ClassIBS

ISTHMUS BUREAU OF SHIPPING

PART 8
ELETRICAL INSTALLATIONS

Rev. 06 *January 2022*

PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 8 ELECTRICAL INSTALLATIONS

CONTENT

Chapter 1 GENERAL 5

1.1 General 5

1.2 Testing 8

Chapter 2 ELECTRICAL INSTALLATIONS AND SYSTEM DESIGN 10

2.1 General 10

2.2 System Design – General 12

2.3 System Design – Protection 16

2.4 Rotating Machines 19

2.5 Switchboards, Section Boards and Distribution Boards 29

2.6 Circuit-breakers, Fuses and Electromagnetic Contactors 34

2.7 Control Appliances 36

2.8 Control gears for Motors and Magnetic Brakes 38

2.9 Cables 41

2.10 Transformers for Power and Lighting 48

2.11 Accumulator Batteries 50

2.12 Semi-conductor Converters for Power 51

2.13 Lighting Fittings 53

2.14 Wiring Accessories 54

2.15 Heating and Cooking Equipment 54

2.16 Explosion-protected Electrical Equipment 55

2.17 High Voltage Electrical Installations 56

2.18 Tests after Installation on Board 61

Chapter 3 DESIGN OF INSTALLATIONS 64

3.1 General 64
3.2 Main Source of Electrical Power and Lighting Systems 64
3.3 Emergency Source of Electrical Power 65
3.4 Starting Arrangement for Emergency Generating Sets 69
3.5 Steering Gear 70
3.6 Navigation Lights, Other Lights, Internal Signals, etc. 70
3.7 Lightning Conductors 71
3.8 Spare parts, Tools and Instruments 71
Chapter 4 ADDITIONAL REQUIREMENTS FOR SHIPS CARRYING SPECIAL CARGOES 74
4.1 General 74
4.2 Tankers, Ships Carrying Liquefied Gases in Bulk and Ships Carrying Dangerous Chemicals in Bulk 74
4.3 Tankers and Ships Carrying Dangerous Chemicals in Bulk Having a Flashpoint Not Exceeding 60°C. 78
4.4 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoint Exceeding 60°C and their Cargos are Heated more than Temperature which is 15°C lower than the Flashpoint 79
4.5 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoint Exceeding 60°C and their Cargos are not Heated or Heated less than Temperature which is 15°C lower than the Flashpoint 80
4.6 Ships Carrying Dangerous Chemicals in Bulk Reacting with other Products to Evolve Flammable Gases 80
4.7 Ships Carrying Liquefied Gases in Bulk 81
4.8 Enclosed Cargo Holds for Carrying Motor Vehicles with Fuel in Their Tanks for Their Own Propulsion and Enclosed Compartments Adjoining the Cargo Holds, etc. 82
4.9 Coal Carriers 82
4.10 Special Requirements for Ships Carrying Dangerous Goods 83
Chapter 5 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS 84
5.1 General 84
5.2 Propulsion Electrical Equipment and Cables 84
5.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits 87

Chapter 6 SPECIAL REQUIREMENTS FOR SHIPS WITH RESTRICTED SERVICE, SMALL SHIPS AND FISHING VESSELS 89

6.1 General 89

6.2 Electrical Installations of Ships Specified in 6.1.1(1) 89

6.3 Electrical Installations of Ships Specified in 6.1.1(2) 92

6.4 Electrical Installations of Ships Specified in 6.1.1(3) 92

6.5 Electrical Installations of Ships Specified in 6.1.1(4) 93

6.6 Electrical Installations of Vessels Specified in 6.1.1(5) 93

6.7 Electrical Installations of Vessels Specified in 6.1.1(6) 93

6.8 Electrical Installations of Vessels Specified in 6.1.1(7) 94

Index of Tables

Table 1.1 Ambient Temperature 8

Table 1.2 Angle of Inclination 8

Table 2.1 Voltage and Frequency Fluctuation 10

Table 2.2 Limits of Temperature Rise for Rotating Machines (Based on ambient temperature 45°C) 21

Table 2.3 Values of F_1 24

Table 2.4 Minimum Clearance and Creepage Distances inside the Terminal Box of Rotating Machine 25

Table 2.5 Testing Voltage 28

Table 2.6 Minimum Values of Test Voltage and Insulation Resistance 29

Table 2.7 Minimum Clearance Distances for Busbars 31

Table 2.8 Instruments for d.c. Generator Panels 31

Table 2.9 Instruments for a.c. Generator Panels 32

Table 2.10 Limits of Temperature Rise of Electrical Appliances for Switch Boards (Based on ambient temperature 45°C) 34

Table 2.11 Minimum Clearances and Creepage Distances for Control Appliances 37

Table 2.12 Limit of Temperature Rise of Controlgears for Motors (Based on ambient temperature 45°C) 40

Table 2.13 Current Rating of Cable (for continuous services) (Based on ambient temperature 45°C) 43

Table 2.14 Correction Factor for Various Ambient Temperatures 43

Table 2.15 Limit of Temperature Rise of Transformers (Based on ambient temperature 45°C) 49

Table 2.16 Minimum Air Clearances 59

Table 2.17 Minimum Insulation Resistance 62

Table 3.1 Spare parts for Generators, Exciters and Motors 72

Table 3.2 Additional Spare parts for Steering Gear Motors without Stand-by Motor or Motor-generator 73

Table 3.3 Spare Parts for Control Gear 73

Table 3.4 Spare Parts for Brakes 73

Table 3.5 Spare Parts for Switchboards, Section Boards and Distribution Boards 73

PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 8 ELECTRICAL INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1. The requirements in this part apply to the electrical equipment and wirings for ships (hereinafter referred to as the electrical installations).

