Polski Rejestr Statków

RULES
FOR CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART VIII

ELECTRICAL INSTALLATIONS AND CONTROL SYSTEMS

2015
July

GDAŃSK

RULES FOR CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS developed and published by Polski Rejestr Statków, 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 Installations and Control Systems
Part IX – Materials and Welding.

Part VIII – Electrical Installations and Control Systems – July 2015 was approved by the PRS Board on 17 June 2015 and enters into force on 1 July 2015.

From the entry into force, the requirements of *Part VIII – Electrical Installations and Control Systems* fully apply to new ships.

With regard to existing ships, the requirements of *Part VIII – Electrical Installations and Control Systems* are applicable within the scope specified in *Part I – Classification Regulations.*

The requirements of *Part VIII – Electrical Installations and Control Systems* are extended by the following Publications:

Publication No. 9/P – Requirements for Computer Systems,
Publication No. 11/P – Environmental Tests on Marine Equipment,
Publication No. 15/P – Current Rating Tables for Cables, Wires and Busbars in Marine Installations,
Publication No. 35/P – One Man Bridge Operation (OMBO) Ships,
Publication No. 42/P – Testing of Electric Machines.
Publication No. 25/P – Technical Requirements for Shipboard Power Electronic Systems,
Publication No. 79/P – Type Testing Procedure for Crankcase Oil Mist Detection and Alarm Equipment,
Publication No. 106/P – ECO Class Rules
Publikacja Nr 5/I – Wytyczne do przeprowadzania okresowych przeglądów klasyfikacyjnych elektrycznych urządzeń przeciwwybuchowych na statkach w eksploatacji (available in Polish only),
Publikacja Nr 9/I – Materiały elektroizolacyjne (available in Polish only).

PRS/OP, 06/2015

CONTENTS

1 GENERAL

1.1 Application

1.1.1 *Part VIII – Electrical Installations and Control Systems* applies to electrical installations and automatic systems in sea-going ships subject to PRS survey, as well as to particular types of equipment, systems and their components in accordance with 1.3.

1.1.2 It is recommended that the relevant requirements of *Part VIII* should also cover electrical equipment installed on ships, not specified in 1.3.2 and 1.3.3.

1.1.3 In addition to the requirements of the present Part of the *Rules*, the electrical equipment shall fulfil the requirements of the national or international standards indicated by PRS.

1.1.4 In reasonably justified cases, the requirements of the present Part of the *Rules* may be waived or extended by PRS, e.g.: in the case of innovatory solutions implementation.

1.2 Definitions

Definitions and explanations relating to the general terminology of the *Rules for the Classification and Construction of Sea-going Ships* (hereinafter referred to as the *Rules*) are provided in *Part I – Classification Regulations.* Wherever, in *Part VIII*, definitions contained in other Parts of the *Rules* are used, reference to these Parts is made.

For the purpose of *Part VIII,* the following additional definitions have been adopted:

Additional source of electric power – a source of electric power intended to supply the electrical equipment for domestic, living and technological applications only. Additional source of electric power with its distribution system and consumers shall be totally separated from all other ship electric power systems.

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-dependent structural item used in automatic systems (e.g. relay, resistor, logic element, sensor, final control element).

Dead ship condition – a condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power. The absence of power means the starting battery discharge, the absence of starting air needed for restoring the operation of the main propulsion plant, boilers and auxiliaries.

Earthing – metallic connection of equipment terminal with the ship metal hull.

Emergency condition – a condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electric power.

Emergency lighting – lighting of the ship 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 on board the ship in the case of the loss of voltage in the main switchboard busbars.

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 for maintain safety of the ship during emergency.

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

Fire-retardant insulating material – material satisfying the requirements specified in *Publication No. 11/P – Environmental Tests on Marine Equipment*.

Hazardous area – an area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

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 kW (kVA).

Machinery space – see sub-paragraph 1.2, *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 ship in normal operational and habitable conditions.

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

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

Normal operational and habitable condition – a condition under which the ship as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, and emergency boat winches, as well as the designed comfortable conditions of habitability are in working order and functioning normally.

Passive-EM equipment – electrical equipment which, when used as intended, does not create or produce any switching or oscillation of current or voltage and is not affected by electromagnetic disturbances, e.g. cables, cables accessories; equipment containing only resistive loads without any automatic switching device; batteries and accumulators.

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 supplying the ship power network or individual consumers on board the ship.

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

Uninterruptible Power System (UPS) – combination of converters, switches and energy storage means, e.g. batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

Zones – hazardous areas are classified into zones based upon frequency of the occurrence and duration of an explosive atmosphere, as follows:

Zone 0 – a hazardous area in which an explosive gas atmosphere is present continuously or is present for long periods. In Zone 0, only the following explosion-proof electrical equipment may be installed:
- intrinsically safe apparatus (Exia);
- simple electrical apparatus (thermocouples, photocells, strain gauges, junction boxes, switching devices), not capable of storing or generating electrical power;
- electrical apparatus certified for use in Zone 0;
- submersible electrically-driven pumps, having at least two independent methods of shutting down automatically in the event of low liquid level.

Zone 1 – an area, in which an explosive gas atmosphere is likely to occur in normal operation. In Zone 1, the following explosion-proof electrical equipment may be installed:
- electrical equipment that may be considered for Zone 0;
- intrinsically safe apparatus (Exib), flameproof (Exd), pressurized (Exp), increased safety type (Exe), encapsulated (Exm), sand filled (Exq), oil-immersed apparatus (Exo), certified specially (Exs);
- hull fittings containing the terminals for anodes or electrodes of an impressed current cathodic protection or transducers (such as those for depth-sounding or log systems), provided that such fittings are of gastight construction or are housed within a gas tight enclosure and are not located adjacent to a cargo tank bulkhead;
- through runs of cables.

