indicators, as well as with audible and visual alarms to operate when the cooling air temperature exceeds the permissible level.

17.3.1.3 Audible and visual alarms are to be provided to operate when the temperature of electric motors and generators of the electric propulsion plant rises above the limits specified in Table 3.2 of Appendix 2.

17.3.1.4 Air-cooled electric motors of the main propulsion plant are to be equipped with two induced ventilation fans, each having the capacity sufficient to ensure normal conditions of motor operation. Visual signals of fan operation and audible signals of fan stoppage are to be provided.

17.3.1.5 Generators and motors are to be provided with filters purifying the cooling air, with ventilation system both closed and open. Ventilation ducts are to be of such a design as to prevent water from penetrating the machine.

17.3.1.6 Liquid-cooled electric machines are to be of such design as to prevent overboard water from penetrating the machine windings. Devices for monitoring the cooling system operation are to be provided.

17.3.1.7 Liquid-cooled systems of multi-rotor machines are to be separate for each rotor.

17.3.2 Lubrication of Bearings

17.3.2.1 A pressure lubrication system for the bearings of electric propulsion machinery is to have two lubricating oil pumps, each with a delivery sufficient to ensure normal operating conditions of the plant.

17.3.2.2 Where pressure lubrication of bearings is used, the oil system of electric propulsion motor is to incorporate a filter and a feed gravity tank to ensure oil supply to the bearings for not less than 15 minutes with the pump switched off unless the bearing design provides for normal lubrication for the period from the cutting off of power supply to the motor until the naval ship' stop.

17.3.2.3 A circulating lubrication system is to be provided with visual and audible alarms operating at a low level in gravity tank, as well as with means for measuring the oil temperature at outlet.

17.3.3 Machine Excitation

17.3.3.1 The machine excitation system is to be fed from at least two converters of electric power (exciters) so that if one of them fails, the remaining sets are capable of meeting the total exciting power requirements even at elevated loads, such as are incident to manoeuvring.

It is admissible for the exciting systems of machines to be fed from the busbar of the main switchboard, provided that power supply is assured under all conditions in accordance with the above requirements.

17.3.3.2 Excitation systems for direct current motors and generators are to be so designed that the decay or interruption of excitation of propeller electric propulsion motor results in immediate disappearance of excitation in generators or in voltage reduction of generator to zero.

This requirement may be waived for systems of direct current or direct voltage of direct current with two or more motors. It may also be waived when a special excitation system is used which ensures machine safety in such case.

17.3.3.3 Excitation circuits are to include devices for discharging the magnetic excitation energy in the event of sudden opening of a circuit (see also 5.4.3).

17.3.3.4 Excitation and its automatic control systems are to be so designed that electric propulsion motors are safeguarded from overspeeding in the event of the propeller breaking down or loss. In direct-current systems, this requirement applies to all motors, which constitute a direct-current loop.

17.3.3.5 Where the exciters of the electric propulsion machines are intended to be used for feeding other machinery or devices, a suitable interlock is to be provided to prevent their use for supply purposes while the propulsion plant is in operation, or a notice is to be provided in a suitable place to specify that this source of supply may only be used with the propulsion plant at a standstill. This requirement does not apply to stand-by exciters.

17.3.3.6 In direct-current systems, protection is to be provided to ensure the switching-off of generators and motors excitation in the event of interruption of the main current circuit.

17.4 Switches in Main and Excitation Circuits

17.4.1 No automatic circuit-breakers are to be installed in the excitation circuits other than those which de-energise machines in the event of a short circuit or a failure in the main current circuit.

17.4.2 Where a definitive sequence of switching operations is to be assured, reliable interlock to prevent the possibility of wrong switching is to be provided.

17.4.3 Switchgear intended for selecting modes of operation circuits while they are de-energised is to be suitably interlocked to prevent its closing or switching over in the energised condition.

17.4.4 In direct-current systems, generators and motors are to be switched on and switched off with the excitation switched off, without disconnection of a direct-current loop.

17.5 Control of the Main Electric Propulsion Plant

17.5.1 Each main electric propulsion plant is to be provided with the main control station located in the machinery space.

Additional remote control stations may be installed at locations from which the naval ship control is effected.

17.5.2 Where control from the switchboard or desk of the propulsion plant involves the use of an electric, pneumatic or hydraulic drive, damage to such drive should not render the propulsion plant inoperative and the switchboard or desk control station is to be immediately ready for manual operation.

17.5.3 Where several electric propulsion control stations are available, a suitable switch placed in the main control station is to be provided to change over the stations. This switch is to permit only one control station to be switched on.

17.5.4 The change-over switch is to be fitted with interlocking to prevent changing over from one control station to another without previous removal of excitation from the propulsion plant, this operation is to be effected by setting the handle of the station in operation to the position ”STOP”.

In such a case, irrespective of the position of the handle on the newly switched on control station, the propulsion plant may only be started from the position ”STOP”.

17.5.5 The electric propulsion plant control stations are to meet the requirements of sub-chapter 1.13 of *Part VI – Machinery Installations and Refrigerating Plants*.

17.5.6 It is permitted to apply mechanically connected main propulsion plant control stations located on the main command station to synchronise their operation when they are used alternately. However, the possibility of controlling single motors of main electric propulsion plant is to be provided.

17.5.7 The design of the electric propulsion plant remote control system is to be such as not to require from the personnel any time delay when changing the position of the handle on the control station situated in the main command station.

17.5.8 The remote control system of the electric propulsion plant is to be fitted with interlocking that would preclude the starting of the main propulsion engine with the shaft turning gear switched on.

17.6 Main Electrical Propulsion with Semiconductor Converters

17.6.1 General Requirements

17.6.1.1 The output of the main sources of electric power and of receivers connected to the busbars of the main electric propulsion is to be selected with regard to the expected voltage and current distortions on these busbars caused by operation of converters and the transient conditions of the machines, as well as with regard to additional distortions due to the asymmetry of the voltages.

17.6.1.2 Main generators, rectifiers, propulsion motors, as well as the main circuit equipment are to withstand the electric overload of the value not less than 250 per cent of the rated current during 2 s.

17.6.1.3 The output of main propulsion electric motors is to be selected with regard to the expected voltage distortions at the outlet of the semiconductor converter.

17.6.1.4 Main generators and main propulsion electric motors are to ensure technical characteristics related to the naval ship's intended service during voltage and current distortions caused by the semiconductor converters operation.

17.6.1.5 Overload capability of main generators and main propulsion motors is to correspond to the naval ship's operating conditions. If necessary, compensation of reduction of overload capability caused by presence of higher voltage harmonic components during operation of the semiconductor converters is to be ensured.

17.6.1.6 Filter condensers used for the reduction of network distortions are to be provided with discharging devices.

17.6.1.7 Electric power consumers requiring voltage supply of higher quality are to be supplied from other sources of power or are to have local devices for the reduction of higher harmonic components to the technically accepted level.

17.6.2 Alternating-Direct Current Main Electric Propulsion

17.6.2.1 The current pulsation coefficient of propulsion motors supplied by the rectified current is to be determined by the formula:

$$K_n = \frac{\sqrt{\sum_{i=2}^{n} I_i^2}}{I_{dn}} \cdot 100\% \qquad (17.6.2.1)$$

where:

i – harmonic component;

I_i – root-mean-square current of i-harmonic component;

I_{dn} – constant component of rectified current under rated conditions;
n – maximum harmonic component taken into account.

The value of coefficient K_n for propulsion motors supplied from direct-current generators is not to exceed 2 per cent.

17.6.2.2 The dynamic-braking current is not to exceed the value of 200 per cent of the rated current.

17.6.3 Alternating-Alternating Current Main Electric Propulsion

Output of main generators is to be selected taking into account expected irregularity of phase loads caused by the usage of semiconductor frequency converters.

17.7 Protection of the Electric Propulsion Plant

17.7.1 The electric propulsion plant is to have short-circuit and overload protection. Operation of the overload protection is to be preceded by the operation of audible and visual alarms.

The overload protection is not to operate at overloads during manoeuvring.

17.7.2 Thyristor converters in the main and excitation circuits of the main propulsion plant motors and generators are to be provided with the following protections:

.1 against internal and external short-circuits and overloads;
.2 against overvoltage;
.3 against the change of the form of the inverter operation (arc-through) if the converter is intended for the inverter operation;
.4 against supply voltage decay in control systems.

17.7.3 Fuses are not to be used as a means of protection in the main and excitation circuits of electric machines.

17.7.4 The electric systems are to have earth-fault monitoring with signal actuated when the earth current exceeds 20 A.

17.7.5 Where direct-current generators are connected in series, appropriate measures are to be taken to avoid the reversal of any of the sets when the generator mover stops. Measures are to be taken in such case to ensure that the propulsion plant is not out of action but the generator rendered inoperative is disconnected.

17.7.6 Arrangements are to be made to limit or utilise the power generated by the main propulsion motor under transient conditions or during propeller reversals if such power is likely to cause the overspeeding of the generator prime movers. Speed increases of the main propulsion prime movers are to be limited to the values specified in 2.10 of *Part VII – Machinery, Boilers and Pressure Vessels*.

17.7.7 The electric propulsion plant is to have protection preventing its self-starting after the operation of any protective device.

17.8 Measuring and Monitoring Instruments

17.8.1 Given below is a minimum list of measuring instruments that are to be provided in order to ensure permanent and direct indication of the system parameters that affect the operation of the electric propulsion plant:

.1 an ammeter in the main current circuit;
.2 a voltmeter in the main current circuit;
.3 an ammeter in the excitation circuit for adjustable excitation systems;
.4 a voltmeter in the excitation circuit for adjustable excitation systems;
.5 a tachometer for main propulsion motors or propeller shafts.

For alternating-current systems, the following is to be provided additionally:

.1 a frequency indicator;
.2 a synchroniser, in the case of parallel operation of generators;
.3 a wattmeter.

17.8.2 The electric propulsion plant is to be fitted with an insulation resistance monitoring instrument.

The main current circuit is to be provided with continuous insulation resistance monitoring, as well as with visual and audible alarms operating in the event of an inadmissible decrease of the insulating resistance.

17.8.3 Each control station is to be provided with a visual signal indicating the presence of voltage in control circuits.

17.9 Electric Couplings

17.9.1 General Requirements

17.9.1.1 The requirements of this sub-chapter apply also to the electric couplings fitted in systems other than main propulsion plant.

17.9.1.2 Electric couplings are to be so designed as to enable their dismantling without the necessity to disassemble the internal combustion engine or reducer.

17.9.1.3 Electric couplings are to be so designed and arranged as to be freely accessible for maintenance, brush replacement and air gap measurements without the necessity to dismantle the couplings.

17.9.1.4 Enclosures and bearing discs are to be made of steel or materials of equivalent strength.

17.9.1.5 The rotating parts of couplings and their windings are to be so designed or secured that they cannot be damaged in the event of a sudden stop.

17.9.1.6 Electric couplings are not to produce axial thrust. They are to be balanced to comply with the requirements of sub-chapter 4.1 of *Part VII – Machinery, Boilers and Pressure Vessels.*

17.9.1.7 The maximum torque under excitation forcing conditions is not to exceed twice the rated torque of the coupling.

17.9.2 Protection and Interlocking

17.9.2.1 Electric couplings are to have such system of connections or are to be so interlocked that it will be totally impossible for the coupling to be excited when the main propulsion motor is started up or reversed.

17.9.2.2 Where several main propulsion motors are used to drive the same transmission, the excitation system of the electric couplings is to be interlocked to prevent the motors, which rotate in the opposite directions from being started simultaneously.

17.9.3 Electric Coupling Excitation

17.9.3.1 The excitation windings of electric couplings are to be protected against short-circuit and overvoltage.

17.9.3.2 The excitation circuit of an electric coupling is to incorporate at least:

.1 a two-pole switch;
.2 a discharging device for magnetic stream;
.3 short-circuit protection.