2. For electrical installations for small ships, ships with special limitations for their service and fishing vessels and electrical installations for ships other than those to which the Society s permission are given, the application of the requirements of this part may partly be modified in accordance with the requirements of **Chapter 6** except those specified for the protection of shocks, fire and other hazards caused by electricity.

1.1.2 Equivalency

Electrical installations which do not fully comply with the requirements of this part may be accepted, provided that there are unavoidable but justifiable reasons precluding the due compliance with the requirements of this part and that the electrical installations are deemed by the society to be equivalent to those specified in this part.

1.1.3 Electrical Installations with Novel Design Features

For electrical installations manufactured or installed with novel design features the society may impose appropriate requirements of this part to the extent practically applicable with additional requirements made on design and test procedures other than those specified in this part and accept such installation if they are proved to fit the intended service and are capable of maintaining ship’s propulsion and securing the safety of life and the ship to the satisfaction of the Society.

1.1.4 Definitions

Terms used in this part are defined as follows:

1. “Hazardous areas” are the following areas or the spaces where flammable or explosive substances are placed and where it is likely to arise flammable or explosive gases or vapours from these substances.

(a) Zone 0: areas or spaces in which an explosive gas atmosphere is present continuously or is present for long periods

(b) Zone 1: areas or spaces in which an explosive gas atmosphere is likely to occur in normal condition

(c) Zone 2: areas or spaces in which an explosive gas atmosphere is likely to occur in abnormal condition

2. "Non-hazardous areas" are the areas or the spaces in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

3. "Source of release" are the point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive atmosphere may be formed under normal operating conditions, for example valves and flanges in cargo piping systems. The continuous fully welded parts are not considered as source of release.

4. "Selective tripping" is such an arrangement that only the protective device nearest to a fault point is opened automatically in order to maintain the power supply to the rest of sound circuits, in the event of a fault in the circuit having protective devices connected in series.

5. "Preference tripping" is such an arrangement that the protective device for unessential circuits are opened automatically in order to ensure the power supply for service specified in 3.2.1-2, when any one generator becomes overloaded or likely.

6. "Normal operational and habitable condition" is 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 communication 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.

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

8. "Main source of electrical power" is a source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

9. "Main generating station" is the space in which the main source of electrical power is situated.

10. "Main switchboard" is a switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ship's services.

11. "Emergency source of electrical power" is a source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

12. "Emergency switchboard" is a switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or the transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

13. "Electrical equipment with type of protection "n" is the electrical equipment such that, in normal operation, it is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur.

1.1.5 Drawings and Data

The drawings and data to be submitted are as follows. In case where the Society deems necessary, submission of other drawings and data than those specified here may be requested.

1. Drawings:

(a) Sectional assembly of generators, motors and electromagnetic slip couplings for electric propulsion.

(b) Equipment including complete rating, main dimensions, main materials used and weights.

(c) Key diagram and explanation of electric propulsion control gears.

(d) Sectional assembly of generators (main, auxiliary and emergency) of 100 *kW* (or *kVA*) and over, including complete rating, main dimensions, main materials used and weights.

(e) Arrangement plan (including specifications of main parts such as circuit breakers, fuses, instruments and cables) and circuit diagrams of main switchboard and emergency switchboard.

(f) Plans of arrangement of electrical equipment and of cable installation.

(g) Diagrams of the wiring system including normal working current, rated current, prospective short-circuit.

(h) current in the circuits, line drop of voltages, type of cables, cable sizes, rating and setting of circuit breakers, rating of fuses and switches, and breaking capacity of circuit breakers and fuses.

2. Data:

(a) Explanation of electric propulsion system.

(b) Investigation table of electrical power.

(c) List of particulars of high voltage electrical equipment.

(d) For tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk,

(e) Drawings indicating hazardous areas and the list of electrical equipment installed in the hazardous areas.

(f) Maintenance records of batteries (*See* **1.1.7**)

(g) For ships carrying dangerous cargos specified in **19.3.2, Part 6**, drawings indicating the loaded position of the dangerous cargos and the list of electrical equipment installed in there.

1.1.6 Ambient Conditions

1. The ambient conditions given in **Table 1.1** and **Table 1.2** are to be applied unless otherwise specified, to the design, selection and arrangement of electrical installations as to ensure proper operation.

2. The operation of all electrical equipment is to be sufficient under such conditions of vibration as to arise in normal practice.

1.1.7 Maintenance records of batteries

As for batteries fitted for use of the services necessary to provide normal operational conditions of propulsion and safety of the ship, maintenance records included necessary information required by the Society are to be kept on board.

Table 1.1 Ambient Temperature

	Location, arrangement	Temperature (°C)
Air	In enclosed spaces	0 to 45
	In spaces subject temperatures exceeding 45° and below 0°C	According to specific local conditions
	On the open deck	-25 to 45
Seawater	---	32

Table 1.2 Angle of Inclination

Installations Components	Athwartships[1]		Bow-and-stern[1]	
Installations Components	Static inclination (List)	Dynamic inclination (Rolling)	Static inclination (Trim)	Dynamic inclination (Pitching)
Electrical installation excluding items started below	15°	22.5°	5°	7.5°
Emergency electrical installations, switch gear (circuit breakers, etc.), electric and electronic appliances	22.5°[2]	22.5°[2]	10°	10°

Notes:

1 Athwartships and bow-and-stern inclinations may occur simultaneously.

2 In ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk, emergency power supply is to remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30°.