Zone 2 – an area in which an explosive gas atmosphere is not likely to occur in normal operation and if it does occur, it is likely to do so infrequently and will exist for a short period of time. In Zone 2, the following explosion-proof electrical equipment may be installed:
- any electrical equipment that may be considered for Zone 1;
- tested specially for Zone 2 (Exn);
- pressurized, accepted by PRS;
- having an enclosure filled with a liquid dielectric or encapsulated, accepted by PRS;
- the type which ensures the absence of sparks and arcs and of “hot spots” during its normal operation.

1.3 Scope of Survey

1.3.1 General

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

1.3.2 Survey of Electrical Installation in Ship

1.3.2.1 The following types of equipment and systems are subject to PRS survey during installation on board:

.1 electrical propulsion plant;
.2 main and emergency, including transitional, sources of electric power;
.3 power and lighting transformers and electric power converters used in equipment listed in 1.3.2.1;
.4 distribution gear and control and monitoring panels;
.5 electric drives for:
- machinery essential for the operation of propulsion engines,
- steering gear and all devices for active steering of the ship,
- controllable pitch propellers,
- windlasses, mooring and towing winches,
- boat winches,
- starting air compressors and air compressors for sound signals,
- bilge and ballast pumps as well as cargo pumps on tankers;
- watertight doors and fire doors,
- pumps and compressors of the smothering system,
- ventilating fans in machinery spaces, cofferdams, cargo holds and hazardous rooms and spaces;

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

1.3.2.2 PRS classification survey on board the ship covers also all automatic systems which control or monitor machinery, equipment or installations subject to PRS survey in accordance with the provisions of the present Part of the *Rules*.

1.3.2.3 Electrical equipment intended for domestic, living and technological application shall be surveyed by PRS within the following scope:

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

1.3.3 Survey of Electrical Equipment Manufacture

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 survey during manufacture:

.1 generating sets;
.2 generators and electric motors of rating 50 kW (kVA) and above;
.3 transformers above 20 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 uninterruptible power system (UPS) units of 3 kVA and above;
.26 other items of electrical equipment not listed above, as required by PRS.

1.3.3.2 Each explosion-proof electrical equipment shall be surveyed (with respect to its explosion proofness) by a special body recognised by PRS for this purpose, irrespective of whether or not this equipment is subject to survey 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 specified in Appendix 2.

1.4 Technical Documentation of a Ship

1.4.1 Classification Documentation of a Ship under Construction

1.4.1.1 Prior to the commencement of ship construction, documentation listed in 1.4.1.2 to 1.4.1.4, shall be submitted to PRS Head Office 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: power circuits, lighting circuits (up to branch circuit board) and navigation light circuits;
.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 navigation control and monitoring console 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 principle or detailed diagrams of main, excitation, control, monitoring, signalization, protection and interlocking circuits of the ship electric propulsion plant machines;
.6 calculation results of the ship electric propulsion plant generators output necessary to provide operation in all conditions;
.7 calculation results of short-circuit currents on the main switchboard busbars and in the other points of electric 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 apparatus, wiring and busbars of main switchboard and other distribution equipment shall correspond – together with the selection of protective devices;
.8 results of calculation of illumination intensity for important compartments and open locations for information;
.9 diagrams of internal communication and signalling;
.10 principle diagrams of essential electric drives according to 1.3.2.1.5;
.11 diagram of lubricating and air cooling systems of main propulsion el. motors;
.12 diagrams of protective earthing, drawings and if necessary, calculation of lightning conductors for tankers, gas carriers and combined ships;
.13 principle diagram of cable passages with indication of compartments through which they pass;
.14 results of capacity calculations of accumulator batteries supplying emergency lighting, navigation lights, general alarm and fire detection systems;
.15 data on electrical equipment in spaces where explosion hazard exists;
.16 diagrams of remote switching-off ventilation, fuel pumps and lubricating pumps;
.17 arrangement plans of main and emergency generators, main and emergency switchboards, accumulator batteries, equipment of explosion-proof execution.

1.4.1.3 When classed refrigerating installation is foreseen, documentation listed in 1.4.1.2 shall include data concerning electrical equipment of refrigerating installation.

1.4.1.4 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 or their units;
.2 functional diagrams of particular automatic systems with regard to the respective equipment, machinery and installations, giving information concerning: method of supply, functional features, structure, eventual connections with other systems as well as the kind and limit values of parameters covered 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 on board the ship;
.4 in the case of applying computer systems for control or checking the machinery and installations, the above documentation shall be supplemented according to paragraph 1.4, *Publication No. 9/P – Requirements for Computer Systems*.

1.4.2 Workshop Documentation of a Ship under Construction

In the case of approval of the classification documentation listed in 1.4.1, the following workshop documentation shall be submitted to the relevant PRS Branch Office or Survey Station for agreement:
.1 drawings of cabling and cable fastening;
.2 diagrams of final circuits of emergency switchboard and emergency lighting;
.3 diagrams of final circuits of lighting switchboards;
.4 test programme for ship electrical equipment and automated machinery performed alongside the quay and at sea.

1.4.3 Classification Documentation of a Ship under Alteration or Reconstruction

1.4.3.1 Prior to the commencement of alteration or reconstruction of a ship, documentation relating to installations, systems and equipment subject to alteration or reconstruction shall be submitted to PRS Head Office for consideration and approval.

1.4.3.2 Where new machinery or arrangements, covered by the requirements of the *Rules*, are installed, or machinery installed differs substantially from those initially fitted, additional documentation, within the scope required for a new ship, shall be submitted to the PRS Head Office (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 shall be submitted to PRS for consideration:

- **.1** description of the principle of operation and the main characteristics;
- **.2** material specification which shall 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 50 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** data on static or dynamic interference resistance, or the means of testing the electro-magnetic compatibility;
- **.10** definite means of interference damping.

Where necessary, PRS may require that additional documentation and data on 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 to 2.1.4 shall be taken into account.

2.1.1 Climatic Hazards

2.1.1.1 The temperature values, specified in Table 2.1.1.1, shall be taken as the rated ambient air and cooling water temperatures for electrical equipment. The use of electrical equipment for other temperature ranges is subject to PRS consideration in each particular case.