18 ADDITIONAL REQUIREMENTS FOR EQUIPMENT OF ABOVE 1000 V

18.1 General Requirements

The requirements of the present Chapter apply to electrical equipment with rated voltage above 1000 V up to 15 000 V alternating current and are supplementary to those specified in other Chapters of the present Part of the *Rules*. The systems with rated voltage above 15 000 V are subject to special consideration of PRS.

18.1.1 Insulating materials used in electrical equipment of above 1000 V are to ensure, during the continuous service of the naval ship, the insulation resistance of at least 2000 Ω per V of rated voltage.

18.1.2 Warning notices indicating the value of voltage are to be placed at the entries to special electric spaces and on the enclosures of electric equipment located outside these spaces.

18.1.3 In junction boxes and sockets, as well as terminal boxes of electrical equipment with rated voltage above 1000 V, no joints are to be installed or connection of conductors effected if such joints or conductors are rated for lower voltages.

18.2 Power Distribution

18.2.1 Distribution Systems

18.2.1.1 The following systems of electric power distribution may be used in shipboard installations:

.1 a three-core insulated system;

.2 a three-core system with the neutral point earthed directly to the naval ship's hull;

.3 a three-core system with the neutral point earthed to the hull through a low-ohm resistance (value of resistance is to be so selected that the short-circuit earth current is within limits 0.2 ÷ 1.0 of the rated load current of the largest generator);

.4 a three-core system with the neutral point earthed to the naval ship's hull through a high-ohm resistance (value of resistance is to be equal to, or slightly less than, 1/3 value of the capacitive reactance between phase and an earth).

18.2.1.2 The total resistance of the neutral earthing is to be so selected that the short-circuit current passing through the hull is not greater than the rated current of the largest generator but not less than three times the minimum current required to operate any device protecting against short-circuit with the naval ship's hull.

It is permitted to connect all earthing resistors to a common earth busbar which has connection with the hull at least in two places.

Connections with the hull are to be so effected that the rotating currents, which may be expected in such connections, cannot disturb operation of electronic equipment (e.g. electro-navigational, communication and control equipment).

18.2.1.3 It is to be possible to split the main switchboard busbars into at least two sections, each supplied by at least one generator, by means of circuit breakers, switches or switch disconnectors. Alternatively, at least two separate switchboards are to be provided interconnected by means of a cable equipped at both ends with circuit breakers.

Services, which are duplicated, are to be divided between the sections of the main switchboard or between the switchboards where separate, interconnected switchboards are used. For the supply of auxiliary circuits, at least one independent source of electrical power for each section is to be provided. Some receivers, the list of which is to be agreed with PRS, are to be capable of being supplied from both sections.

18.2.1.4 Generator neutrals are to be earthed through resistance in the main switchboard or directly on the generator.

18.2.1.5 For the purpose of maintenance or for the resistance measurements, the neutral conductor of each generator is to be provided with an isolating device so that the earthing connection of generator neutral can be isolated.

18.2.1.6 When using a system with neutral earthed, measures are to be taken to preclude passage of short-circuit current from equipment or cable to the naval ship's hull in the explosion-hazardous zones.

18.2.2 Permissible Voltages

Rated voltages are not to exceed the values specified in Table 18.2.2.

Table 18.2.2

Inter-phase rated voltage, kV	Rated frequency, Hz
3/3.3	50 or 60
6/6.6	50 or 60
10/11	50 or 60
15	50 or 60

18.2.3 Power Supply from External Source of Electric Power

The extent of power supply from an external source of electric power is subject to agreement with PRS in each particular case.

18.3 Protective Devices

18.3.1 General Requirements

18.3.1.1 When different voltages are used in one device, precautions are to be taken to prevent the lower voltage systems from being charged by leakage from the higher voltage systems.

18.3.1.2 The overload protection is to be provided in all phases. No fuses are to be used in the overload protection.

18.3.1.3 In systems with rated voltage greater than 1000 V, visual and audible alarms giving a warning of short-circuit with the naval ship's hull are to be provided.

18.3.2 Protection of Generators

18.3.2.1 Generators are to be provided with protection against short-circuit with the naval ship's hull and inter-phase short circuits in a cable connecting generator with the main switchboard.

18.3.2.2 Generators are to be provided with protection against internal faults.

18.3.2.3 De-energising of generators is to be ensured when any of the protective devices of the generator operates.

18.3.3 Protection of Transformers

18.3.3.1 Transformers are to be protected against short-circuit and overload.

18.3.3.2 Transformers on the low voltage side are to be protected against overload from the side of higher voltage. Type of protection is to be agreed with PRS.

18.3.3.3 If the transformers are designed for parallel operation, actuation of protection device on the primary side is to cause disconnecting the circuit on the secondary side.

18.3.3.4 The voltage measuring transformers are to be protected against short-circuits and overloads on the secondary side.

18.4 Protective Earthing

18.4.1 Metallic enclosure of switchboards is to be provided with copper earthing conductor situated along its whole length, having at least two relevant terminals for connection with the naval ship's hull. One-second short-circuit earth current density in this conductor is not to exceed 150 A/mm^2, and the cross-section of conductor is not to be less than 30 mm^2. Casings of compartments and fields are to be connected to earthing conductor directly or by means of the metal parts of structure. Welded and twisted connections assure proper continuity of earthing, but

for twisted connections the surface of connection is to be protected against corrosion by usage of adequate anti-corrosion surfaces. Dependent on the method of network neutral earthing and the time necessary for operation of protective devices, maximum short-circuit earth current is to be taken into consideration for earthing connections.

18.4.2 Earthing of metal parts of withdrawable circuit-breakers or movable elements are to be effective in each fixed and intermediate position.

18.4.3 Doors of the high voltage compartments are to be connected to the earthed structure by means of copper conductor with a cross-section not less than 6 mm^2.

18.4.4 Metal enclosures of other high voltage equipment are to be earthed by means of flexible copper conductor of such cross-section that one-second short-circuit earth current density is not to exceed 150 A/mm^2, but not less than 16 mm^2.

18.4.5 The secondary windings of measuring current and voltage transformers are to be earthed by means of copper conductor with cross-section of 4 mm^2.

18.4.6 The earthing conductors are to be suitably marked.

18.5 Arrangement and Protection Degree of Electrical Equipment

18.5.1 The electrical equipment is to be located in special electric spaces; the degree of protection of its enclosures is to be at least IP23.

The degree of protection of terminal boxes of electric rotating machines is to be at least IP 44. The degree of enclosure protection of switchgear, monitoring devices and converters is to be at least IP32.

In justified cases, such equipment may be placed outside the special electric spaces, provided the protection degree is at least IP44 and access to live parts is possible only when the voltage is off or with the use of special tools.

18.5.2 An easy-to-read diagram of the arrangement and the connections of electrical equipment is to be located in the special electric space.

18.5.3 Where electrical equipment has not own enclosures, the compartment in which the equipment is fitted is considered as enclosure. The entry into the compartment is to be provided with interlock preventing entry thereto until the supply is switched off and the equipment earthed.

18.6 Switchboards

18.6.1 The switchboards are to be provided with doors locked with a special key, other than those for switchboards and electrical equipment operating at lower voltages.

Opening of the door is to be possible only when the part of main circuit located in the compartment or field of switchboard, which becomes accessible is disconnected from supply.

18.6.2 Circuit breakers used in switchboards are to be of a withdrawable type. Circuit-breakers or their movable elements with apparatus are to have mechanical devices fixing them in the operating position, in the testing position (control circuits are connected), as well as in switched-off position (main circuits and control circuits are disconnected and furthermore, there is safe, insulating clearance in poles of main circuit).

Automatic shielding is to be provided, by means of insulating barriers, of fixed contacts of plug connections in live condition when circuit-breaker or movable element is withdrawn to the testing position, switched-off position or withdrawn totally from the switchboard.

Pulling out or pushing in of the circuit breaker or movable element to the operating position is to be possible only when switchgear is in open condition.

If electrical or other energy is required for the operation of circuit breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components. However, the tripping due to overload, short-circuit or under-voltage is to be independent of any stored electrical energy sources.

18.6.3 For the purpose of short-circuiting the busbars and the outgoing switchboard circuits with each other and with the naval ship's hull, switches rated for the maximum short-circuit current are to be provided in the switchboard.

The possibility of using a portable short-circuiting device instead of a stationary one will be subject to special consideration by PRS in each particular case.

18.6.4 Along the free-standing switchboards a passageway is to be provided for inspection of the switchboard and the switchgear. The width of the passageway between the switchboard and the wall is not to be less than 800 mm and that between the parallel switchboard sections – not less than 1000 mm.

If such passageways are intended for maintenance of the switchboard, their width is to be increased to 1000 mm and 1200 mm, respectively.

Such passageway widths are required irrespective of the type of the accidental touch protection applied.

18.6.5 The clearances between the live parts of electrical equipment and the protective barriers and enclosures are not to be less than those given in Table 18.6.5.

Table 18.6.5

No.	Rated voltage, kV	Minimum height of passageway, mm	Minimum protective clearances, in mm, of live parts from barriers and enclosures consisting in:	
			tight doors and barriers	insulating handrails
1	3/3.3	2500	70	600
2	6/6.6	2500	100	600
3	10/11	2500	140	700
4	15	2500	180	700

Where it is necessary to apply lower clearances, voltage pulse test is to be carried out.

18.6.6 Switchboards are to be provided with devices intended for reduction of overpressure in case of internal short-circuit arcs to ensure the mechanical strength of enclosure. The devices are to be so located that the influence of hot and ionised gases would not endanger personnel and compartment, in which they are located.

Occurrence of short-circuit arc is to result in immediate disconnecting of the damaged circuit.

18.7 Electric Machines

18.7.1 Electric generators and electric motors stator windings are to have all phase ends brought out to a separate terminal box.

18.7.2 Electric machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

18.7.3 Heating arrangements are to be provided to prevent the accumulation of moisture and condensation within the machines when they are stopped. It is recommended that such means are automatically switched on at stand-still and switched off at starting.

18.7.4 Where machines are cooled with a refrigerant, heat exchangers of rotating machines are to be of the double tube type. In a normally attended position, a visual and audible alarm is to be given to monitor water cooler leakage.

In addition to the tests normally required for rotating machinery, a high voltage test is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surge. This test applies to coils for rotating machinery to be used either in earthed or insulated system and is to be considered as acceptance test. The test is to be carried out in accordance with PN-EN 60034-15 Standard. It is allowed to perform the test according to an other method, proposed by manufacturer, after agreeing it with PRS.

18.8 Transformers

18.8.1 Dry transformers having earthed screens between the windings of the high and low voltages are to be used.

18.8.2 Use of other type transformers is to be agreed with PRS in each particular case.

18.8.3 The isolating of the transformer on the high voltage side is to cause the disconnection of the switch on the low voltage side.

18.8.4 If the voltage on the low voltage side of the transformer does not exceed 1000 V and the windings have the neutral insulated, a protective surge arrester is to be connected between the neutral of each transformer and the naval ship's hull. Such a surge arrester is to be selected for operation at a voltage not exceeding 80% of the minimum proof voltage of the equipment supplied by the transformer in question.

18.8.5 Parallel to the surge arrester, insulation monitoring instruments or an insulation fault indicator in the lower voltage circuit supplied by the transformer in question may be connected. Such devices are not to interfere with the proper operation of the arrester.

18.9 Cabling

18.9.1 For three-phase alternating-current cabling, three-core cables with multi-wire cores are to be used.

18.9.2 The cross-sectional area of power cable conductor is not to be less than 10 mm^2.

18.9.3 Cable types used in the network of over 1000 V are to be agreed with PRS.

18.9.4 The cables of the network of over 1000 V are to be installed separately from the network cables for voltages of up to 1000 V and are to be clearly marked.