1.2 Testing

1.2.1 Shop Tests

1. Electrical equipment specified below is to be tested in accordance with the respective requirements in this part at the manufacturer s works or at other works having the adequate apparatus for testing and inspections. However, tests for equipment with small capacity specified in **(4)** and **(5)** may be as deemed appropriate by the Society.

(1) Rotating machines for propulsion and their control equipment

(2) Ship service generators (main, auxiliary and emergency)

(3) Main and emergency switchboards

(4) Motors for auxiliary machinery specified in 1.1.5-1(1) to 1.1.5-1(3), Part 7 (hereinafter referred to as the motors for essential services in this part).

(5) Control gears for the motors specified in **(4).**

(6) Transformers for power and lighting of single phase 1 *kVA* or more and three phase 5 *kVA* or more excluding those for special service such as one for a Suez Canal Search Light.

(7) Power semi-conductor rectifiers of not less than 5*kW* and their accessories used for supplying power to electrical equipment specified in **(1)** to **(5).**

(8) Other electrical equipment as deemed necessary by the Society.

2. For the electrical equipment used for the auxiliary machinery for specific use of ship specified in 1.1.5-1(4) and 1.1.5-1(5), Part 7, and those as deemed necessary by the Society, those are to be tested in accordance with the respective requirements in this part.

3. For the electrical equipment manufactured by mass production system, test procedures suited to their production methods, despite of the requirements in **-1**, may be applied subject to the approval of the Society.

4. Electrical equipment and cables shown in the following items **(1)** to **(5)** are to be subjected to type tests for each type of products.

(1) Fuses

(2) Circuit breakers

(3) Electromagnetic contactors

(4) Explosion-protected electrical equipment

(5) Cables for power, lighting and internal communications

5. Electrical equipment and cables having a certificate considered acceptable to the Society may be exempted partially or wholly from the tests and inspections.

1.2.2 Trials

After the electrical equipment and cables have been installed on board the ship, they are to be tested and inspected in accordance with the requirements in 2.18.

1.2.3 Additional Tests and Inspections

The Society may require, when it deems necessary, other tests and inspections than those specified in this part.

Chapter 2 ELECTRICAL INSTALLATIONS AND SYSTEM DESIGN

2.1 General

2.1.1 Scope

This chapter specifies the requirements for electrical equipment and cables and system design relating to electricity.

2.1.2 Voltage and Frequency

1. System voltage is not to exceed:

(1) 500 *V* for generators, power equipment, and heating and cooking equipment connected to fixed wiring

(2) 250 *V* for lighting, heaters in cabins and public rooms, equipment other than those specified in **(1)** above

(3) 15,000 *V a.c.* and 1,500 *V d.c.* for installations for electric propulsion

(4) 15,000 *V a.c.* for *a.c.* generators and *a.c.* power equipment meeting the requirements in 2.17

2. A frequency of 60 *Hz* is recognized as a standard for all alternating current systems.

3. Electrical equipment supplied from the main and emergency switchboards is to be designed and manufactured that it is capable of operating satisfactorily under the normally occurring voltage and frequency fluctuations. Unless otherwise specified, electrical equipment is to operate satisfactorily under the fluctuations in voltage and frequency as given in Table 2.1. Any special system *e.g.* electronic circuits, whose function cannot operate satisfactorily within the limits given in the table is to be supplied by suitable means, *e.g.* through stabilized supply.

Table 2.1 Voltage and Frequency Fluctuation

(a) Voltage and frequency fluctuations for a.c. distribution systems(Note 1)

Type of fluctuation	Fluctuation (Note 4)	
	Permanent	Transient
Voltage	+6%, -10%	± 20% (within 1.5 sec)
Frequency	±5%	± 10% (within 5 sec)

(b) Voltage fluctuations for d.c. distribution systems (Note 2)

Type of fluctuation	Fluctuation (Note 4)
Voltage Fluctuation (Permanent)	± 10%
Voltage cyclic fluctuation deviation	5%
Voltage ripple	10%

(c) Voltage fluctuations for battery systems

Systems	Fluctuation (Note 4)
Components connected to the battery during charging (Note 3)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%

Note 1: A.C. distribution systems mean a. c. generator circuits and a.c. power circuits produced by inverters.

Note 2: D.C. distribution systems mean d. c. generator circuits and d.c. power circuits produced by converters.

Note 3: Different voltage fluctuations as determined by the charging and discharging characteristics, including voltage ripple from the charging devices, may be considered.

Note 4: Numerical values excluding time in the table mean percentage for the rated values.

2.1.3 Construction, Materials, Installations, etc.

1. Electric machinery parts subject to mechanical strength are to be of defect-free sound material. Their proper fits and clearances are to be consistent with the best marine practice and experience.

2. All electrical equipment are to be so constructed and installed as not to cause injury when handled and touched in the normal manner.

3. Insulating materials and insulated windings are to be resistant to moisture, sea air and oil vapour.

4. Bolts, nuts, pins, screws, terminals, studs, springs and such other small parts are to be made of corrosion resistant material or to be suitably protected against corrosion.

5. All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

6. Electrical equipment is to be accessibly placed in well-ventilated and adequately lighted spaces where it is not exposed to risk of mechanical injury or damage arising from water, steam or oil. Where it is unavoidable to be exposed to such risks, the equipment is to be so constructed as to meet the conditions of the locations.