Table 2.1.1.1

Item	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 space, maximum air temperature equal to +50 °C shall be taken.
2) Electronic equipment and components intended to be installed in switchboards, desks and enclosures shall 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 shall 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 shall 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 shall 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 ± 1.0 mm;
– at a frequency from 13.2 Hz to 100 Hz with acceleration amplitude ± 0.7 g.

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 shall 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 25 Hz with displacement amplitude ± 1.6 mm;
– at a frequency from 25 Hz to 100 Hz with acceleration amplitude ± 4.0 g.

2.1.2.2 Electrical equipment shall 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 shall also 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 both transversely and longitudinally.

2.1.2.3 Electrical equipment shall have adequate mechanical strength and shall 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 shall be so designed that it remains operative under steady conditions in all cases, at all deviations from the rated values of voltage and frequency specified in the Tables: Table 2.1.3.1-1 – for a.c. distribution systems, Table 2.1.3.1-2 – for d.c. distribution systems, Table 2.1.3.1-3 – for battery systems (see also 14.1.3.2 to 14.1.3.5).

Table 2.1.3.1-1

Voltage and frequency variations for a.c. distribution systems			
Parameters	Deviations from rated values		
	Prolonged	Transient	
		Value	Time
Voltage	+6%, –10%	±20%	1.5 sec
Frequency	±5%	±10%	5 sec

Table 2.1.3.1-2

Voltage variations for d.c. distribution systems	
Parameters	Variations
Voltage tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (a.c.r.m.s. over steady d.c. voltage)	10%

Table 2.1.3.1-3

Voltage variations for battery systems	
Systems	Variations
Components connected to the battery during charging (see Note)	+30%, –25%
Components not connected to the battery during charging	+20%, –25%
Note: Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.	

2.1.3.2 Where loads are supplied from a battery via an electronic converter or inverter, the maximum permitted d.c. voltage variations shall be taken as those on the load side of the converter or inverter. Where the d.c. is converted into a.c., the maximum variations shall not exceed those specified in Table 2.1.3.1-1.

2.1.4 Electromagnetic Interference

2.1.4.1 Electrical and electronic shipborne equipment shall be resistant to the following 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.

The test parameters are specified in *Publication No. 11/P – Environmental Tests on Marine Equipment* and in IEC 60092-504.

2.1.4.2 Ship electrical and electronic equipment shall not emit excessive electromagnetic, radiated and conducted interferences.

The test parameters are specified in *Publication No. 11/P – Environmental Tests on Marine Equipment* and in IEC 60092-504.

2.1.4.3 For the purpose of protecting the radio receiving equipment from electrical interference, the requirements specified in the *SOLAS Convention* shall be fulfilled (these requirements are also specified in Chapter 4, *Part IV – Radio Equipment* of the *Rules for Statutory Survey of Sea-going Ships*).

2.1.4.4 Screens of power cables, metal coating and armouring of cables shall 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 hull.

2.1.4.5 All signal, control and information cables shall be screened. Metallic screens of these cables shall be earthed appropriately to the number of screens. In the case of using double-screened cables and appearance of high frequency field interference, internal and external screens shall 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 shall 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 star connected to the earthing bus of switchboard, if such bus exists, or directly to ship metallic hull.

2.1.4.8 To prevent contacts with the ship hull, screens of signal conductors shall be covered with an insulated outer sheath.

2.1.4.9 The screens and enclosures of electrical equipment placed on the navigation bridge shall be earthed.

The screens of cables and flexible cords shall be earthed in accordance with 2.4.3.5.

The screens and enclosures of passive-EM 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 that screened cables with pair or multipair twisted wires be used 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 specified in the SOLAS Convention shall be satisfied (these requirements are also specified in sub-chapter 4.2, *Part V – Navigational Equipment* of the *Rules for Statutory Survey of Sea-going Ships*).

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, shall be screened.

2.1.4.13 In ships constructed of non-current-carrying materials where radio equipment installation is required, all cables installed within the radius of 9 m from antenna shall be screened or otherwise effectively protected against interference.

2.2 Materials

2.2.1 Construction Materials

2.2.1.1 The structural parts of electrical equipment shall be made of metal or at least of hardly combustible insulating materials, resistant to sea air and oil vapour effects, or they shall 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 shall be made of corrosion-resistant materials or shall have effective corrosion-resistant covering.

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

.1 rheostat elements which shall 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 conditions;

.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 is subject to PRS consideration in each particular case.

2.2.2 Insulating Materials

2.2.2.1 Insulating materials of live parts shall have adequate dielectric and mechanical strength, resistance to creepage currents, moisture and oil vapour or else they shall be effectively protected.

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

2.2.2.2 Uninsulated parts of electrical equipment shall be cooled by incombustible liquids only.

2.2.2.3 The insulating materials to be used for winding insulation in machines, apparatus and other equipment for essential services shall be those specified in Table 3.1, Appendix 2. The use of insulating materials of at least Class E is recommended.

2.2.2.4 Conductors used in electrical devices for internal connections shall 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 shall fulfil the requirements specified in 16.3.

2.2.3 Usage of materials that contain asbestos in installations (e.g. thermal insulating materials, electrical cable materials, cable penetration sealing, brake linings, circuit breakers arc chutes), including spare parts, is prohibited for all ships according to *SOLAS* Regulation II-1/3-5, IACS UI SC 249 as well as MSC.1/Circ.1374 and MSC.1/Circ.1379.

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 shall be easily dismountable.

2.3.1.2 Where screw fastenings are employed, measures shall 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.) shall be appropriate to the degree of enclosure protection of the equipment in question.

Gaskets shall 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, shall be opened only with the use of tools.

2.3.1.5 Water drainage arrangements shall be provided in electrical equipment where condensation is likely to occur. Channels shall be fitted inside the equipment to ensure condensate drainage from all equipment components. Windings and live parts shall 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, shall 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 shall be used for all the internal wiring in electrical equipment. The use of single-wire conductors is subject to PRS consideration 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 shall have the cross-sectional area of not less than 1 mm^2. For control, protection, measurement of parameters, signaling 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 subject to PRS consent in each particular case.