18.9.5 When installing the cables, the following conditions are to be met:

- **.1** The high-voltage cables intended for distribution of electric power with various voltage values in the network may be installed in a common run, provided the insulation of all the cables installed in the common run is rated for the highest voltage occurring in the run in question;
- **.2** The cables passing through superstructure are to be run in cable pipes or closed ducts;
- **.3** The distance between the cable sheaths in circuits with various rated voltages are to be equal to the values mentioned in column 4 of Table 18.6.5;
- **.4** Cables installed outside the special electric spaces are to be contained in earthed metallic pipes or ducts or are to be provided with earthed metallic sheaths.

18.9.6 It is not permitted to install connecting boxes nor any similar means for clearing the break in cables, damages or for extending the cables.

18.9.7 Rated voltages of cables are not to be less than rated voltages of circuits, in which they are used. In systems with the neutral earthed to the naval ship's hull through high-ohm resistance, without automatic switching-off of a circuit with damaged insulation, as well as in systems with insulated neutral, the rated voltages of cables are not to be less than rated voltage between phases of circuit.

18.10 Voltage Tests

Prior to commissioning, each cable system is to be tested by carrying out:

.1 Insulation resistance measurement,

.2 Direct current voltage test by voltage, U, meeting the requirement:

$$U \geq 1.6(2.5\ Uo + 2), \quad [\text{kV}] \tag{18.10.1-1}$$

for cables with rating not exceeding 3.6 kV, and

$$U \geq 4.2\ Uo, \quad [\text{kV}] \tag{18.10.1-2}$$

for cables with rating exceeding 3.6 kV,
where:

Uo – rated voltage for which cables are designed, measured between the conductor and earthing or screen, kV.

The cable is to be supplied for at least 15 minutes. After the test, the cable cores are to be earthed for the time sufficient for removal of electrostatic charges,

.3 Insulation resistance measurement after voltage test.

Alternatively, alternating voltage test may be carried out in accordance with cable manufacturer's recommendations, with voltage not less than the working voltage, applied for at least 24 hours.

Tests conducted based on Publication IEC 60502 are also admissible.

19 DYNAMIC POSITIONING SYSTEMS

19.1 General Requirements

19.1.1 The requirements of this Chapter apply to naval ships provided with dynamic positioning systems and are additional to these given in other Chapters of these Rules, pertaining to the equipment and systems forming: electric power, propulsion and control systems.

19.1.2 The dynamic positioning system installed onboard a naval ship is to be certified by PRS.

19.2 Functional Requirements

19.2.1 General Requirements

19.2.1.1 The purpose of the dynamic positioning system is to maintain, with the predetermined accuracy, position and heading of the naval ship and, additionally for the ship in motion, its speed and track.

19.2.1.2 Technical parameters, which are to comply with 19.2.1.1, are to be agreed with PRS in each particular case.

19.2.1.3 Redundant components and systems are to be immediately ready to operate and are to have such capacity that is needed for the operation. Operation transfer to redundant component or system is to be automatic, as far as practicable, smooth and needs for the operator to intervene are to be kept to a minimum. Failure in one system is in no case be transferred to the other redundant system.

19.2.1.4 Redundant components of the dynamic positioning system are to be so arranged that results of fire, flooding or mechanical damage be kept to a minimum.

19.2.1.5 The dynamic positioning system is to be so designed that it is capable of co-operation with warfare and command transmitting equipment and systems, including hydro-acoustic and underwater weapons systems. Number and type of connections as well as functional requirements are to be in each case specified in tactical-technical specifications.

19.2.1.6 The minimum required components of the dynamic positioning system are specified by PRS in each particular case, depending on the type and purpose of the naval ship.

19.2.2 Power System

19.2.2.1 The power system is to be divisible into two or more systems such that in the event of failure of one system at least one other system will remain in operation. The operating systems are to be arranged by bus-tie breakers to separate automatically upon failures in one of the systems.

19.2.2.2 In the event of failure of one of power systems, such power is to be maintained as to be enable safe evacuating of the naval ship from the area of operation.

19.2.2.3 If a power management system is installed in the naval ship's power plant, its adequate redundancy is to be provided or reliability to the satisfaction of PRS is to be demonstrated.

19.2.3 Thruster System

19.2.3.1 Additionally to the requirements given in *Part VII – Machinery, Boilers and Pressure Vessels*, the requirements of this sub-chapter are to be complied with.

19.2.3.2 The thruster system is to provide adequate thrust in longitudinal and lateral directions, and provide yawing moment for heading control.

19.2.3.3 The thruster system is to be connected to the power system in such a way that the requirement of 19.2.3.2 can be complied with even after failure of one of the constituent power systems and the thrusters connected to that system.

19.2.3.4 Failure of thruster system is not make the thruster to operate in an uncontrolled mode.

19.2.4 Dynamic Positioning Control System

19.2.4.1 Each of the dynamic positioning control stations is to: :

- **.1** ensure that the operator has a good view of the vessel's exterior and the surrounding area;
- **.2** ensure that the operator has information necessary for safe control of the system and, upon request, other information displayed at all times;
- **.3** provide for easy selection of positioning control mode: manual by joystick or automatic by computer control, and the active mode is to be clearly displayed;
- **.4** ensure that alarms and warnings are indicated audibly and visually; a permanent record of the alarms and warnings occurrence is to be provided; the alarm points list is to be agreed with PRS;
- **.5** enable to control all the thrusters manually, by a common joystick and, in the event of failure to dynamic positioning control system, to control each of the thrusters individually, by separate joysticks;
- **.6** provide for immediate, emergency shutdown of each of the thrusters, with each emergency shutdown device being independent of the remote control of the given thruster.

19.2.4.2 Control devices are to be so designed that no single inadvertent act on the operator's panel can lead to a critical condition.

19.2.4.3 The computer systems for the dynamic positioning control system are to comply, within the scope agreed with PRS, with the requirements of *Publication 9/P – Requirements for Computer Based Systems* and of *IEC 60092-504 Standard*.

19.2.4.4 The computer systems of the dynamic positioning control systems are to meet the following requirements:

.1 They are to consist of at least two independent, self-controlling and inter-checking systems. Common facilities of these systems, when damaged, are not to be capable of causing the failure of all systems;

.2 An alarm is to be initiated if any computer fails or is not ready to take over control;

.3 Redundant computer systems are to provide automatic transfer of control after a failure in one of the computer systems. The automatic transfer is to be smooth, and within the acceptable limitations of the operation;

.4 An uninterruptible power supply (UPS) is to be provided for each computer system to ensure that it operates for a minimum of 30 minutes following the main supply failure.

19.2.4.5 Position reference systems are to comply with the following requirements:

.1 They are to be redundant with permanent position reading possible during operation;

.2 They are to be of different types and operate using various operation principles;

.3 They are to produce data with adequate accuracy for the intended positioning operation;

.4 They are to be monitored by the control system initiating an alarm in the case the signals from the position reference systems differ significantly;

.5 Where for the correct operation of the ship position reference system, a vertical reference system, which enables reduction of naval ship rolling effect on the position reference system indications, is necessary, such a system is to be installed. The number of vertical reference systems is to correspond to the number of naval ship position reference systems.

19.2.4.6 Sensors are to comply with the following requirements:

.1 They are to at least measure naval ship heading, motions, and wind speed and direction;

.2 Where they are the only source of signals for the naval ship, they are to be at least redundant together with associated equipment, such as giro compasses;

.3 Where they serve the same purpose and are connected to redundant systems, they are to be arranged independently so that failure of one will not affect the others.

19.2.5 Cable Network and Piping Systems

19.2.5.1 In naval ships provided with dynamic positioning system, cables, fuel, lubricating oil, hydraulic oil and cooling water pipings are to be so arranged with due regard to fire hazards, flooding or mechanical damage.

19.3 Essential Systems which are not Part of the Dynamic Positioning System

19.3.1 Systems not directly part of the dynamic positioning system but which in the event of failure could cause failure of the system (e.g. common fire extinguishing systems, engine ventilation systems and emergency shutdown systems), are also to comply with the relevant requirements of this Chapter.

19.4 Framework of Tests

19.4.1 The naval ship is to be provided with checklists ensuring appropriate operation tests of the dynamic positioning system. The checklists are to be approved by PRS.

19.4.2 The naval ship is to be provided with PRS approved dynamic positioning instructions to specify/contain:

.1 weather conditions, or

.2 hazard analysis results in the case the dynamic positioning system is provided with adequate software permanently defining the ship's capability to maintain position; the software used for hazard analysis is to initiate an alarm when ship's position is liable to be lost due to a failure. Such software is also to provide for a possibility of simulating emergency conditions and to enable assessment of the naval ship manoeuvrability (based on manually entered data, e.g. those concerning weather tendencies), lack of respect to which may cause loss of position, thus endangered safety of the naval ship.

20 AUTOMATION AND REMOTE CONTROL SYSTEMS

20.1 Application

The requirements of the present Chapter apply to all control systems, irrespective of the extent of naval ship's automation.

20.2 Design Requirements

20.2.1 General Requirements

20.2.1.1 Computerised automatic systems are to meet the requirements given in *Publication No. 9/P – Requirements for Computer Based Systems*.

20.2.1.2 Automated machinery provided with automatic or remote control system, as well as, to the necessary extent, with monitoring systems, is, in addition, to be provided with means of local manual control.

In each case of failure in automatic or remote control system, the possibility of local control is to be maintained.

20.2.1.3 Where machinery or installation is remotely controlled, it should be possible for the operator to check, with sufficient reliance, from his control station whether his command has been carried out by remote control system.

20.2.1.4 Where remote control of the main propulsion from the main command station/navigation bridge has been applied and the ship machinery space is continuously manned, local control in the event of remote control system failure is to be provided.

Additionally, the possibility of controlling auxiliary machinery, essential for the operation of the main propulsion and ship safety, from a local position is to be ensured.

20.2.1.5 It is recommended to use control systems with global asymptotical stability features (that means that the set value may be achieved only in the infinity).

20.2.1.6 Where machinery space of the naval ship is to be continuously attended by one person, the extent of the necessary remote or automatic control will be specially considered by PRS, in view of the location of the control station and surveillance procedure adopted for the machinery, as well as their service requirements.

20.2.2 Requirements for Components and Units of Automatic Systems

20.2.2.1 Components and units used in automatic systems are to comply additionally with the requirements of the relevant Parts of the *Rules*.

20.2.2.2 Individual components and units of systems and their external connections are to be permanently and clearly marked. The marking is to ensure an easy identification with the drawings and, in the case of sensors, is also to indicate their purpose and the set point.

20.2.2.3 Damping arrangements (shock absorbers), which are used to protect components and units against the influence of shocks and vibration, are to be provided with stops to protect them against damage in case of excessive rolling amplitudes.

20.2.2.4 Control elements intended for fixing the settings are to be secured against unintentional change of the position. Their repeated securing in case of readjustment is to be enabled.

20.2.2.5 Conducting surfaces of plug-in connections are to be of such design as to prevent the increase of contact resistance limiting the correct operation of the equipment.

20.2.2.6 At the terminals of cables and bunches of conductors to the components, as well as at the connections to moving parts, means are to be provided
to relieve components from the influence of tension of cables and conductors.

20.2.2.7 Replaceable blocks (cassettes) with plug-in connections are to be so designed as to preclude the possibility of erroneous replacement. They should also be capable of being effectively and permanently fixed in working position.

When it is necessary, due to design or functional features of the component or unit, the permanent marking of correct mounting position should be provided or the component or unit itself should be so designed that mounting in other than correct position is impossible.

20.2.2.8 Printed circuit cards are to be covered with electroinsulating varnish on the side on which current lines are located.

20.2.2.9 Final control elements (servo-motors, controllers, etc.) are to be so designed that no uncontrollable movement of their working parts is possible.

20.2.2.10 Pneumatic and hydraulic components and units are to withstand, without damage, short-time overloads caused by an increase of the working medium pressure equal to 1.5 times the rated value.

20.2.2.11 Pressure sensors are to be connected to the piping installation by means of 3-way cocks in order to supply the testing pressure, de-aeration of the piping and disconnecting of the damaged sensor.