7. No electrical installation are to be installed in spaces where explosive gases are liable to accumulate or in compartments assigned principally to accumulator batteries, in paint lockers, in acetylene stores or in similar spaces unless the following requirements **(1)** to **(4)** are satisfied:

(1) Electrical equipment essential for operational purposes

(2) Electrical equipment of a type which will not ignite the mixtures concerned

(3) Electrical equipment appropriate to the spaces concerned

(4) Electrical equipment which is appropriately certified for safe usage in dusts, vapours or gases likely to be encountered

8. Electrical equipment and cables are to be placed at such a safe distance from the magnetic compasses or are to be so screened that the interfering external magnetic field is controlled to negligible extent even when circuits are switched on and off.

9. Cables and apparatus for services required to be operable under fire conditions are to be so arranged that the loss of services in any one area due to localized fire is minimized.

10. Motors are to be provided with a terminal box.

2.1.4 Earthing

1. Non-current-carrying exposed metal parts of electrical equipment which are not intended to be live but which are liable under fault conditions to become live are to be effectively earthed except the followings:

(1) They are supplied at a voltage not exceeding 50 *V d.c.* or 50 *V a.c.* root mean square between conductors.

However, auto-transformers are not to be used for the purpose of achieving this voltage.

(2) They are supplied at a voltage not exceeding 250 *V* by safety isolating transformers supplying only one consuming device.

(3) They are constructed in accordance with the principle of double isolation.

2. Additional safety means are to be provided for portable electrical apparatus for use in confined or exceptionally damp spaces where particular risks due to conductivity may exist.

3. Where earthing connections are necessary, the earthing conductors are to be of copper or other approved materials, and are to be properly protected against damage, and, where necessary, erosion. The size of the earthing conductors is to be deemed appropriate by the Society according to the cross sectional area of the current-carrying conductors and installation of the earthing lines.

2.1.5 Clearance and Creepage Distances

1. The clearance and creepage distances between live parts and between live part and earthed metal (hereinafter in this part referred to as the "clearance and creepage distances") are to be adequate for the working voltage having regard to the nature and service condition of the insulating material.

2. The clearance and creepage distances inside the terminal boxes of rotating machines, the switchboard busbars and the control appliances are to comply with the relevant requirements of this Part.

2.2 System Design – General

2.2.1 Distribution Systems

1. The following distribution systems are considered as a standard:

(1) Two-wire direct current

(2) Three-wire direct current (three-wire insulated system or three-wire mid-wire earthed system)

(3) Two-wire, single-phase alternating current

(4) Three-wire, three-phase alternating current

(5) Four-wire, three-phase alternating current

2. Notwithstanding the requirement in **-1**, a hull return distribution system may be used for the following systems.

(1) Impressed current cathodic protection systems for external hull protection

(2) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any dangerous spaces

(3) Insulation monitoring systems provided the circulation current does not exceed 30 *mA* under any circumstances

2.2.2 Insulation Monitoring System

When a distribution system, whether primary or secondary, for power, heating or lighting, with no connection to earth is used, a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication of abnormally low insulation values is to be provided.

2.2.3 Unbalance of Loads

1. For three-wire direct current systems, unbalance of the load between an outer conductor and the middle wire at the switchboards, section boards and distribution boards is not to exceed 15 % of the full load current as far as possible.

2. For three-wire or four-wire three-phase alternating current systems, unbalance of the load on each phase at the switchboards, section boards and distribution boards is not to exceed 15 % of the full load current as far as possible.

2.2.4 Diversity Factor

1. Circuits supplying two or more final-subcircuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity factor.

2. The diversity factor specified in **-1** may be applied to the calculation of the cross sectional area of conductors and ratings of switchgears (including circuit breakers and switches) and fuses.

2.2.5 Feeder Circuits

1. Motors for essential services requiring dual arrangement are to be supplied by individual circuits without the use of common feeders, protective devices and control gears.

2. Auxiliaries in the machinery spaces, cargo gears and ventilating fans are to be independently supplied from switchboards or distribution boards.

3. Ventilating fans for the cargo holds and those for the accommodation spaces are not to be supplied from the common feeder circuits.

4. Lighting circuits and motor circuits are to be arranged to be supplied independently from the switchboards.

5. A final sub-circuit of rating exceeding 15 *A* is not to supply more than one appliance.

2.2.6 Motor Circuits

A separate final sub-circuit is to be provided, as a rule, for every motor for essential service and for every motor of rating at 1 *kW* or more.

2.2.7 Lighting Circuits

1. Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power except cabin fans and electrical appliances for domestic use.

2. The number of lighting points supplied by a final sub-circuit of rating 15 *A* or less is not to exceed :

10 for the circuits up to 50 *V*

14 for the circuits from 51 *V* up to 130 *V*

24 for the circuits from 131 *V* up to 250 *V*

In cases where the number of lighting points and total load current are invariable, more than the number of points specified above may be connected to the final sub-circuit, provided that the aggregate load current does not exceed 80% of the rating of protective device in the circuit.

3. In a final sub-circuit of rating not exceeding 10 *A* for panel lighting and electric signs, where lampholders are closely grouped, the number of points supplied is unrestricted.

4. In spaces such as compartments where the main engine or boilers are provided, large machinery rooms, large galleys, corridors, stairways leading to boat-decks and public spaces, lighting is to be supplied from at least two circuits and to be so arranged that failure of any one circuit will not leave these spaces in darkness. One of the circuits may be emergency lighting circuit.

5. Emergency lighting circuits are to be in accordance with the requirements in 3.3.

2.2.8 Circuits for Internal Communication Systems and Navigational Aids

1. Essential internal communication and signal systems and navigational aids are to have completely self-sustaining independent circuits for ensuring the perfect maintenance of their functions as far as possible.