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

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

2.3.3.5 Insulated conductors shall be laid out and secured in such a manner that the method used for their attachment and arrangement does not lead to reduced insulation resistance and that they are not 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 shall be so effected that, under rated operating conditions, the insulation of conductors is not exposed to overheating.

2.3.4 Degrees of Enclosures Protection

2.3.4.1 Electrical equipment shall be provided with appropriate protective enclosures depending on their location or other suitable measures shall 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 protection of electrical equipment installed in rooms and spaces of the ship shall be chosen in accordance with Table 2.3.4.2.

Table 2.3.4.2

Item	Electrical equipment location (examples)	Conditions in equipment location	Design according to degree of protection
1 2 3 4 5 6 7	Ammonia plant rooms (refrigerating machinery) Accumulator battery rooms Lamp rooms Paint rooms Stores for welding-gas bottles Holds classified as explosion-hazardous Tunnels for pipes containing oil with a flash-point of 60 °C or below	Danger of explosion	Certified safe-type (see 2.8)
8 9	Dry accommodation spaces Dry control rooms	Danger of touching live parts only	IP20
10 11 12 13 14 15 16 17	Rooms on the bridge Engine and boiler rooms above floor Steering gear rooms Refrigerating machinery rooms (excluding ammonia plant) Emergency machinery rooms General store-rooms Pantries Provision rooms	Danger of dripping liquid and/or moderate mechanical damage	IP22
18	Bathrooms and showers	Increased danger of liquid occurrence and/or mechanical damage	IP34
19 20 21 22 23 24 25	Engine and boiler rooms below floor Closed fuel oil separator rooms Closed lubricating oil separator rooms Ballast pump-rooms Refrigerated rooms Galleys and laundries Machinery space area protected by local water-spraying fire-extinguishing system covering the areas A and B according to Fig. 2.3.4.2.	Increased danger of liquid occurrence and mechanical damage	IP44
26 27 28	Rooms intended for fish processing Shaft or pipe tunnels in double bottom Holds	Danger of liquid spraying, cargo dust presence, serious mechanical damage, aggressive fumes	IP55
29	Open decks	Danger of occurrence of liquids in large quantities	IP56

Notes:

1) Where the protection is not achieved by the equipment enclosure itself, other means or the location where it is installed shall ensure the degree of protection required in the Table.
2) For crude oil tankers, combined ships, ships intended or adapted for operation in the area of oil spillage – see 22.5.4.
3) The area protected by local water-spraying fire-extinguishing system is shown in Fig. 2.3.4.2.

A – a protected area – an area which is required to be protected by local water-spraying fire-extinguishing system

B – an area adjacent to a protected area, exposed to direct spray

C – an adjacent area, other than A and B areas, where water may extend.

4) In area C, according to Fig. 2.3.4.2, the electrical and electronic equipment may have a lower protection degree than IP44, provided evidence of suitability for use in these areas is submitted, taking into account the design and equipment layout, e.g. the position of inlet ventilation openings. The cooling airflow for the equipment shall be ensured.

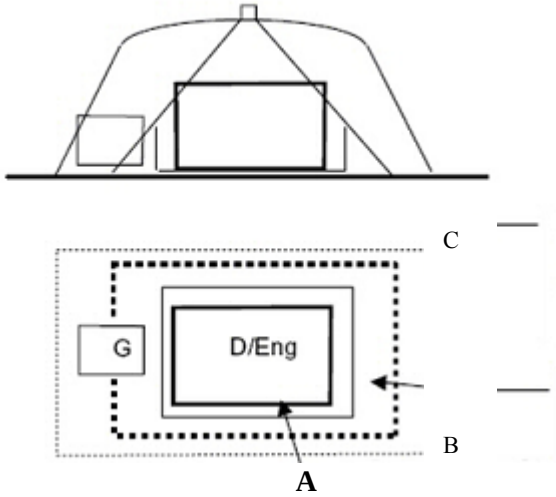

Fig. 2.3.4.2

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, shall be fitted with an earth terminal marked with the symbol.⏚

Depending on the purpose of the electrical equipment, provision shall 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) shall have a reliable electric contact with a component fitted with an earth terminal (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 shall be earthed.

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

2.4.2 Earthing of Aluminium Superstructures in Steel Ships

Superstructures of aluminium alloys fastened to the ship steel hull, but insulated from it, shall be earthed with a special conductor having a cross-section not less than 16 mm^2 which shall be corrosion-resistant and such that will not start electrolytic corrosion at the point of contact of the superstructure with the hull.

Such earthing connections shall 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 structure shall not have a diameter 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 shall not be used for other purposes than fastening the earthing wires. Bolts, which are screwed to a material (without nuts), shall be made of brass or other corrosion-resistant material.

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

2.4.3.2 Fixed electrical equipment shall 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 shall 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 hull under all operating conditions.

For the purpose of earthing effected with an external earthing wire, copper wire shall be used. A wire of another 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 shall not be less than that specified in Table 2.4.3.2.

Table 2.4.3.2

Cross-section of cable connected to appliance, [mm^2]	Minimum 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, however 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 shall be equal to the nominal section of the feeding cable core for cables up to 16 mm^2 and shall 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 shall be effected through the earthed jack of a socket outlet or other earthed connecting elements and through the earthed copper core of the feeding cable. Cross-section of the earthing core shall not 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 shall not be disconnected.

2.4.3.5 Earthing of screens and metal sheaths of cables shall 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 shall 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 shall be accessible for inspection and protected against getting loose and against mechanical damage.

2.4.3.7 Cargo tanks and their process plant, including piping systems, shall have relevant connection with the ship hull. Resistance between them and hull of the ship shall not exceed 1 MΩ. In the case of lack of stable connection with the hull, bonding straps shall be used.