20.2.2.12 Pneumatic and hydraulic components and units are to maintain their performance characteristics under the deviation of supply pressure from the rated value within ± 20%.

20.2.2.13 Temperature sensors fitted in pipings conveying combustible media are to be mounted in appropriate sockets.

20.2.3 Requirements for Automatic Systems

20.2.3.1 All control systems essential for the operation of the ship propulsion, machinery control and safety are to operate independently or are to be so designed that a failure in one of those systems will not interfere with the operation of the other systems.

20.2.3.2 Electric and electronic circuits of automatic systems are to be provided with means of protection capable of selective disconnecting the damaged parts of the system.

20.2.3.3 Each automatic system is to be so designed that the failure in one circuit of lamps, sirens and similar signalling devices does not interfere with the operation of other circuits.

20.2.3.4 Failure of power supply to automatic or remote control systems is not to result in dangerous conditions.

20.2.3.5 Automatic systems are to be built of such components and units that their replacement with the other ones of the same type does not affect the operation of the system. If readjustment is necessary, it should be possible by simple means.

20.2.3.6 Automatic systems are to be protected against malfunctions as a result of short time deviations of parameters due to rolling and pitching, starting or stopping of the machinery or due to other similar, normal fluctuation of parameters.

20.2.3.7 Automatic systems are to be so designed that typical failures of such systems do not result in hazardous conditions and do not lead to the secondary failures in the system itself and in automated machinery concerned.

20.2.3.8 Each automatic or remote control system is to prevent the automatic restart of controlled machinery after its emergency stopping by the safety system. Restart should be possible after manual reset (e.g. by control lever being brought to start position). Other solutions are admissible after agreeing with, or upon request of, PRS.

20.2.3.9 Replaceable and controllable components of automatic systems, as well as the test points are to be arranged with permanent and easy access.

20.2.3.10 Components or units of automatic systems are to be so designed as to ensure the possibility of their checking and calibration during operation.

20.2.3.11 Measuring range of analogue sensors should be at least 20% greater than the expected deviation of the input signal value (measured parameter).

20.2.3.12 Pneumatic systems are to be fitted with effective means for ensuring the required degree of purity and dryness of air supplied.

20.2.3.13 Drying and filtering equipment used in pneumatic automatic systems of main propulsion and propulsion plant are to be doubled and so arranged as to ensure the operation of one of them when the other is out of action. Doubled drying and filtering equipment need not be used, provided it is of self-cleaning type or of such design that quick replacement of contaminated inserts is possible without stopping the air supply.

20.2.3.14 In supply piping of pneumatic systems, automatic safety valves are to be provided to prevent an increase of pressure by more than 0.1 per cent of the working pressure.

20.2.3.15 Where hydraulic, pneumatic, electric and electronic components are situated in common desks, consoles and other similar units, they are to be so separated from each other that possible leakage of working medium does not affect the electric, electronic or pneumatic components.

The sections of desks, consoles and other units which incorporate the equipment containing liquid medium, are to be provided with drip trays fitted with drain pipes.

20.2.3.16 Where components and units requiring forced cooling are used, effective means are to be provided to prevent their damage in case of cooling failure. Measures are also to be taken to enable components or units to operate in case of contamination by the cooling air.

20.2.3.17 Elements intended for control are to be arranged with easy access, and are to be marked appropriately to their assignment, as well as are to be secured against self-acting change of the position.

20.3 Power Supply of Automatic Systems

20.3.1 Where power supply to electrically driven essential machinery and equipment is required both from the main and emergency sources, electric and electronic control systems of such machinery and equipment are also to be supplied from two independent sources.

20.3.2 Control system of the main propulsion is to be supplied through two independent feeders. One of these feeders is to be supplied from the main switchboard (directly or through a transformer) and the second may be supplied from the nearest section switchboard supplying essential consumers. Switching on of the second power source is to be effected automatically.

20.3.3 Where automatic control systems of auxiliary machinery are supplied from the circuit supplying the prime mover of the machinery, starting of the stand-by (doubling) units is to be possible also in case of voltage failure in the supply circuit of the machinery actually in operation.

20.3.4 Automatic systems or their hydraulic and pneumatic parts are to be supplied by means of two compressors or two pumps.

20.3.5 Power supply to control system of generating sets, their safety system and safety system of the main engines is to be so arranged that the systems are capable of operating, irrespective of the voltage on the main switchboard.

20.3.6 Alarm system is to be always supplied from two independent power sources. Switching on of the stand-by power source is to be effected automatically.

Where the stand-by power source of the alarm system is an automatically started emergency generating set, the alarm system circuits monitoring the conditions affecting the ship's manoeuvrability and parameters of generating sets and prime movers are to be additionally supplied from an accumulator battery of a capacity sufficient for 30 minute operation of that part of the system.

20.3.7 Supply of automatic equipment essential for starting and operation of the emergency generating set is to be taken from starting accumulator batteries or from separate battery located in the emergency generating set compartment.

20.4 Monitoring Systems

20.4.1 Alarm System

20.4.1.1 Alarm signalling is to meet the applicable requirements of the present Chapter and to comply with the provisions of the *Code on Alarms and Indicators, 1995,* within the scope agreed with PRS.

20.4.1.2 Depending on the extent of machinery automation, the alarm system is to give the following types of alarms:

- **.1** alarm to indicate that limit values of parameters have been exceeded;
- **.2** alarm to indicate that safety system has operated;
- **.3** alarm to indicate the failure of power supply to particular automatic system or that the stand-by power supply has been switched on;
- **.4** alarm to indicate that other values or conditions resulting from the detailed requirements of the present Part of the *Rules* have been changed.

Alarm conditions of machinery are to be indicated in the relevant control stations. The arrangement of the alarm display is to assist in identifying the particular fault condition and its location within the machinery space.

20.4.1.3 Alarm system is to function independently of control and safety systems so that a failure or malfunction in these systems will not prevent the alarm system from operating. Possible interconnection of these systems, restricted to the source of alarm only, will be specially considered by PRS.

20.4.1.4 Alarm system is to have such self-monitoring properties that alarm signal will be given in the case of a broken circuit or other typical failures.

20.4.1.5 The alarm system is to operate simultaneously both visual and audible signals.

20.4.1.6 Visual signal is to be given by intermittent light and should indicate the reasons causing the alarm. Cancelling the visual signal should be possible only after the reasons of its operation have been eliminated. Acknowledgement of visual signal is to be clearly indicated by the change of its form (e.g. change from intermittent light to steady light or change in flickering frequency).

20.4.1.7 Audible signal may be common for all types of alarms. If the possibility of switching off the audible signal is provided – the readiness of actuating new alarms from other parameters is to be maintained until the reason of previous signal has been eliminated. Switching off audible signals is not to extinguish visual signals. Audible signals for machinery are to be clearly distinguished from surrounding sounds and other audible signals, e.g. fire, CO_2 releasing, etc alarms. The local switching off of the audible signal in the main command station/navigation bridge and in the accommodation area, if provided, is not to stop the audible signal in the machinery space.

20.4.1.8 For easy identification of transitory alarm conditions which are automatically eliminated, the alarm system is to have memory features, so that the transitory alarm conditions can be maintained until they are acknowledged.

20.4.1.9 Disconnection or omission of any part of the alarm system is to be clearly indicated.

20.4.1.10 Alarm system is to be capable of being tested during normal machinery operation. Where practicable, means are to be provided at convenient and accessible locations to permit the sensors to be tested without affecting the operation of the machinery.

20.4.1.11 A short-time interruption of power supply to the alarm system is not to cause a loss of information on alarm conditions prior to the interruption.

20.4.1.12 When visual signals are given by means of lamps, the colour of a visual signal is to be adequate to the character of this signal and the size of the system in accordance with 4.5.5.

20.4.1.13 Where a dimmer is provided for indicators of any alarm system installed in the main command station/navigation bridge, it is to be so designed that full dimming of these indicators lights is precluded.

20.4.2 Safety System

20.4.2.1 Safety system of particular units of automated machinery plant is to operate automatically after exceeding limit values of the given parameters causing a failure and is to cover fault conditions assumed with regard to operational properties and characteristics of the machinery concerned so that:

.1 normal operating conditions are restored, or

.2 the machinery operation is temporarily adjusted to the prevailing conditions (by reducing the load of machinery), or

.3 machinery and boilers are protected from failure by stopping (in the case of machinery) or by shutting off the fuel (in the case of boilers).

20.4.2.2 Means are to be provided to trace the cause of the safety system action.

20.4.2.3 The safety system intended for the functions specified in 20.4.2.1.3 is to be independent of all other control and alarm systems so that failure or malfunction in these systems will not prevent the safety system from operating.

For the safety system intended for functions listed in 20.4.2.1.1 and 20.4.2.1.2, complete independence of other control and alarm systems is not required.

20.4.2.4 Safety system is to have such self-monitoring properties that, with the requirements of 20.4.2.6 satisfied, alarm signal will be given at least in case of short circuit, earth fault, broken fuse or broken circuit.

20.4.2.5 Safety systems of different units of the machinery plant are to be independent. Failure in the safety system of one part of the plant or of the whole plant is not to interfere with the operation of the safety system in another part of the plant.

20.4.2.6 Safety system is to intervene after operation of the alarm system in the relevant sequence of functions.

20.4.2.7 Safety system is to be so designed that the failure in the system does not cause hazardous conditions. This feature is to be maintained, not only with regard to the safety of the system itself and associated machinery, but also to the safety of the whole machinery installation and the ship.

20.4.2.8 When the safety system has stopped a unit, the unit is not to be restarted automatically, but only after a manual reset has been carried out (see also 20.2.3.8). Other arrangements are admissible after agreeing with, or upon request by, PRS.

20.4.2.9 When the switching-off facilities in the safety system of the main propulsion are provided, the switching-off device is to be of such a design as to exclude the possibility of its unintentional use, and in the case of the safety system being switched off, its position is to be indicated by means of a special signal.

20.4.3 Indicating and Recording Systems

20.4.3.1 Indicating and recording systems are to be independent of other systems and so designed that their failures do not affect the other systems.

20.4.3.2 A failure in recording system is to be indicated by an audible and visual signal.

20.4.3.3 Means are to be provided to ensure accurate reading of indication on indicating instruments taking into account lighting conditions at the point of their installation.

20.4.3.4 Indicating instruments are to be so designed that the operator will receive all necessary information directly, without the necessity of calculations in the units normally used for the measured variable.

20.5 Main Propulsion Control Systems

20.5.1 Main propulsion remote control system is to ensure the control, within the whole working scope and under all operation conditions, including manoeuvres, of the number of revolutions of the propulsion engine, direction of the propeller thrust forces and pitch of the controllable pitch propeller, if any.

20.5.2 The remote control from the main command station/navigation bridge is to be limited to a single control element (lever, wheel, etc.) separate for each propeller, and all the auxiliary control functions are to be performed automatically. The protection against overloading of the propulsion and against the continuous operation of the propulsion within the banned speed range is to be actuated by the remote control, where necessary.

In naval ships whose propulsion system consists of non-reversible engine operating through reversing reduction gear or controllable pitch propeller, the arrangement with two control elements may be used, provided that the control system is so designed that an erroneous manoeuvre does not result in stopping the engine.

20.5.3 The remote control system is to be independent of engine room telegraph or any other means of communication used for giving the manoeuvre commands. It is permitted to use one lever for both systems.

20.5.4 Auxiliary control operations performed by the remote control system after any setting of the control system, including emergency reversing from ”full ahead”, are to proceed in the programmed sequence with the time intervals required by the main engine being respected.

The programme is not to be time-dependent only, but it is to take account of the operational parameters of the main engine auxiliary installations and signals acknowledging the performance of the sequence of actions according to the programme

Stoppage in the programme performance is to be alarmed. A simultaneous indication of the place of interruption is recommended.

Where the main turbines are used, the control system is to be so designed that when maintaining the necessary manoeuvrability of the propulsion system, the changes of controlled parameters of the turbine set do not cause hazardous disturbances in the operation of auxiliary machinery and installations, such as boilers, condenser installations, etc.