2. Cables for communication systems are to be so arranged that no induced interference would be caused.

3. No switch is to be provided for feeder circuits of general alarm devices, except for operating switch. Where circuit breaker is used, a suitable means is to be taken to prevent the breaker from being kept off position.

2.2.9 Circuits for Radio Installation

Feeder circuits for radio installations are to be arranged in accordance with the requirements of relevant international and national regulations.

2.2.10 Circuits for Electric Heating and Cooking Equipment

1. Each item of electric heating and cooking equipment is to be connected to a separate final sub-circuit except that up to 10 small electric heaters of aggregate current rating not exceeding 15 *A* may be connected to single final sub-circuit.

2. Electric heating and cooking equipment are to be controlled by the multipole linked switches mounted in the vicinity of the equipment. However, small electric heaters connected to a final sub-circuit of rating not exceeding 15*A* may be controlled by a single-pole switch.

2.2.11 Circuits for Shore Connections

1. Where arrangements are made for the supply of electricity from a source on shore, a connection box is to be installed in a suitable position. In case where shore connection cables can be drawn into a switchboard easily and put into service safely, the connection box may be omitted provided the protective devices and checking devices specified in **-2** are equipped on the switchboard.

2. The connection box is to contain terminals to facilitate a satisfactory connection and a circuit-breaker or an isolating switch with fuses. A means is to be provided for checking the phase sequence (for three-phase alternating current) or the polarity (for direct current).

3. In case where power is supplied from the three-wire neutral earthed system, an earth terminal is to be provided for connecting the hull to an appropriate earth in addition to those specified in **-2**.

4. At the connection box a notice is to be provided giving information on the system of supply and nominal voltage (and frequency if *a.c.*) of the system and the procedure for carrying out the connection.

5. Cables between the connection box and the switchboard are to be permanently fixed and a pilot lamp for source and a switch or a circuit-breaker are to be provided on the switchboard.

2.2.12 Disconnecting Switches of Circuits

1. Power circuits and lighting circuits terminating in the cargo holds or coal bunkers are to be provided with the multipole linked switches situated outside these spaces. Provision is to be made for locking in “off” position of the switches or switch boxes for these lighting circuits.

2. Feeder circuits for the electrical equipment installed in hazardous areas are to be provided with multipole linked isolation switches in a non-hazardous area. In addition, the isolation switches are to be clearly labelled to identify the electrical equipment to be connected with.

2.2.13 Remote Stopping of Ventilating Fans and Pumps

1. Remote stopping of ventilating fans and pumps are to comply with the requirements in **5.2.1-2** and **5.2.2-2** through **-4, Part 6**.

In case where fuses are used to protect a remote stopping circuit specified in **5.2.1-2** and **5.2.2-2** through **-4, Part 6** and are only closed when they operates, consideration is to be given against the fuse element failure

2.3 System Design – Protection

2.3.1 General

Electrical installations of ships are to be protected against accidental over currents including short-circuit. The protective devices are to be capable of continuously serving other circuits as far as possible by breaking a fault circuit and eliminating damage to the system and hazard of fire.

2.3.2 Protection against Overload

1. The overcurrent trip characteristics of circuit-breakers and the fusing characteristics of fuses are to be chosen suitably taking into consideration the thermal capacity of electrical equipment and cables to be protected thereby.

Fuses above 200 *A* are not to be used for overload protection.

2. The ratings or appropriate setting of the overload protection device for each circuit are to be permanently indicated at the location of the protection device, and the current-carrying capacity of each circuit is to be indicated.

3. The overload relays of circuit-breakers for generators and overload protections, except moulded-case circuit breakers, are to be capable of adjusting their current setting and time-delay characteristics.

2.3.3 Protection against Short-circuit

1. The breaking capacity of every protective device is to be not less than the maximum value of the short circuit current which can flow at the point of installation at the instant of constant separation.

2. The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is not to be less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

3. In case where the rated breaking capacity and/or rated making capacity of short-circuit protection are (is) not in compliance with the requirements in **-1** and **-2**, fuses or circuit-breakers having the breaking capacity not less than the prospective short-circuit current are to be provided at the power source side of the foregoing short-circuit protection.

Circuit-breakers for the generator are not to be used for this purpose. The circuit-breakers connected to the load side are not to be excessively damaged and are to be capable of further service in the following cases:

(1) When the short-circuit current is broken by the back-up circuit-breaker or fuse.

(2) When the circuit-breaker connected to the load side is closed on the short-circuit current while the back-up circuit-breaker or fuse breaks the current.

4. In the absence of precise data of rotating machines, the following short-circuit currents at the machine terminals are to be assumed. Where the motors are as load, short-circuit current is to be the sum of short-circuit currents of generators and that of motors:

(1) *D.C.* systems

Ten times the rated current for generators normally connected (including spare).

Six times the rated current for motors simultaneously in service.

(2) *A.C.* systems

Ten times the rated current for generators normally connected (including spare).

Three times the rated current for motors simultaneously in service.

2.3.4 Protection of Circuits

1. Each pole and phase of all insulated circuits except neutral and equalizer circuits are to be provided with short-circuit protection.

2. All circuits liable to be overloaded are to be provided with overload protection as indicated below:

(1) Two-wire *d.c.* or single-phase *a.c.* system: at least one line or phase

(2) Three-wire *d.c.* system: both outer lines

(3) Three-phase, three-wire system: at least two phases

(4) Three-phase, four-wire system: each phase

3. A fuse, a non-linked switch or a non-linked circuit-breaker is not to be inserted in an earthed conductor and a neutral line.