2.4.3.8 In the case of application of bonding straps, they shall be:
– clearly visible (in order to immediate verification of their failures);
– designed and installed in such way that they are protected against possible mechanical failures and corrosive atmosphere/products;
– easy for installation and replacement.

2.5 Lightning Protection

2.5.1 General Requirements

2.5.1.1 The ship shall be fitted with a lightning protection, whose protection zone will comprise all arrangements required for 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 shall be provided.

2.5.1.2 The lightning installation shall 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. shall be used as spikes if provision is made for their electrical connection to the ship 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 shall be provided.

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

2.5.2.4 Spikes shall 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 shall 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 its top.

2.5.3 Lightning Conductor

2.5.3.1 The lightning conductor shall 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 shall be led on the outer side of the mast and superstructures and as straight as possible with a minimum number of bends which shall be smooth and have the largest possible radii.

2.5.3.3 Lightning conductors shall not pass through explosion-hazardous spaces.

2.5.4 Earthing

2.5.4.1 In composite 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 shall be made for earthing the lightning conductors or the ship steel hull to an efficient earth on shore when the 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 shall be welded, clamped, riveted or bolted with clamps.

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

Clamps and bolts shall be made of copper, copper alloys or steel suitably protected against corrosion.

2.5.6 Earthing Installation

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

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

Pipelines located on the deck on which explosive gases may occur, but not related to the explosion hazardous spaces, may be earthed to the ship hull at every 30 m.

2.5.6.3 Metal parts located near the lightning conductors shall 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 hull.

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

2.5.6.4 All connections in the earthing installation shall be accessible for inspection and protected against mechanical damage.

2.6 Arrangement of Equipment

2.6.1 Electrical and automation equipment shall 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 shall 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 shall 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.

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

2.6.5 The electrical equipment shall 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 Open live parts of electrical equipment shall not be situated closer than 300 mm horizontally and 1200 mm vertically to non-protected combustible materials.

2.6.7 When installing electrical equipment having enclosures made of material other than that used for the ship structures, suitable means to prevent electrolytic corrosion shall be provided, where necessary.

2.7 Special Electrical Spaces

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

2.7.2 Special electrical spaces shall not 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 shall be fixed on the tanks within these spaces.

2.7.3 No exits, opening 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 shall be installed in special electrical spaces, in passageways and servicing areas of open-type electrical equipment.

2.8 Electrical Equipment in Hazardous Spaces

2.8.1 The requirements of the present sub-chapter 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 7 of Table 2.3.4.2.

Additional requirements for the installation of electrical equipment in crude oil tankers, combined ships, ships intended or adapted for operation in the area of oil spillage are specified in 22.5, whereas the requirements for the installation of electrical equipment in ships having holds and other spaces for carrying vehicles with fuel in their tanks, as well as tank cars and tank trucks carrying cargoes subject to explosion hazards are specified in 22.3.

2.8.2 The electrical installations in hazardous spaces and rooms shall be made in accordance with IEC Publication 60092-506.

In 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 paint stores and spaces leading to paint stores shall fulfil the requirements specified in 2.8.3 to 2.8.5.

The installation of electrical equipment in accumulator battery rooms shall fulfil the requirements specified in 13.6.

The installation of echo depth sounder oscillators and their cables shall fulfil the requirements specified in SOLAS Convention (these requirements are also specified in 4.2.4, *Part V – Navigational Equipment* of the *Rules for Statutory Survey of Sea-going Ships*).

2.8.3 Electrical equipment may be installed in paint 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 pressurized enclosure (Exp), increased safety type (Exe), with special enclosure (Exs).

This equipment shall 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 paint stores shall switch off all poles and phases. It is recommended that such devices 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 paint stores ventilation ducts or to 3 m from output openings of mechanical ventilation, the following electrical equipment is permitted to be installed:

– electrical equipment of explosion-proof construction allowed for paint 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 pressurized enclosure or enclosure resistant to vapour (degree of enclosure protection at least IP55) which surface does not reach unacceptably high temperature,
– cables.

2.8.5 Adjacent spaces having exit to paint stores may be considered as non-hazardous spaces, provided that:
– doors to the paint stores are gastight, self-closing type without holders,
– in the paint 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 are flammable liquids in the store.

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

In spaces where dust with air may temporarily produce explosive mixtures 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.

Electrical equipment installed in those rooms shall 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 shall be determined for a layer of dust 5 mm thick).

2.8.7 Lighting fixtures of explosion-proof construction shall be so installed that, except the fastening points, free space of at least 100 mm is left around.

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

2.8.9 Fastening of electrical equipment to the walls of tanks intended for flammable liquids is not permitted. In no case shall the distance between electrical equipment and the tank walls 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 hazardous rooms and spaces , electrical equipment of explosion-proof construction shall be installed as a rule.

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

.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 shall be changed at least 10 times).

2.8.11 In cargo holds for the carriage of cargoes in containers, subject to explosion hazard, electrical equipment and cables shall not be installed. If the installation of electrical equipment is necessary, it shall be of explosion-proof construction, i.e. of intrinsically safe type (Exi), ventilated type or with pressurized 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 hazardous spaces and rooms, only cables intended for electrical equipment located in these spaces and rooms shall be installed.

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

2.8.13 Cables installed in hazardous rooms and spaces shall 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 hazardous rooms and spaces shall 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 hazardous rooms and spaces, or supplying electrical equipment located in these rooms and spaces, shall be earthed at least at both ends.

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

2.8.17 No cables of portable electrical equipment shall pass through 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 ship shall be provided with main source of electric power of sufficient capacity to supply all essential services of the ship in conditions specified in 3.1.6. The main source of electric power shall consist of at least two generators with an independent prime mover.

In ships of 300 tons gross tonnage and downward (except passenger ships), accumulator battery may be used as main source of power.

The main generating station shall be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads. Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station, provided there is access between the spaces.