20.5.5 The remote control station on the main command station/navigation bridge is to be equipped with the device for stopping the main engine in case of emergency independently of the remote control system.

20.5.6 Automatic interlocking of the remote starting of the main engine is to be provided in failure hazardous conditions, e.g. when the crankshaft turning gear is under operation or in case of lack of lubricating oil pressure.

20.5.7 In the case of the turbine main propulsion, a device for the slow turning of rotor is to be provided. It is to start automatically when the turbine stops for a longer period of time than permitted, as specified by manufacturer. Possibility of switching off this device from the main command station/navigation bridge is to be provided. In naval ships with permanently attended machinery spaces, automatic starting of the turning device need not be applied.

20.5.8 The remote control system is to be so designed as to give alarm in case of failure, and the number of revolutions, as well as the direction of propeller screw thrust be maintained till the local station takes over the control. It especially refers to the power supply decay (electric, pneumatic and hydraulic). The decay is not to cause a serious and abrupt change in the power of the main propulsion being developed and in the direction of the propeller revolutions.

20.5.9 The number of the repeated starting (reversing) attempts in the case of faulty starts (reverses) is to be limited in order to preserve enough starting energy to perform manual starts. The alarm is to be given at the starting energy drop to the level indispensable to manual starts.

The minimum level of the starting energy at which the alarm starts to operate is to be such that:

.1 for starting by means of compressed air, six starts of reversible engine from the local control station and three starts of non-reversible engine could be performed;

.2 for electrical starting – three starts of non-reversible engine could be performed.

20.5.10 Simultaneous control of the main propulsion from more than one station should be excluded. The control from several conjugated control units is allowed from one control station.

20.5.11 The remote control system is to be so designed that the transfer of control from one station to another will not cause any essential change in thrust of a screw or in rotations of the main engine.

20.5.12 Each control station is to be equipped with the indicator informing which station is in charge of control.

Transfer of the control from one station to another is to be accompanied by audible and visual signals at both stations. The control from a new control station is to be possible only after it has been acknowledged in a suitable form that the control was taken over.

20.5.13 Number, type and arrangement of the main propulsion remote control stations are to be adopted to the type of supervision over the machinery. One of such stations is to be superior to others. The superior control station is to be located in the machinery space (engine control room). Only the superior control station may overtake the control from the station on the main command station/navigation bridge or from other remote control stations. The superior control station is to have monitoring facilities of all important parameters of the propulsion system and associated installations, irrespective of which control station is actually in charge.

Instructions: The adequate hardware of the remote control stations is to be provided so that the operator has a possibility of supervising the execution of commands and monitoring the parameters of the main engine operation within the range appropriate for a given station. The control stations are to be equipped with:

- indicators of number of revolutions and direction of rotation of the propeller shaft,
- indicators of number of revolutions and direction of rotation of the main engine when disengaging coupling is used,
- indicators of propeller speed and direction of rotation in the case of fixed pitch propellers,
- indicators of propeller speed and pitch position in the case of controllable pitch propeller,
- alarm system annunciators and in particular, indicators informing about the conditions affecting the ship's manoeuvrability (see also 20.5.9),
- indicators informing which station is in charge of control,
- emergency shut-down device of the main engine,
- device for switching off the slow turning of the main turbine rotor (see 20.5.7),
- switching-off device of the main engine safety system (see 20.4.2.9),

Where several conjugated control units are used at one control station, only one of them may be provided with the above-mentioned indicators of the alarm system. In the vicinity of the remaining control units, only an indicator informing about the alarm signal may be used.

20.5.14 The remote control system is to be so designed that in the case of rapid commands following each other, the last one is always performed. The process of executing the commands is not to depend on the speed with which the control element has been moved.

20.5.15 In multi-engine propulsion system, each propulsion engine (or a group of such engines) driving one propeller is to be provided with an independent remote control system.

20.5.16 Remote control system of two or more main propulsion engines driving one propeller is to be capable of automatic equilizing the load of operating engines.

20.5.17 The automatic systems of main propulsion remote control from the main command station/navigation bridge are to warn the officer on watch on the main command station/navigation bridge that load reduction or main propulsion stoppage is liable to happen, as well as inform that the above has happened. Such warnings are to be effected also when the machinery spaces are permanently manned. The warning is to be given well in advance to ensure appropriate response of the watch on the main command station/navigation bridge. In the case of no watch response or the erroneous one which could result in damage, safety system is to operate to avoid propulsion damage.

20.6 Electrical Power Supply and Distribution Control System

20.6.1 The arrangement of the naval ship's electric generating plant is to ensure the continuity of electric power supply in accordance with the following requirements:

.1 For naval ships having electric power demand normally supplied by one generator, there are to be adequate provisions in case of its failure for automatic starting and connecting to the main switchboard a stand-by generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the naval ship with automatic restarting of the essential auxiliaries, including, where necessary, sequential operations. This stand-by electric power is to be available to take over the load in not more than 45 seconds.

.2 For naval ships having electric power demand normally supplied by two or more generating sets operating in parallel, arrangements are to be provided (e.g. load shedding) to ensure that in case of failure of one of these units, the remaining ones are kept in operation without overload, to permit propulsion and steering and to ensure the safety of the naval ship.

When the arrangement specified in .1 is to be applied in ships where the main generating set is driven by a steam turbine, the prime mover of stand-by power supply unit is to be an internal combustion engine.

20.6.2 The control system of generating set internal combustion engines should, in case of failure of first automatic or remote starting, so limit the number of repeated automatic starting attempts of the same engine or engines driving the remaining sets that the quantity of air left in air receivers or, in the case of electric starting, the quantity of electric energy left in the battery is sufficient to perform, from the local control station, at least three starts of one of the generating sets having the highest output.

20.6.3 Failure to start the generating set is to be signalled by the alarm system.

20.6.4 The automatic control system of generating sets is to be provided with interlocking arrangement preventing the generating set from being automatically connected when a short-circuit occurs on the busbars of the main switchboard.

20.7 Automatic Control Systems of Steam Boilers

20.7.1 Control characteristics of different automatic control systems of steam boilers operation are to be so selected as to maintain the water level, steam pressure and other controlled parameters within the predetermined limits over the entire load range of the boiler, and to ensure rapid changes of boiler load in accordance with boiler characteristics.

20.7.2 The automatic control system of boiler firing installation is to be so designed that starting of a cold boiler is only possible from the local control station.

20.7.3 The automatic control system of boiler firing installation is to be so designed that fuel supply is only possible when, additionally to the conditions specified in para. 9.13.11.1 of *Part VII – Machinery, Boilers and Pressure Vessels* the following conditions are fulfilled:

.1 water level is normal,

.2 viscosity and temperature of fuel oil are sufficient for its proper atomisation,

.3 prepurging of the combustion chamber has been effected during at least 30 s, and the dampers in the air ducts are fully opened,

.4 fuel supply to the burners is set for the minimum value.

20.7.4 The automatic control system of boiler firing installation is to be so designed that purging of combustion chamber always takes place after the fuel supply has been cut off, whether manually or automatically. For the boiler fired by more than one burner, purging of the combustion chamber is to take place after switching off of the last burner.

20.7.5 Where the boiler is fired by more than one burner, the control systems of burners are to be independent of each other as far as practicable.

In any case, failure of pilot burner control system is not to disturb the operation of the main burners.

20.7.6 The automatic boiler firing installation is to be provided with safety system shutting off the fuel oil supply as specified in para. 9.13.11.2 of *Part VII – Machinery, Boilers and Pressure Vessels* and also when the following failures occur:

.1 the ignition of the fuel fails within 5 s from the beginning of fuel admission;

.2 the viscosity or the temperature of fuel oil is too low;

.3 the values of parameters of steam or air intended for fuel atomising fall;

.4 the water level in the boiler is below the permissible value.

20.7.7 The restarting of firing installation after the elimination of defects is to be possible from the local control station only.

The automatic control system of boiler firing installation is to be so designed that the ignition device is switched on after a certain time of purging the combustion chamber in accordance with the manufacturer's requirements.

20.8 Control Systems of Piping Installations

20.8.1 Power operated valves of piping systems controlled automatically or remotely are also to be provided with means for manual control.

20.8.2 The valves, mentioned in 20.8.1, are to be situated in places readily accessible for manual operation under all normal service conditions.

20.8.3 All components of valve control system fitted inside the double bottom are to be so designed as to be capable of normal operation when completely flooded under the water head resulting from the maximum draught of the ship.

20.8.4 Where piping systems are intended to be alternately used for different purposes (e.g. for ballast or fuel transfer), their control system is to be provided with such interlocking and protection arrangements as to meet the relevant requirements for interconnection of such piping systems given in *Part VI – Machinery Installations and Refrigerating Plants.*

21 UNATTENDED OPERATION OF MACHINERY SPACE AND ONE MAN OPERATION OF THE MAIN COMMAND STATION/ WHEELHOUSE

21.1 Application

21.1.1 The requirements of the present Chapter apply to naval ships which have machinery space adapted for unattended operation (mark **AUT**) or which are adapted for the one man operation of a bridge (mark **NAV1**). Automation system of these naval ships is to meet also the requirements given in other Chapters of the present Part of the *Rules*.

21.1.2 For the purpose of receiving the mark **AUT**, which means the ship's ability for unattended operation of the machinery space during sea voyage in peace conditions, the requirements given in 21.2 to 21.4 are to be fulfilled within the scope agreed with PRS. These requirements have been set out under the assumption that the number of engineering staff on board is sufficient to maintain seaworthiness of the ship in case of failure of automatic systems, as well as to carry out routine adjustment and inspection of the operation of such systems in machinery space.

21.1.3 For the purpose of receiving the mark **NAV1**, which means that the ship is adapted for the one man operation of the main command station/wheelhouse during sea voyage in peace conditions, naval ships are to meet the requirements given in *Publication No. 35/P – One Man Bridge Operated (OMBO) Ships* within the scope agreed with PRS.

21.2 General Requirements

21.2.1 The extent of machinery automation is to be such that the operation of machinery periodically unattended is possible during a period of 8 hours. This applies to the following machinery and equipment:

- **.1** the main propulsion, together with auxiliary machinery;
- **.2** electric power supply and distribution;
- **.3** steam, water and heating oil boilers;
- **.4** other machinery, equipment and systems necessary for naval ship seaworthiness, within the scope agreed with PRS.

The automatic control systems maintaining working parameters (temperature, pressure, viscosity, etc.) are to be provided. These systems are to be capable of maintaining the working parameters under all normal service conditions, including manoeuvring, within the limits appropriate for the considered machinery, equipment and installations.

21.2.2 Upon separate agreement with PRS, the extent of automation of some simple and daily irregular operations may be limited to remote control from the ship's main command station/wheelhouse.

21.2.3 The local manual control may be applied as the only means of control to perform:

.1 operations carried out at regular intervals, if, due to the character of these operations or the design of the plant, the intervals are greater than the assumed unmanned period;

.2 operations carried out irregularly and not requiring quick response to alternations of the conditions (e.g. blowing-off sea valves or chests with the exception of the case specified in 21.2.5, change-over to filling, emptying, cleaning or heating the tanks, etc.);

.3 operations associated with starting the installations.

21.2.4 The power units developing the auxiliary energy (pneumatic or hydraulic) used in automatic systems are to start automatically so that the continuity of power supply is maintained in all service conditions.

21.2.5 In naval ships with ice strengthening **L1A** and **L1** expected to navigate in ice with unmanned machinery space, arrangements for cleaning sea valves and chests are to be remotely controlled from the main command station/wheelhouse.

21.2.6 Where on board naval ship with the mark for unattended machinery space added to the class symbol, refrigerating plant classed with PRS is fitted, the extent of automation of such plant, its monitoring systems and the arrangement of indicators of such systems will be specially considered by PRS in each particular case.