2.3.5 Protection of Generators

1. Generators are to be protected against short-circuit and overcurrent by a multipole circuit-breaker arranged to open simultaneously all insulated poles, or in the case of generators less than 50 *kW* not arranged to run in parallel, may be protected by a multipole-linked switch with fuse or a circuit-breaker in each insulated pole. The overload protection is to be suitable to the thermal capacity of generators.

2. For *d.c.* generators arranged to operate in parallel, in addition to the requirement in **-1**, an instantaneous reverse-current protection, operating at a fixed value of reverse-current within the limits of 2% to 15% of the rated current of the generator, is to be provided. This requirement, however, does not apply to the reverse-current generated from load side, *e.g.* cargo winch motors, etc.

3. For *a.c.* generators arranged to operate in parallel, in addition to the requirement in **-1**, a reverse-power protection, with time delay, selected and set within the limits of 2 % to 15 % of the full load to a value fixed in accordance with the characteristics of the prime mover, is to be provided.

2.3.6 Load Shedding

1. To protect the main generators against overload, means are to be provided to disconnect unessential loads automatically. In this case, the means may be consisted of two or more stage tripping.

2. In addition to the preference tripping in **-1**, further preference tripping may be arranged subject to the conditions specified otherwise by the society.

2.3.7 Protection of Feeder Circuits

1. Supply circuits to section boards, distribution boards, grouped starters and the similar are to be protected against overload and short-circuit by multi-pole circuit-breakers or fuses. In case where the fuses are used, a switch complying with the requirements in **2.14.3** is to be provided at the power source side of the fuses.

2. Each insulated pole of the final sub-circuits is to be protected against short-circuit and overload by a circuit-breaker or fuse. In case where fuses are used, a switch complying with the requirements in **2.14.3** is, as a rule, to be provided at the power source side of the fuses. And for the protection of supply circuits of the steering gears, the requirements in **15.2.7, Part 7** are to apply.

3. Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

4. In case where fuses are used to protect three-phase *a.c.* motor circuits, consideration is to be given to protection against single phasing.

5. In case where condensers for phase advance are used, overvoltage protective devices are to be installed as required.

2.3.8 Protection of Power and Lighting Transformers

1. The primary circuits of power and lighting transformers are to be protected against short-circuit and overcurrent by multipole circuit-breakers or fuses.

2. When transformers are arranged to operate in parallel, a means of isolation is to be provided on the secondary circuits.

2.3.9 Protection of Electric Motor

1. Motors of rating exceeding 0.5 *kW* and all motors for essential services, except the motors for steering gears, are to be protected individually against overload. The overload protection for motors for the steering gears is to comply with the requirements in **15.2.7, Part 7**.

2. The protective devices are to have delay characteristics to enable the motor to start.

3. For motors for intermittent services, the current setting and the delay are to be chosen in relation to the load factor of the motor.

2.3.10 Protection of Lighting

Lighting circuits are to be protected against short-circuit and overload.

2.3.11 Protection of Meters, Pilot Lamps and Control Circuits

1. Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps together with their connecting leads by means of fuses fitted to each insulating pole. A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided that any damage of pilot lamp circuit does not cause failures on the supply to essential equipment.

2. Insulated wires for control and instrument circuits directly led from busbars and generator mains are to be protected by fuses at the nearest location to the connecting points. Insulated wires between the fuses and the connecting points are not to be bunched together with the wires for other circuits.

3. Fuses in circuits such as those of automatic voltage regulators where loss of voltage might have serious consequences may be omitted. If omitted, a proper means is to be provided to prevent risk of fire in the unprotected part of the installation.

2.3.12 Protection of Batteries

Accumulator batteries other than engine starting batteries are to be protected against overload and short-circuit with devices placed as near as practicable to the batteries. Emergency batteries supplying essential services may have short-circuit protection only.

2.4 Rotating Machines

2.4.1 Prime Movers for Generators

Prime movers for generators are to be constructed in accordance with the requirements in **Part 7** and, in addition, their governors are to be in accordance with the requirements in **2.4.2**.

2.4.2 Characteristics of Governors

1. Characteristics of governors on prime movers for the main generator are to be capable of maintaining the speed within the following limits.

(1) Momentary variations are to be 10% or less of the maximum rated speed when the rated load of the generator is suddenly thrown off. When difficulty arises to meet the above requirements, characteristics of the governors are to be deemed appropriate by the Society.

(2) Momentary variations are to be 10% or less of the maximum rated speed when 50% of the rated load of the generator is suddenly thrown on followed by the remaining 50% load suddenly thrown on after an interval to restore the steady state. The speed is to return to within 1% of the final steady speed in not more than 5 *seconds*

When difficulty arises to meet the above requirements or when an installation requires different characteristics, characteristics of the governors are to be as deemed appropriate by the Society.

(3) At all loads in a range between no load and the rated load the permanent speed variation is within ±5% of the maximum rated speed.

2. Characteristics of governors on prime movers driving emergency generators are to be capable of maintaining the speed with the following limits:

(1) Momentary variation is to be of the values specified in **-1(1)** when total emergency consumer load is suddenly thrown off.

(2) Momentary variation is to be of the values specified in **-1(2)**, and the speed is to return to within 1% of the final steady speed in not more than 5 *seconds*, when total emergency consumer load is suddenly thrown on. When difficulty arises to meet the above requirements, characteristics of the governors are to be as deemed appropriate by the Society.