3.1.2 The number and the capacity of the generating sets and power converters composing the main source of electric power shall 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, mentioned in 3.1.6, maintaining the minimum comfortable conditions of habitability;

.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 provide at the same time the services required in 9.3.1 to 9.3.3 or 22.1.2.1 to 22.1.2.3 (see also paragraph 1.8.4, *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 shall 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 additionally:

.1 the shaft generator runs with a constant rotary speed at variable rotational speed of the main engine or propeller shaft;

.2 there is a possibility of starting the ship main engine in the event of failure of any of the generating sets;

.3 there is a possibility of the shaft generator operating even when the vessel is stopped.

The use of shaft generators, running with a variable rotary speed depending on the ship main engine or propeller shaft, which constitute the main source of electric power, will be specially considered by PRS.

3.1.6 The number and the capacity of the main source of electric power shall be determined taking account of the following operating conditions of the ship:

.1 running conditions;

.2 manoeuvring;

.3 in the event of fire, piercing of the hull or in other conditions having effect on the ship safety;

.4 other – according to the ship assignment.

3.1.7 Each hull of the catamaran shall be provided with at least one generating set.

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

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

3.1.10 Relevant parameters of sources and consumers of electrical power shall be presented in order to make necessary calculations for preparation of *Ship Energy Efficiency Management Plan* (SEEMP).

3.2 Electric Generating Sets

3.2.1 General Requirements

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

3.2.1.2 Generating sets shall 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 network, the generators shall 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 shall 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 difference between the actual value of voltage curve and the corresponding value of the 1st harmonic shall not exceed 5 per cent of the 1st harmonic peak value.

3.2.2 Load Sharing between Generating Sets Running in Parallel

3.2.2.1 The regulator characteristics of prime movers used to drive alternating-current generators intended to operate in parallel shall 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 shall be provided with a device for precise regulation of the load change 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 shall 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 shall 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 shall be such that in parallel operation the load on individual generators is shared, as far as possible, in proportion to the output of each generator.

At loads within 20 to 100 per cent of the rated value, the load on individual generators shall not 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 shall not vary from the value proportional to their output by more than 10 per cent of rated output.

3.2.3 Shaft Generators

3.2.3.1 Shaft generators used as main source of electric power for shipboard electrical network shall 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.

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

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 shall 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 shall be sufficient for actuation of automatic protective devices.

3.2.3.4 Shaft generators shall 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 shall be provided. It is permitted that the voltage of the shaft generator terminals be suitably reduced.

3.2.3.6 The main switchboard shall 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 connect to the ship network, visual signalling shall automatically switch on warning on the navigation bridge that a change of the rotational speed of the main propulsion may result in a change of the ship network parameters exceeding the limits specified in 10.6, 10.7 and 2.1.3.1.

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

3.2.3.9 Generators and generator systems, having the ship propulsion machinery as their prime mover, but not forming part of the ship main source of electrical power, may be used whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions, provided that:

- **.1** there are fitted sufficient and adequately rated additional generators which constitute the main source of electrical power, meeting the requirements specified in 3.1.1;
- **.2** within the declared operating range of the generators and/or generator systems, voltage and frequency variations meet the requirements of 10.6.2 and 2.1.3.1, respectively;
- **.3** arrangements are fitted to automatically start one or more of the generators, constituting the main source of electrical power in the event of power drop and also upon the frequency variations exceeding by ± 10% the limits specified in 2;
- **.4** the short-circuit current of the generator and/or generator system is sufficient to trip the generator /generator system circuit-breaker taking into account the selectivity of the distribution system protective devices;
- **.5** where considered appropriate, load shedding arrangements are fitted to meet the requirements specified in 8.2.3;
- **.6** on ships having remote control of the ship propulsion machinery from the navigation bridge means are provided, or procedures are in place, so as to ensure that supplies to the essential services are maintained during manoeuvring conditions in order to avoid a blackout situation.

3.3 Number and Power of Transformers

In ships where lighting and other essential services are powered through transformers, provision shall be made for not less than two transformers of such capacity that in case of failure of the largest unit, the remaining transformers will be 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 shall 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 (other than passenger ships), only one transformer may be provided.

3.4 Power Supply from an External Source of Electric Power

3.4.1 If provision has been made for the ship network to be supplied from an external source of electric power, a terminal for power supply from an external source of electric power shall be installed in the ship. The circuit supplied by an external electric power source shall fulfil the requirements specified in 4.5.4.7.

The external supply terminal shall 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 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 shall 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; where the length of the cable between the main switchboard and the terminal is less than 10 m, the terminal need not be provided with protection;
- **.3** a voltmeter or signal lamps to show the presence of voltage on terminals;
- **.4** a device or a possibility of 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;
- **.7** at the external supply terminal or nearby, a device for mechanical fastening of the flexible cable led to the terminal and cable hangers shall be provided.

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 shall 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 shall have equalizing connections.

3.5.3 Where alternating-current generators are intended to operate in parallel, a synchronizer shall be installed in the main switchboard.

Where synchronizing is arranged to operate automatically, a stand-by manual synchronizer shall be provided.

Lamps for manual synchronizing shall be provided, irrespective of whether or not synchronoscopes have been fitted for manual or automatic synchronizing.

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

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

3.5.6 Where the main source of electrical power is necessary for propulsion of the ship or where the total output of generators running in parallel is over 1000 kW (kVA), the main switchboard busbars shall be subdivided into at least two parts, which should normally be connected by circuit breakers, switches, isolating switches or other means approved by PRS.

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

3.5.7 Sectionalisation of the main switchboard busbars for supplying the electrical equipment in each hull of the catamaran shall be provided.