21.2.7 Means are to be provided for detecting a rise of water in the machinery space bilges or bilge wells. For this purpose, the following requirements are to be fulfilled:

.1 Bilge wells are to be large enough to accommodate normal drainage during the unattended period. Arrangement of these wells and level sensors is to be such that accumulation of liquids may be detected at all normal angles of heel and trim as specified in sub-chapter 1.6 of *Part VI – Machinery Installations and Refrigerating Plants.*

.2 In the case where bilge system of machinery space drainage is controlled automatically, means are to be provided to indicate when the influx of liquid is greater than the pump capacity or that the pump is operating more frequently than would normally be expected.

Instructions: In order to meet the above requirement, the following measures may be taken:

- smaller bilge wells to cover a reasonable period of time of accommodating normal drainage,
- alarms of bilge pump operating for more than 15 minutes,
- alarm of high water level in bilge wells, operating prior to automatic starting of the pump.

Where automatically controlled bilge pumps are provided, special attention is to be given to oil pollution prevention requirements.

.3 Alarms of high water level in bilges and those resulting from the requirements of sub-paragraph .2 are to be given in the space specified in 21.3.7, at the engineers accommodation area and on the main command station/wheelhouse.

21.2.8 Where steam or electric heaters are provided in fuel or lubricating oil systems, they are to be provided, additionally to a temperature control, with at least high temperature alarm or low flow alarm, except where the temperature dangerous for ignition of the medium cannot be reached.

21.2.9 The requirements for fire detecting systems in machinery space are given in Chapter 4 of *Part V – Fire Protection*.

21.2.10 The systems and equipment fitted in an enclosure (capsule) are to be provided with an alarm on operating the fire detection system and/or automatic fire-extinguishing system, connected with the main fire detection station.

21.3 Monitoring Systems

21.3.1 The extent and operation principles of monitoring systems are to comply with Table 21.3.1.

Where the extent of monitored parameters differs from that specified in the Table or where it is proposed to install the systems based on different operation principles, special consideration will be given by PRS in each particular case.

Automatic change-over of stand-by machinery in auxiliary systems of the main internal combustion engine, as required by Table 21.3.1, need not be applied if at least two main engines are provided for naval ship propulsion, each having independent auxiliary systems, as well as independent safety system which will stop one of the engines, when necessary, and will simultaneously disconnect that engine from the propulsion system.

21.3.2 The alarm system is to cover all automated machinery, as well as all types of alarms specified in 20.4.1.2.

21.3.3 Where the concentration of alarms is necessary in the engine room alarm panel, only such individual alarms may be concentrated which are related to parameters which cannot be exceeded simultaneously, as well as such which are associated with the same machinery, provided that individual alarms are indicated at the location of this machinery.

Group alarms are to comply with all the requirements for alarm system specified in 20.4.1.

21.3.4 The alarm system annunciators are to be so located that during the unmanned period of machinery, the engineering personnel on duty is made aware that a machinery fault has occurred.

21.3.5 If the navigating officer of the watch on the main command station/wheelhouse is the sole watch-keeper, then, in the event a machinery fault

being monitored at the control location for machinery, the alarm system is to be such that this watch-keeper is made aware when:

.1 a machinery fault has occurred;

.2 the machinery fault is being attended to;

.3 the machinery fault has been rectified.

For carrying out the function mentioned in sub-paragraph .3, means of communication between the main command station/wheelhouse, accommodation spaces for engineering personnel and the machinery spaces may be used.

Instructions: The requirements of the present paragraph may be fulfilled, among other things, through:

– arranging group alarms in the main command station/wheelhouse and accommodation spaces for the engineering personnel responsible for the operation of the machinery and alarm annunciators giving detailed information in the space where the superior control station is located, or

– arranging all alarm annunciators giving detailed information in the main command station/wheelhouse and group alarms in the accommodation spaces of engineering personnel responsible for the operation of the machinery.

In any case, the acknowledgment of alarms in the machinery space and in the accommodation spaces for engineering personnel responsible for the operation of the machinery is to be indicated in the main command station/wheelhouse.

21.3.6 When group alarms are used to indicate alarm conditions in the main command statiion/wheelhouse, the alarm system is to cover the following alarm groups, as applicable:

.1 alarm requesting to stop the main engine;

.2 alarm requesting the load reduction of the main engine;

.3 alarm to indicate that safety system stopping the main engine has operated;

.4 alarm to indicate that safety system reducing the main engine load has operated;

.5 alarm to indicate that starting (reversing) of the main engine has failed;

.6 alarm to indicate failure of the steering gear;

.7 alarm to indicate failure of the power supply to automatic systems;

.8 alarm to indicate the excessive bilge water level in machinery space;

.9 group covering all other alarms as specified in 21.3.1.

Alarms indicating such states of machinery which have direct influence on naval ship's manoeuvrability are to operate in the main command station/ /wheelhouse, no matter which station is actually responsible for the control of machinery.

Switching over of alarm system from the machinery space to the main command station/bridge or v.v. is to be accompanied by visual and audible signal given in accordance with 20.4.1.4, 20.4.1.5 and 20.4.1.6.

21.3.7 All annunciators of alarm system and, to the necessary extent, the displaying instruments of indicating system, are to be concentrated in the space in which the superior control station is situated.

Where in parallel to the control station in the main command station/wheelhouse which is equipped with group alarms, only local control stations in the machinery space are provided, all displaying instruments of indicating system are to be situated on engines, turbines and machinery only, and all annunciators of alarm system giving detailed information are to be concentrated in one place in the machinery space or in an adjacent space having door communication with the machinery space.

21.3.8 Where the repeaters of alarm system annunciators are located within the accommodation spaces, the switching off of the alarm signal (alarm acknowledgment) in the accommodation spaces is also to be indicated in the main command station/wheelhouse.

Where the repeaters of alarm system annunciators are not provided within accommodation spaces, other reliable and efficient means of communication between the main command station/ wheelhouse and the accommodation of the personnel responsible for machinery operation are to be fitted. Such means of communication are also recommended in the case the repeaters of alarm system annunciators are provided.

21.4 Control Systems

21.4.1 Main Propulsion Control Systems

21.4.1.1 In addition to indicators and devices specified in 20.5.13, all main propulsion control stations are to be equipped with an arrangement for immediate stopping of the main engine or turbine. This arrangement is to be independent of the control system.

21.4.1.2 Means are to be provided to keep the starting air pressure at the required level where diesel engines are used for the main propulsion.

21.4.2 Electric Power Supply and Distribution Control Systems

Automatic control of effective reserve output of actually running generating sets is to be provided and the arrangement is to be such that automatic start of large power consuming machinery is only possible when the reserve output of generating sets is sufficient to cover starting and operational power demand of such machinery. In certain circumstances it may be necessary that stand-by generating set be started prior to start of the machinery in question.

Table 21.3.1-1

No.	Machinery, installation or equipment	Parameters[1)]	Alarm system: alarm state/monitored value of parameter	Safety system	Remarks
1	2	3	4	5	6
1	**Main propulsion**				
1.1	Main internal combustion engine (medium and high speed)				
1.1.1	Fuel installation	– pressure of fuel at outlet from filter (at inlet to engine)	– minimum	start of stand-by pump	remote measurement
		– viscosity or temperature of fuel before injection pumps	– maximal and minimum	–	only in case of heavy fuel operation of engine
	–	– fuel leakage from high pressure pipes	– alarm signal	–	
		– level in service tank	– minimum	–	high level alarm signal is required in case of lack of overflow installation
1.1.2	Lubricating oil installation	– pressure of lubricating oil at inlet to main and thrust bearings	– minimum	first stage: start of stand-by pump; second stage: engine stoppage;	remote measurement
		– pressure difference on the lubricating oil filter	– maximal	switching on stand-by pump	remote measurement
		– temperature of lubricating oil at inlet to ME	– maximal	–	remote measurement
		– oil mist concentration in crankcase	– dangerous	Stop of engine	for medium-speed engines of more than 2250 kW output or diameter of cylinder of above 300 mm[3]
		– flow of oil lubrication of cylinders; on each cylinder	– no flow	load reduction	

1	2	3	4	5	6
1.1.3	Turboblowers installation	– pressure of lubricating oil at inlet to turboblowers	– minimum	–	remote measurement if no independent and separate lubricating oil installation is provided
1.1.4	Sea cooling water installation	– pressure of sea water	– minimum	start of stand-by pump	remote control
1.1.5	Cylinder fresh cooling water installation	– pressure or flow of cylinder cooling water at inlet	– minimum	first stage: start of stand-by pump; second stage: load reduction;	remote measurement
		– temperature of cylinder cooling water at outlet	– maximum	load reduction[4)]	remote measurement
		– level in cylinder cooling water expansion tank	– minimum	–	
1.1.6	Starting and control air installation	– pressure of starting air before main shut-off valve	– minimum	–	remote measurement
		– pressure of control air	– minimum	–	remote measurement
1.1.7	Scavenging air system	– temperature in scavenging air tank	– maximum	–	
1.1.8	Exhaust system	– temperature of exhaust gases after each cylinder	– maximum	load reduction	remote measurement, applicable to engines of capacity over 500 kW/ /cylinder
		– temperature of exhaust gases after each cylinder. Deviation from mean value	– maximum	–	applicable to engines of capacity over 500 kW/ /cylinder
1.1.9	Number of engine revolutions	–	–	–	remote measurement
1.1.10	Overspeed		– alarm signal	stop of engine	
1.1.11	Supply failure of control, safety and alarm systems		– alarm signal	–	
1.2	Main gas turbine				

1	2	3	4	5	6
1.2.1	Lubricating oil installation	– pressure of lubricating oil	– minimal	first stage: alarm signal; second stage: stop of turbine	
		– pressure difference on lubricating oil filter	– maximum		
		– temperature of lubricating oil	– maximum	–	
1.2.2	Fuel installation	– pressure of fuel	– maximum		
		– temperature of fuel	– maximum		
1.2.3	Main gear	– pressure of lubricating oil in the gear	– minimum	– first stage: alarm signal; – second stage: stoppage	
1.2.4	Other installations	– rotational speed	– maximum	stop of turbine	Applicable to each shaft of gas generator and turbine
		– temperature of cooling water	– maximum	–	
		– flame decay or failed start	– flame decay or failed start	stoppage	See also the requirement of 3.3.5.2 of Part VI
		– start procedure	– failed start	stoppage	See also the requirement of 3.3.5.2 of Part VI
		– vibration	– maximum	First stage: alarm; Second stage: stoppage	
		– rotor axial displacement	– maximum	stoppage	does not apply to turbines with roller bearings
		– temperature of exhaust gases	– maximum	First stage: alarm Second stage: stoppage	concerns combustion chambers and turbines
		– air underpressure at the inlet to compressor	– maximum	First stage: alarm Second stage: stoppage	
		– supply of turbine control systems	– minimal	–	applies also to hydraulic liquid pressure for speed governor and safety system control devices
		– operation of safety system	– start	–	applies also to manual emergency shutdown

1	2	3	4	5	6
1.3	Main steam turbine				
1.3.1	Lubricating oil installation	– oil pressure before turbine	– minimum	first stage: start of stand-by pump; second stage: shutdown of steam supply to turbine	
		– lubricating oil temperature	– maximum	–	
		– oil level in gravity tank	– minimum	–	
1.3.2	Condensating and cooling water installation	– vacuum in condenser	– minimum	stop of turbine	
		– level in condenser	– maximum, minimum	stop of turbine	
		– level in hot-well	– maximum – minimum	–	
		– level in de-aerator	– maximum – minimum	–	
		– pressure in de-aerator	– minimum	–	
		– pressure or flow of condenser cooling water (after the condenser)	– minimum	start of stand-by pump	
		– pressure of condensate after pump	– minimum	start of stand-by pump	
1.3.3	Steam installation	pressure at inlet to turbine	– maximum, minimum	–	
		– pressure of gland sealing steam	– maximum – minimum	–	for each turbine casing separately
1.3.4	Miscellaneous	– turning gear	– engaged	–	
		– temperature of journal and thrust bearings	– maximum	–	
		– axial rotor displacement	– maximum	stop of turbine	
		– transverse rotor displacement	– maximum	stop of turbine	
		– vibration of turbine casing	– dangerous	stop of turbine	
		– excessive speed of turbine	–	stop of turbine	