(3) At all loads in a range between no load and the total emergency consumer load, the permanent speed variation is to be of the value specified in **-1(3)**.

3. For *a.c.* generating sets operating in parallel, the governor characteristics of the prime movers are to be such that load sharing specified in **2.4.14-4** and **-5** is ensured, and facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

4. Where a turbine-driven *d.c.* generator is arranged to run in parallel with other generators, a switch is to be fitted on each turbine emergency governor to open the generator circuit breakers when the emergency governor comes into function.

2.4.3 Limits of Temperature Rise

The temperature rise of rotating machines is not to exceed the values given in **Table 2.2**, when operated continuously at the rated load or operated intermittently according to their duties. The temperature rise of static exciters for *a.c.* generators is to comply with the requirements in **2.5.10-2**.

2.4.4 Modification of Limits of Temperature Rise

1. Where the ambient temperature exceeds 45°C, limits of temperature rise are to be decreased by the difference from the values given in **Table 2.2**.

2. Where the temperature of primary coolant does not exceed 45°C, the limits of temperature rise may be increased when deemed appropriate by the Society.

3. Where the ambient temperature does not exceed 45°C, the limits of temperature may be increased by the difference from the value given by **Table 2.2**. In this case, the ambient temperature is not to be set below 40°C.

Table 2.2 Limits of Temperature Rise for Rotating Machines (Based on ambient temperature 45°C)

Item	Part of rotating machine	Thermal class A			Thermal class E			Thermal class B			Thermal class F			Thermal class H		
		T	R	E.T.D	T	R	E.T.D	T	R	E.T.D	T	R	E.T.D	T	R	E.T.D
1a	*A.C.* windings of machines having outputs of 5,000 *kW* (or *KVA*) or more	-	55	60	-	-	-	-	75	80	-	95	100	-	120	125
1b	*A.C* windings of machines having outputs above 200*kW* (or *kVA*) but less than 5,000 *kW* (or *KVa*)	-	55	60	-	70	-	-	75	85	-	100	105	-	120	125
1c	*A.C* windings of machines having outputs above 200*kW* (or *kVA*) or less, other than those in items 1d or 1e*1	-	55	-	-	70	-	-	75	-	-	100	-	-	120	-
1d	*A.C* windings of machines having rated outputs of less than 600*W* (or *VA*)*1	-	60	-	-	70	-	-	80	-	-	105	-	-	125	-
1e	*A.C* windings of machines are self-cooled without fan and/or with encapsulated windings*1	-	60	-	-	70	-	-	80	-	-	105	-	-	125	-
2	Windings of armatures having commutators	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
3	Field winding of a.c and d.c machines having d.c. excitation other than those in item 4	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
4a	Field windings of synchronous machines with cylindrical rotors having d.c excitation winding embedded in slots except synchronous induction motors	-	-	-	-	-	-	-	85	-	-	105	-	-	130	-
4b	Stationary field windings, of d.c machines, having more than one layer	45	55	-	60	70	-	65	75	85	80	100	105	100	120	130
4c	Low resistance fild winding of a.c. and d.c. machines and compensating windings of d.c. machines having more than one layer	55	55	-	70	70	-	75	75	-	95	95	-	120	120	-
4d	Single-layer windings of a.c. and d.c. machines with exposed bare or varnished metal surfaces and single-layer compensating windings of d.c. machines *2	60	60	-	75	75	-	85	85	-	105	105	-	130	130	-
5	Permanently short-circuited windings	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts.														
6	Commutators and slip-rings and their brushes and brush gear	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts. In addition, temperatures are not exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over														
7	Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts.														

Notes:

1 With application of the super position method to windings of machines rated 200 *kW* (or *kVA*) or less with insulation classes A, E, B and F, marked with *1, the limits of temperature rise given for the resistance method may be exceeded by 5*K*

2 Also includes multiple layer windings marked with *2 provided that the under layers are each in contact with the circulating primary coolant.

3 T = Thermometer method, R = Resistance method, E.T.D. = Embedded temperature detector

2.4.5 Overload Capability

Rotating machines are to withstand the following excess current or torque test by maintaining the voltage, rotating speed and frequency as near to their rated values as possible. For the special types of deck machinery motors (winch, windlass, capstan, etc.), those overload scaling may be dealt with as considered appropriate by the Society.

(1) Excess current capability

(a) *A.C.* generators

150% of rated current 2 *minutes*

(b) *D.C.* generators

150% of rated current

Rated output (*kW*) / Rated rotating speed $(rpm) \leq 1 for\ 45\ seconds$

Rated output (*kW*) / Rated rotating speed $(rpm) > 1 for\ 30\ seconds$

(2) Excess torque capability

(a) Polyphase induction motors and *d.c.* motor

160% of rated torque 15 *seconds*

(b) Polyphase synchronous motors

i) Synchronous (wound rotor) induction motors

135% of rated torque 15 *seconds*

ii) Synchronous (cylindrical rotor) induction motors

135% of rated torque 15 *seconds*

iii) Synchronous (salient pole) induction motors

150% of rated torque 15 *seconds*

2.4.6 Short-circuit Scaling

1. Ship's service generators are to be capable of withstanding the mechanical and thermal effects of fault current for the duration of any time delay which may be fitted in a tripping device for selective tripping.

2. Generators and their excitation system are to be capable of maintaining the current of at least three times of their rated full load current for a duration of at least 2 *seconds* or for the duration of any time delay which may be fitted in a tripping device for selective tripping.