4 DISTRIBUTION OF ELECTRIC POWER

4.1 Distribution Systems

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

.1 for voltages up to 1000 V alternating current:
- **.1.1** three-phase three-wire insulated system;
- **.1.2** three-phase three-wire system with neutral earthed;

.2 in addition, for voltages up to 500 V alternating current:
- **.2.1** three-phase four-wire system with neutral earthed but without hull return;
- **.2.2** single-phase two-wire insulated system;
- **.2.3** single-phase two-wire system with one wire earthed;

.3 for direct current:
- **.3.1** two-wire insulated system;
- **.3.2** single-wire system with hull return, for voltages of up to 50 V only, under the following conditions:
  - in ships of gross tonnage less than 1600 (RT),
  - in ships of gross tonnage 1600 (RT) and above in restricted and locally earthed systems (e.g. in the starting system of internal combustion engines);
- **.3.3** two-wire system with one pole earthed;
- **.3.4** three-wire system with neutral earthed.

The use of other systems is subject to PRS consideration in each particular case.

4.2 Permissible Voltages

4.2.1 The voltages across the terminals of the sources of electric power, at the frequency of 50 Hz and 60 Hz, depending on the applied distribution systems, are specified in 4.1.1.

Additional requirements for electrical equipment with the rated voltage higher than 1000 V are specified in Chapter 18.

4.2.2 The permissible rated voltages across the terminals of alternating current-consuming appliances shall not exceed the values specified in Table 4.2.2.

4.2.3 The rated voltages across the terminals of direct current-consuming appliances shall not exceed the values specified in Table 4.2.3.

Table 4.2.2

Item	Type of consumers	Permissible voltage, [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 supplying power consumers, fixed permanently when used; control circuits, heating and space heating appliances in cabins and passenger spaces (see 15.2.5)	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	250
4	Socket-outlets installed in spaces with increased humidity or in extra humid spaces intended for supplying equipment without reinforced or double insulation	50

Table 4.2.3

Item	Type of consumers	Permissible voltage [V]
1	Power consumers	500
2	Cooking, heating appliances, etc.	250
3	Lighting, socket-outlets[1]	250

[*] Inscriptions indicating the necessity of using the appliances only with double or reinforced insulation or appliances separated from the voltage exceeding the safety voltage shall be provided near socket-outlets for a voltage exceeding the safety voltage, installed in spaces with increased humidity or in extra humid spaces.

4.3 Power Supply to Essential Services

4.3.1 The following consumers shall be supplied with electric power by separate feeders from the main switchboard busbars:

.1 steering gear electric drives (see also 5.5.2);
.2 electric drives of main propulsion plant excitation units;
.3 electric drives of machinery ensuring the operation of the main propulsion;
.4 electric drives of machinery ensuring the operation of the generating sets constituting the main source of electric power;
.5 electric drives of machinery ensuring the operation of the controllable pitch propellers;
.6 switchboards of the ship control and monitoring desk (see also 4.4);
.7 windlass electric drives (see also 4.3.3);
.8 fire pump electric drives;
.9 bilge pump electric drives;
.10 gyrocompasses;
.11 electric drives of compressors and sprinkler system pumps;
.12 switchboard of cargo hold refrigerating installations;
.13 section switchboards of the main lighting;
.14 switchboards of radio communication equipment;
.15 navigational equipment switchboards;
.16 switchboards of navigation lights;
.17 section switchboards of other essential services concentrated in accordance with similar function performed;
.18 switchboards of automatic gear of fire detection alarm system;
.19 switchboards for supplying the mooring equipment, cargo handling gear, boat winches, ventilation and heating appliances;
.20 chargers of starting batteries and of batteries supplying essential services;
.21 switchboards supplying electric drives of watertight door closing appliances and of appliances keeping the fire doors open, as well as switchboards of signals indicating the position and closing of watertight and fire doors;
.22 switchboards of cargo refrigerating installation of low pressure carbon dioxide fire-extinguishing system;
.23 switchboards for lighting the air-sheds and those of the signalling lights for helicopter landing fields;
.24 other consumers which will be specially considered by PRS in each particular case.

The consumers specified in .3, .5, .9, .10, .14, .15, .16, .18, .21 may be supplied from switchboards specified in .6 and .17 by separate circuits equipped with switchgear and protective devices.

4.3.2 When two or more devices of the same purpose as that of electric drives specified in 4.3.1 are fitted, except those indicated in 4.3.1.1, 4.3.1.2 and 4.3.1.11, at least one of the drives of these devices shall be supplied by a separate feeder from the main switchboard. The electric drives of other devices of this kind may be supplied from section switchboards or special switchboards intended for supplying essential services.

4.3.3 When the main switchboards busbars are sectionalized and provided with means for isolating the sections, then the electric drives, section switchboards, special distribution boards or panels, if they are doubled or supplied by two feeders, shall be connected to two different main switchboard busbar sections.

4.3.4 In cargo ships of restricted service **II** and **III** and in some cases, upon special agreement with PRS, in cargo ships of other areas of navigation, the windlass may be supplied from the cargo winch switchboard or any other switchboard, provided its power supply is taken directly from the main switchboard and a suitable protection is fitted.

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

4.3.6 Power supply to automation systems shall fulfil the requirements specified in 20.3.

4.3.7 Where the main source of electrical power is necessary for propulsion and steering of the ship, the system shall 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 maintained or immediately restored in the case of loss of any one of the generators in service.

4.4 Power Supply to Ship 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 shall be supplied by separate feeders.

4.4.2 It is permitted to supply the equipment specified in 4.3.1 from the switchboards built into ship navigation control and monitoring console, provided the requirements of 4.4.3 to 4.4.7 are met (see also 9.4.3).

4.4.3 The switchboards of control and monitoring console shall be supplied from the main switchboard directly or through a transformer by two independent feeders connected to different sections of the main switchboard busbars (where sectionalized busbars are used) or shall be supplied by one feeder from the main switchboard and by one feeder from the emergency switchboard if the generating set is the emergency source of energy.

4.4.4 In addition, the switchboards of control and monitoring console shall 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.

4.4.5 The switchboard shall be provided with a change-over switch for feeders specified in 4.4.3. If an automatic change-over switch is used, manual switching of feeders shall also be ensured. In that case, provision shall be made for appropriate interlocking.

4.4.6 Each consumer specified in 4.3.1 supplied from the switchboard of control and monitoring console shall be supplied by a separate feeder (see also 9.4.3).