1	2	3	4	5	6
1.4	Main gear	– pressure of lubricating oil at inlet	– minimum	first stage: start of stand-by pump[2]; second stage: stop of main engine	
		– temperature of lubricating oil at inlet	– maximum	–	
		– pressure difference on lubricating oil filter	– maximum	–	
		– temperature of main bearings	– maximum	–	
		– temperature of thrust bearing	– maximum	–	
		– oil pressure in hydraulic coupling	– minimum	–	only in the case of separate oil system
1.5	Shaft line	– temperature of thrust and stern tube bearings	– maximum	–	
		– level in gravity tank of stern tube lubrication	– minimum	–	
1.6	c.p. propeller control	– oil pressure in servo-system of c.p. propeller	– minimum	start of stand-by pump	
		– oil temperature in servo-system of c.p. propeller at outlet	– maximum	–	
1.7	Compressors	– pressure of compressor lubricating oil	– minimum	stop of compressor	
		– flow of compressor cooling water	– no flow	stop of compressor	
		– temperature of compressor cooling water at outlet	– maximum	–	

1	2	3	4	5	6
2	**Electric installation**				
2.1	Main switchboards	– insulation resistance	– minimum	functional features of safety system with regard to item 2.1 and 2.2 will be separately considered depending on the arrangement	
			– maximum		
		– voltage	– minimum		
			– maximum		
		– frequency	– minimum		
2.2	Main generators	– load current	– maximum		
		– short-circuit current	– minimum		
		– reverse power	– maximum		
2.3	Internal combustion engines driving electrical generators	– pressure of lubricating oil at inlet	– minimum	stop of engine	
		– flow or pressure of cooling water	– no flow	stop of engine	
		– temperature of lubricating oil at inlet	– maximum	–	
		– oil mist concentration in crankcase	– maximum	stop of engine	for engines having power of more than 2250 kW or a cylinder bore of more than 300 mm
		engine overspeed		stop of engine	
		– level in cooling medium expansion tank, if not connected to the main system	– minimum		
		– temperature of cooling water or air at outlet	– maximum		
		– fuel leakage from high pressure pipes	– physical value agreed with PRS depending on design		

1	2	3	4	5	6
		– level in fuel oil service tank	– minimum		
		– pressure of starting air before engine or in receiver	– minimum		before engine – only in the case of remote starting of stand-by generating set from the main command station/ bridge
		– oil fuel viscosity or temperature before injection pumps	– minimum and maximum		for the engines using heavy fuel
		– temperature of exhaust gases after each cylinder	– maximum		for the engines rated over 500 kW/ cylinder
2.4	Gas turbines driving generators	– pressure of lubricating oil	– minimum	first stage: alarm second stage: stoppage	
		– temperature of lubricating oil	– maximum		
		– speed	– maximum	stop of turbine	
		– temperature of exhaust gases before the turbine	– maximum		
		– flame decay or failed ignition	– flame decay or failed ignition	stop of turbine	
		– vibration	– high		
		– lack of supply to control circuits	– lack of supply		
		– safety system operation	– start		
2.5	Steam turbines driving generators	– pressure of lub. oil at inlet	– maximum	stop of turbine	
		– temperature of lub oil at inlet	– maximum	–	with regard to counter-pressure or vacuum
		– pressure in condenser	– maximum or minimum	stop of turbine	
		– level in condenser	– maximum – maximum	– stop of turbine	
		– axial rotor displacement			

1	2	3	4	5	6
2.6	Steering gear with electric or electrohydraulic propulsion	– supply voltage – load current – short-circuit current	– minimum – maximum – minimum	switching on of second feeder or second power supply unit depending on the arrangement disconnection of drive	
2.7	Electrical drives of other essential machinery	– load current – short-circuit current	– maximum – minimum	depending on the arrangement disconnection of drive	
3	**Piping installation**				
3.1	Bilge system	– vacuum on suction side of the pump – level in bilge wells of machinery space	– minimum – maximum	– –	 separate alarm signal on the main command station/bridge (21.2.8) is recommended
3.2	Fuel oil treatment installations	– level in fuel settling tank – water seal of fuel purifier – fuel temperature at purifier inlet – level in purifier wastes tank	– minimum – loss of water – maximum – minimum – maximum	– – – –	only in the case when purifier is to be in operation during unmanned period
3.3	Sludge installations	– level in sludge tanks	– maximum	–	
4	**Steam boilers and associated installation**				
4.1	Boiler	– pressure of steam – water level – temperature of superheated steam – temperature of saturated steam	– maximum – maximum – minimum – maximum – maximum	– shutdown of fuel oil supply at minimum level – –	 for main boilers only for main boilers only

1	2	3	4	5	6
4.2	Circulating pump	– water flow through pump	– no flow	depending on arran-gement of system and type of boiler	
4.3	Feed water installation	– pressure on delivery side of feed water pump	– minimum	start of stand-by pump	
		– pressure of lubricating oil at inlet to the turbine driving feed water pump	– minimum	stop of turbine and start of stand-by pump	for main boilers only
4.4	Firing installation	– pressure of fuel oil before burner	– minimum	–	
		– flame extinguishing	–	shutdown of fuel oil supply	
		– pressure of combustion air	– minimum	shutdown of fuel oil supply	
		– temperature of fuel oil before burner	– maximum – minimum	shutdown of fuel oil supply at minimum temperature	
		– level in daily service tank	– minimum	–	for auxiliary boilers only in the case when boiler is necessary for the operation of main engine
		– rotary air heater	– stopping	shutdown of fuel oil supply	for main boilers only
		– pressure of atomising steam	– minimum	shutdown of fuel oil supply	for main boilers only
5	**Fire alarm and detection system**	– operation of fire detection system and/or automatic fire-extinguishing system	– alarm	–	applies also to equipment of enclosed (capsule) structure
6	**Classified refrigerating plant**	–	– malfunction	–	group alarm signal
		–	– failure	–	group alarm signal on operation of safety system

[1] Parameters covered by safety and alarm systems, with the exception of levels and flow, are also to be covered by indicating system.

[2] The stand-by pump may also be started by the “no flow” signal.

[3] One oil mist detector for each engine, having two independent outputs for initiating the alarm and shut-down, would satisfy the requirement for independence between alarm and shut-down system.

[4] Two separate sensors are required for alarm and load reduction.

[5] Where outlet flow cannot be monitored due to engine design, alternative arrangements may be accepted by PRS.

22 ADDITIONAL REQUIREMENTS FOR NON-METALLIC NAVAL SHIPS

22.1 Lightning and Earthing Installation

22.1.1 In naval ships having non-metallic hulls, i.e. with plating non-conveying current, all metal parts effectively electrically connected with a plate made of corrosion-resistant material of surface area, measured in m^2, corresponding to not less than 10% of ship's length given in metres, are used as earthing. The plate of minimum thickness of 4 mm and minimum width of 100 mm is to be so fixed to the non-metallic hull plating that it is immersed in water under all conditions of sailing. It is recommended to use earthing plates made of porous copper alloys. Metal ship's hull structures permanently immersed in water of appropriate size (e.g. ballast fin or centreboard fin, propeller shaft struts, etc) may be used as earthing plate.

22.1.2 Any earthing of electrical equipment and systems, cable screens and lightning systems, mentioned in chapter 2 are to be connected to the earthing plate referred to in 22.1.1.

22.1.3 In the non-metallic plated structure naval ship all parts of the lightning protection (spike, lightning conductor) are to be made of metal according to 2.5.2.4 and 2.5.2.5, as well as 2.5.3.

22.1.4 Any connections of earthing conductors and lightning installation are to be clean, non-painted and marked with a symbol specified in 2.4.

22.1.5 Earthing effectiveness is to be checked in all operational conditions of power-electronic, radiolocation and radio-communication equipment.

22.1.6 Design principles of the above mentioned installations are to be agreed with PRS.

23 SPARE PARTS

23.1 General Requirements

23.1.1 The amount, kind and location of spare parts on board the naval ship are specified by PRS in each particular case. The construction of electrical and automation equipment, manufacturer's recommendations, intended service conditions and the voyage time are to be taken into account. Furthermore, for remote control and automatic systems, exchange of the entire elements or units (blocks, cassettes, etc.) but not exchange of their particular components, is to be taken as a rule.

23.1.2 Spare parts, together with relevant tools, materials and instruments are to be located in an easily accessible place protected against corrosion.

Table 23.2
Spare parts recommended for ship's electrical equipment

No.	Equipment	Spare parts	Q-ty of spare parts	Remarks
1	2	3	4	5
1	Rotating generators and exciters	Brushes	1 set	Of each type per 3 identical machines
		Brush-holders	1pc	
		Bearings	1 set	
2	Static exciters	Controllable and non-controllable rectifiers	1 pc of each type	For 3 static exciters of the same type
		Resistors and condensers of the power circuits inductance	1 pc of each type	
		Complete exciter	1 pc	
3	Electric motors	Brushes	1 set	Per 6 motors of each type
		Brush-holders	1 pc	
		Complete motor	1 pc	
4	Steering gear	Brushes	1 set	For each motor
		Brush-holders	1 pc	
		Bearings	1 set	
		Complete electric motor	1 unit	Only for steering gear with one motor
5	V-belt drives	V-belts	1 set	For each drive

1	2	3		4	5
6	Main, emergency and auxiliary switchboards, control desks, etc. (quantity of spare parts for the whole naval ship)	Knife switches, rotary switches, etc. Automatic circuit-breakers for current up to 63 A		2 pc	Of each type
		Automatic circuit breakers for the current over 63 A	Replaceable contacts	1 set	Of each type
			Arc chutes	1 set	
			Complete circuit brakers	1 pc	
		Fuses		2 pcs	Of each type
7	Starting and control apparatus and contactors	Complete apparatus or contactor		1 pc	Of each type per 6 identical devices
8	Emergency lighting	Incandescent lamps		1 set	If lighting supply voltage differs from naval ship's network voltage
9	Navigation lanterns	Incandescent lamps		2 pcs for each lantern	
10	Switchboard of navigation lanterns	Relay		2 pcs	
		Pilot lamps		1 set	
11	Portable measuring instruments	Insulation resistance measuring instrument		1 unit	A multi-purpose multi-range instrument recommended
		Ammeter		1 unit	
		Voltmeter		1 unit	
		Ohmmeter		1 unit	
12	Fans for refrigerated spaces	Complete fan		1 unit	Per 6 fans of the same type
		motor		1 unit	
		bearings		1 set	
		propeller		1 unit	
13	Sensors	sensor		1 pc	Of each type per 6 the same units
14	Electronic panels	panel		As agreed with PRS	
15	Other electronic parts	Complete part or repair set		As agreed with PRS	

Appendix 1

INSULATION RESISTANCE OF CABLE NETWORK

1 The insulation resistance to naval ship's hull of the cable network electrical circuits, measured during trials on completion of the ship construction or during surveys of naval ships in service is not to be less than that given in Table 1.

Table 1

No.	Designation of circuit	Minimum insulation resistance, MΩ		
		up to 125 V	125 to 500 V	over 500 V
1	Supply to lighting installations	0.3	1.0	–
2	Supply to power consumers	–	1.0	2000 Ω per volt of the rated voltage
3	Communication installation (unless otherwise specified)	0.3	1.0	–

2 During the test, each circuit can be divided into any number of individual sections by means of switches installed in it or by withdrawing the fuses, or by disconnecting the consumers.

Appendix 2

VALUES OF MECHANICAL AND ELECTRICAL PARAMETERS TO BE CHECKED IN THE COURSE OF TESTING TYPE OF EQUIPMENT AND THE SHIP'S ELECTRICAL INSTALLATIONS

1 Insulation Resistance

1.1 The value of insulation resistance of the new electrical equipment measured at the manufacturer's or research laboratory is to meet the requirements of the relevant national standards but is not to be less than:

– 10 MΩ in cold condition, 1 MΩ in hot condition – for equipment of rated voltage up to 65 V,

– 100 MΩ in cold condition, 10 MΩ in hot condition – for equipment of rated voltage over 65 V.

For electric machines, at the insulation resistance measurements after the electric strength test, the value of insulation resistance in hot condition equal to 1 MΩ is permitted.

1.2 The value of insulation resistance to hull, as well as between phases (poles) of electrical equipment, measured during testing after completion of the ship construction is not to be less than the values indicated in Table 1.2.

The insulation resistance of the electrical equipment, measured during surveys of ships in service may be less than the values indicated in Table 1.2, but is not to be below 2000 Ω per volt of the rated consumer voltage.

The insulation resistance values indicated in Table 1.2 are applicable to electrical equipment having a voltage up to 1000 V.

The minimum values of insulation resistance of electrical equipment having a voltage of over 1000 V are to comply with the requirements of 18.1.1.

Insulation resistance readings are to be taken one minute after the application of the test voltage.

Table 1.2

No.	Type of electrical equipment	Minimum insulation resistance at 20 ± 5 °C ambient temperature and humidity up to 85%, MΩ	
		in cold condition	in hot condition
1	Electric machines	1	1
2	Transformers	5	2
3	Switchboards	1	–
4	Machine control gear	5	–

2 Dielectric Strength of Insulation

2.1 General Requirements

The dielectric strength of insulation in electrical installations, with the exception of that pertaining to individual types described under 2.2 of the present Appendix, is to be tested by applying, for 1 minute, an alternating sinusoidal test voltage having a frequency of 50 Hz and the r.m.s. value as shown in Table 2.1.

Table 2.1

Rated voltage U_n, V	Test voltage U_p, V
up to 65	$2\,U_n + 500$
66 to 250	1500
251 to 500	2000
501 to 1000	$2\,U_n + 1000$
over 1000	$3U_n$

Table 2.1 is not applicable to communication appliances and electrical devices incorporating semiconductor elements for which the test voltage value will be specially considered by PRS in each particular case.

2.2 Machines, Transformers and Apparatus

2.2.1 The insulation of electric machine windings is to withstand for 1 minute, without breakdown and sparking, an alternating, practically sinusoidal test voltage having a frequency of 50 Hz and the r.m.s. value as shown in Table 2.2.1.

Table 2.2.1
Test voltage at the test of dielectric strength of insulation

No.	Electric machine or part thereof		Test voltage r.m.s. value, U_p, V
1	2		3
1	Insulated parts of machines rated at	less than 1 kW (kVA)	$2\,U_n + 500$
		from 1 kW (kVA) to 10 000 kW (kVA)	$2\,U_n + 1000$ but not less than 1500
2	Field windings of direct-current machines supplied from external source		$2\,U_w + 1000$ but not less than 1500
3	Field windings of synchronous generators		$10\,U_w$ but not less than 1500 and not more than 3500
4	Field windings of synchronous motors, when:	starting with the field winding short-circuited or connected directly to the rotor, or starting with the a.c. winding idle	$2\,U_w + 1000$ but not less than 1500

1	2	3	4
		starting either with the field winding closed through resistance connected in series, or with the field winding open, regardless of whether it is sectionalised or not	2 U_m + 1000 but not less than 1500
5	Rotor windings of slip-ring induction motors or of synchronous induction motors if not permanently short-circuited (e.g. if intended for resistor starting):	for non-reversing motors or motors reversible from standstill only	2 U_r + 1000 but not less than 1500
		for reversible motors, as well as those braked by counter-current	4 U_r + 1000 but not less than 1500
6	Rotor windings of direct-current reversible crane motors		3 U_n + 1000 but not less than 1500
7	Exciters, except those mentioned in items 2 and 8		As for the field windings they are intended to supply
8	Exciters of synchronous motors or synchronised induction motors if they are disconnected from the motor during starting, or if one of the poles is connected to earth		2 U_n + 1000 but not less than 1500

U_n – rated voltage, V;
U_w – maximum value of rated excitation voltage, V;
U_m – maximum value of voltage which may occur under starting conditions between the terminals of the field winding, or, in the case of a sectionalised field winding, between branch terminals, V;
U_r – voltage between the slip rings or terminals of the rotor at standstill, with rated voltage applied to the stator terminals, V;

2.2.2 In addition to the tests specified in Table 2.2.1, the electric machines are to withstand for 3 minutes, without damage, an elevated interturn test voltage at terminals equal to 1.3 times the rated voltage value. Machines operating within a certain voltage range are to withstand an interturn insulation test voltage equal to 1.3 times the highest voltage level.

2.2.3 While tested at the manufacturer's works, the transformers are to withstand, for 1 minute, a test for dielectric strength of insulation by application of test voltage equal to twice the rated voltage between phases plus 1000 V, but not lower than 2500 V. An alternating current test voltage of the above value at any frequency between 25 and 100 Hz is to be applied in turn between each winding and the remaining windings connected to frame and earthed cores.

This test is to be carried out after the temperature rise test, if any.

The interturn insulation is to withstand a test voltage equal to twice the voltage which occurs between turns, coils and coil terminals when the rated voltage is applied to the transformer terminals. The duration of the test is not to be less than that obtained from formula 2.2.3, but not less than 15 s.

$$t = \frac{2f_n}{f_{pr}} \tag{2.2.3}$$

t – duration of the test, min.
f_n– rated frequency of the transformer, Hz;
f_{pr} – frequency of the test voltage, Hz.

2.2.4 The insulation of electric apparatus is to withstand, for 1 minute, without breakdown or sparking, a practically sinusoidal a.c. test voltage having a frequency of 50 Hz and r.m.s. value as indicated in Table 2.2.4.

Table 2.2.4

Rated voltage, V	Test voltage, V
up to 65	1000
66 to 250	2000
251 to 660	2500
661 to 800	3000
801 to 1200	3500
1201 to 7500	$3U_n$

2.2.5 The test voltage for fuses rated at up to 500 V is to be 3000 V.

2.2.6 The insulation of windings of electromagnetic tripping device is to withstand, for 1 minute, without a breakdown or sparking, a practically sinusoidal test voltage having a frequency of 50 Hz and r.m.s. value of 2000 V.

3 Temperature Rise Limits

3.1 The temperature rise limits for insulation material under continuous duty conditions are listed in Table 3.1.

Table 3.1

Class of insulation	Temperature rise limit, °C
A	105
E	120
B	130
F	155
H	180
200, 220, 250	over 180

Where the insulation is composed of different materials, the temperature that each of the materials is allowed to reach is not to be higher than the temperature rise limit for a given material.

Where the insulation consists of several layers of different materials and it is not possible to measure the temperature reached by particular materials, the

temperature rise limit for the composite is to be assumed to be that applicable to the lowest class of the material used.

A material used solely for mechanical protection or for separating shims may be of a lower class of insulation.

3.2 The temperature rise limits for electric machines are given in Table 3.2. They are based on the cooling air temperature of 45°C. Where the coolant temperature is lower than the said values, the temperature rise limits may be increased accordingly, but not more than by 10°C.

Where the coolant temperature is higher than the above values, the temperature rise limits are to be reduced accordingly.

Table 3.2

Temperature rise limits for electric machines at 45 °C cooling-air temperature

No.	Electrical parts	Classes of insulating material														
		A			E			B			F			H		
		Method of measurement, °C														
		Thermometer	Resistance	Built-in sensors	Thermometer	Resistance	Built-in sensors	Thermometer	Resistance	Built-in sensors	Thermometer	Resistance	Built-in sensors	Thermometer	Resistance	Built-in sensors
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	A.C. windings of synchronous and asynchronous machines rated at 5000 kVA and higher, or having a core length of 1 m and over	–	55	55	–	65	65	–	75	75	–	95	95	–	120	120
2	Windings of A.C. machines rated at under 5000 kVA and having a core length of less than 1 m. Field windings of D.C. and A.C. machines, D.C. excited, except such as are listed under 3, 4 and 5. Windings of rotors connected with commutator	45	55	–	60	70	–	65	75	–	80	95	–	100	120	–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
3	Field windings of D.C. excited non-salient-pole machines	–	60	–	–	75	–	–	85	–	–	105	–	–	120	–
4	Single-layer field windings with exposed surface	60	60	–	75	75	–	85	85	–	105	105	–	130	130	–
5	Low resistance field windings with more than one layer, as well as compensating windings	55	55	–	70	70	–	75	75	–	95	95	–	120	120	–
6	Permanently short-circuited windings, insulated	55	–	–	70	–	–	75	–	–	95	–	–	120	–	–
7	Permanently short-circuited windings, uninsulated	The temperature rise of such parts is not to be so high as to constitute risk of damage to insulating and other adjacent materials														
8	Steel cores and other parts out of contact with windings															
9	Steel cores and other parts in contact with windings	55	–	–	70	–	–	75	–	–	95	–	–	120	–	–
10	Commutators and slip rings open and enclosed	55	–	–	65	–	–	75	–	–	85	–	–	95	–	–

3.3 The temperature rise for transformers operating at the rated load and at an ambient temperature of 45°C is not to exceed the values given in Table 3.3.

Table 3.3

No.	Transformer parts	Method of measurement	Temperature rise limits for insulation classes, °C				
			A	E	B	F	H
1	Windings	Resistance	55	65	75	95	120
2	Cores and other parts	Thermometer	The temperature rise is not to be higher than that allowed for adjacent materials				

3.4 The temperature rise limits for various parts of equipment (apparatus) at the ambient temperature of +45°C are not to be higher than the values given in Table 3.4.

Table 3.4

No.	Equipment (apparatus) parts			Temperature rise limits, °C
1	Massive spring contacts	copper	continuous duty	35
			eight-hour continuous duty, intermittent duty, short-time duty	55
		silver or with silver inserts		*
		other metals or sintered cermets		depending on quality of metal or sintered cermet
2	Brush contacts			25
3	Busbar connections	no protection against oxidation at point of contact		45
		protected against oxidation at point contact by:	tin or cadmium plating, silver plating	55 75
		soldered or welded connections		75
4	Magnets, magnet cores, and similar parts			the same as for insulation in contact with the said parts
5	Manual controls	metallic		10
		insulant		20
6	Enclosures, shields or parts liable to be touched accidentally			35
7	Enclosures of rheostats suitably guarded against accidental touch			200
8	Cooling air from rheostats when taking measurements at a distance of 25 mm			175

* The temperature rise is admissible only up to a level at which a hot part does not cause heating of the adjacent parts above their temperature rise limit.

4 Cyclic Irregularity of Electric Generating Sets

Cyclic irregularity, per revolution, of electric generating sets using piston engines as prime movers is not to exceed the values given in Table 4.

Cyclic irregularity, per revolution, for all loads, rated load inclusive, at rated speed, is determined from the formula:

$$S = \frac{\omega_{\max} - \omega_{\min}}{\omega_{av}} \tag{4}$$

ω_{max} – maximum angular velocity;
ω_{min} – minimum angular velocity;
ω_{av} – average angular velocity.

Table 4

Number of engine impulses per second	Cyclic irregularity	
	one- or two-cylinder engines	engines with more than two cylinders
under 10	1/75	1/150
10 to 20	1/75	number of impulses per second/1500
over 20	1/75	1/75

5 Vibration Resistance

The requirements are specified in *Publication No. 75/P* – "*Environmental Tests of Naval Ship Equipmen*"*t*.

6 Climatic Tests

The requirements are specified in Publication *No. 75/P* – "*Environmental Tests of Naval Ship Equipment*".

7 Inflammability Test of Electro-Insulating Materials

The requirements are specified in *Publication No. 75/P* – "*Environmental Tests of Naval Ship Equipment*".