4.4.7 In the control and monitoring console, a visual signalling device indicating the presence of voltage shall be fitted.

4.4.8 The ship navigation control and monitoring consoles shall be provided with a means to check the functioning of test lamps, e.g. “lamp test” button.

4.5 Distribution Switchboards

4.5.1 Switchboard Constructions

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

4.5.1.2 Switchboards shall be of rigid construction capable of withstanding the mechanical stresses liable to occur under service conditions or as a result of short-circuits.

4.5.1.3 Switchboards shall be at least protected from drip. This protection is not required if the switchboards shall be located in spaces where the conditions are such that no vertically falling drops of liquid can get into the switchboard (see 4.5.6.2).

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

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

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

4.5.1.6 Main, emergency and section switchboards and control desks shall be provided with handrails fitted on their front side. Switchboards accessible from the rear shall 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.

Near the main and emergency switchboards of rating 50 V and above, floors shall be covered with non-conducting mats or gratings at the front and rear of the switchboards.

4.5.1.7 The generator panels of main switchboards shall be provided with lighting fittings supplied on the side of the generator, but before its main circuit-breaker or from at least two different sections of busbars through selector switch where sectionalised busbars are used in accordance with 3.5.6.

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

4.5.1.9 The design of wall switchboards shall be such as to provide access to parts which require attendance. The switchboard doors shall 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 operating position shall 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 of permissible short-circuit load for copper busbars, shall be taken in accordance with the relevant standards.

4.5.2.2 Equalizer busbars shall 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 effects under operating or short-circuit conditions shall not cause a temperature rise in excess of that allowable for a given insulating material.

4.5.2.4 Busbars and bare conductors in switchboard shall 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 shall be determined in accordance with the relevant standards.

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

4.5.2.6 The natural frequency of copper busbars shall 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.

4.5.2.7 Busbars and bare conductors of different polarity shall 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 equalizer connection shall be marked with white transverse bands in addition to the appropriate colour as given above.

4.5.2.8 Busbars and bare conductors of different phases shall 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.

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

Short-circuit protective equipment shall conform to specific conditions of the ship 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 shall be taken into consideration:

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

Calculation of the minimum short-circuit current shall be performed 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 shall not 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 shall not 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 shall not 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 shall 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 shall 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 shall have a pole in the equalizer 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 shall be performed 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 shall be taken into account. The source of current shall include all the generators which may be connected in parallel and all the motors running simultaneously. Currents induced by generators and motors shall be calculated according to IEC 61363-1 standard.

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

– big motors (power above 100 kW):

$I''_M = 6.25\ I_{rM}$

$I_{acM} = 4I_{rM}$, t = T/2

$I_{pM} = 10I_{rM,}$

– small motors:

$I''_M = 5I_{rM}$

$I_{acM} = 3.2I_{rM}$, t = T/2

$I_{pM} = 8I_{rM}$

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 shall be taken.

Calculation shall be performed for all cases of short-circuit necessary for obtaining the system characteristics.

4.5.4 Arrangement of Apparatuses and Measuring Instruments

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

Switches may be not 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 shall 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 grouped in the central control console of main switchboard or in the central control desk.

4.5.4.3 One ammeter and one voltmeter shall be provided for each direct-current generator on the main and emergency switchboards.

4.5.4.4 The following instruments shall 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 or 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).

4.5.4.5 In ships with a low-power 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.

4.5.4.6 Ammeters shall 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.

4.5.4.7 On the main switchboard in the circuit supplied by an external electric power source, the following shall be provided:

.1 a switchgear and a protective device;

.2 a voltmeter or indicating lamps.

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

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

In ships with unattended machinery space, such signals shall be provided also in the central control station.

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

The upper scale limits of the instruments used shall not be 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 subject to PRS consent in each particular case.

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

4.5.4.11 Where possible, switchgear shall 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 energized in the open position.

4.5.4.12 Where switchboard outgoing circuits are provided with switches and fuses, the fuses shall be fitted between busbars and switches. Other pattern of fuse and switch installation is subject to PRS consideration in each particular case.

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

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

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

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

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

The fuses in an a.c. circuit shall 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 shall be on the left side, on the top, or closer to be reached.

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

4.5.4.18 The ammeters of compound-wound generators designed for operation in parallel shall be installed in the pole circuit which is not connected to the equalizer.

4.5.4.19 Flexible stranded conductors shall be used for connection of instruments located on movable or drawn-out parts.

4.5.4.20 Apparatus, instruments, panels and outgoing circuits shall have their designations marked on the switchboards.

The position of switchgear shall also be indicated. Besides, marking shall be provided to indicate the rated current of the fuses, as well as the setting of the circuits-breakers, thermal relays and other switches.

4.5.5 Visual Signals

4.5.5.1 For visual signals, colours specified in Table 4.5.5.1 shall be used.

Table 4.5.5.1

Item	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 energized. All in order
5	White	General information	Permanent	Signals used when required. Notations relating to automatic action. Other additional signals

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.

4.5.6 Arrangement of Switchboards

4.5.6.1 The main switchboards and section boards having open live parts on the rear side, installed along the ship side below the load waterline, shall be protected from water with special metal shields or by means of any other equivalent measures.

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

4.5.6.3 If switchboards with the degree of protection IP10 and lower are located in a special space, cabinet or recess, such spaces shall be made of non-combustible material or shall have a lining of such material. If the switchboards are located in a space having a deck area of less than 4 m^2, such space is treated as space of category (5) – see sub-chapter 2.2.2, *Part V – Fire Protection.*

4.5.6.4 The arrangement of pipelines and tanks near the electrical equipment shall conform to the requirements specified in paragraphs 1.16.11.11, 1.16.11.14, 1.16.11.16 and 1.16.11.17, *Part VI – Machinery Installations and Refrigerating Plants*.

4.5.6.5 The navigation light switchboard shall be located on the navigation bridge where it is readily accessible and visible for the personnel on watch.