2.4.7 Overspeed Capability

Rotating machines are to withstand the overspeed conditions for 2 *minutes* in accordance with the followings:

(1) *A.C.* machines

(a) *A.C.* machines other than series and universal motors

120% of the maximum rated speed

(b) Series and universal motors

110% of the no-load speed at rated frequency

(2) *D.C.* machines

(a) Shunt-wound and separately excited motors

120% of the highest rated speed or 115% of the corresponding no-load speed, whichever is greater

(b) Compound-wound motors having speed regulation of 35% or less

120% of the highest rated speed or 115% of the corresponding no-load speed, whichever is greater but not exceeding 150% of the highest rated speed

(c) Compound-wound motors, having speed regulation greater than 35% and series-wound motors

110% of the maximum safe speed assigned by the manufacturer

(d) Permanent-magnet excited motors

In the case of series winding, **(b)** or **(c)** is to be satisfied. In the other cases, **(a)** is to be satisfied.

(e) Generators

120% of the rated speed

2.4.8 Shaft Currents

Means are to be taken, if necessary, to prevent the ill effects of flow of currents circulating between the shaft and the bearings.

2.4.9 Precaution to the Effect of Condensation of Moisture

Where there is a fear of deterioration of insulations due to condensation of moisture within rotating machines, suitable means are to be provided to avoid it.

2.4.10 Air Coolers

Where air coolers are provided for rotating machines, they are to be so arranged as to be kept from entry of water into the machines due to leakage or condensation in the air coolers.

2.4.11 Shaft of Rotating Machine

1. The shaft materials for electric propulsion motors of 100 *kw* and over and for main engine driven generators where the shaft is part of the propulsion shafting, are to be in compliance with the requirements in **Part 10**.

2. The shaft materials for rotating machines used for essential services but other than those specified in **-1**, are to be in accordance with a standard deemed appropriate by the Society.

3. When welding is applied to the shaft and other torque members of rotating machines, the plan is subject to the approval of the Society.

4. The shafts of generator are to comply with the following requirements.

(1) The diameter of the generator shaft in the length from the section where rotor is fixed to the shaft end of prime mover is not to be less than value obtained from the formula specified in **6.2.2, Part 7**.

H, N_0 and F_1 in the formula, however, mean as follows:

H: Output of rotating machines at maximum continuous rating (kW)

N_0: Number of revolutions of rotating machine shaft at maximum continuous rating (rpm)

F_1: Factor given in **Table 2.3**

In case where bearings are arranged on both sides of a generator, the diameter of the shafts around the coupling on the prime mover may be reduced gradually to 0.93 times the diameter obtained from the foregoing formula.

(2) The diameter of the shaft is to be such that due consideration is given to the amount of bending of the shaft so as to keep designed air gap between stator and rotor at all speeds in the actual range.

(3) In case of generators driven by diesel engines, the torsional vibration of the shafting is to comply with the relevant requirements in **Chapter 8, Part 7**.

Table 2.3 Values of F_1

Bearing arrangement of a rotating machine	In case of generator driven by steam or gas turbine, generator driven by diesel engine through slip type coupling (Note)	In case of generator driven diesel engine other that those mentioned in the left-hand column
Where bearings are arranged at both sides of rotating machines	110	115
In case where bearings are arranged at prime movers or load sides of rotating machines	120	125

Note: Slip type coupling signifies hydraulic coupling, electro-magnetic coupling or the equivalent.

2.4.12 Clearance and Creepage Distances inside Terminal Boxes

1. The clearance and creepage distances inside the terminal box of rotating machines are not to be less than the values given in **Table 2.4**.

2. The requirements specified in **-1** are not applied when an insulating barrier is used and also not applied to small motors such as controlling motors, synchros, etc.

Table 2.4 Minimum Clearance and Creepage Distances inside the Terminal Box of Rotating Machine

Rated voltage (*V*)	Clearance (*mm*)	Creepage (*mm*)
61~250	5	8
251~380	6	10
381~500	8	12

2.4.13 *D.C.* Generators

1. *D.C.* generators other than those specified in **-2** are to be either:

(1) Compound-wound generators; or

(2) Shunt-wound generators with automatic voltage regulators.

2. *D.C.* generators used for charging batteries without series regulating resistor are to be either:

(1) Shunt-wound generators; or

(2) Compound-wound generators with switches arranged so that the series winding may be rendered inoperative.

3. Field regulator for *d.c.* generator is to be capable of adjusting the voltage of the generator to within 0.5% of the rated voltage for machines above 100 *kW* and 1% of the rated voltage for smaller machines respectively at all loads between no load and full load at any temperature within the working range.

4. The overall voltage regulation of *d.c.* generator is to be in accordance with the following requirements. The rotating speed is to be adjusted to the rated speed at full load:

(1) Shunt-wound generators

After the temperature test, when the voltage sets at full load, the steady voltage at no load is not to exceed 115 % of the full load value, and the voltage obtained at any value of load is not to exceed the no load value.

(2) Compound-wound generators

After the temperature test, when the voltage at 20% load adjusted within ±1% of the rated voltage, the voltage at full load is to be within ±1.5% of the rated voltage, then the average of the ascending and descending load/voltage curves between 20% load and full load is not to vary by more than 3% from the rated voltage.

Note: For compound-wound generators operated in parallel, the drop in voltage may be acceptable up to 4% of the rated voltage when the load is gradually increased from 20% load to full load.

(3) Three-wire generators

In addition to compliance with the requirements in **(1)** and **(2)**, when operating at the rated current on the heavier loaded sides, *i.e.* either positive or negative leads, with the rated voltage between the positive and negative leads and a current of 25 % of the generator current rating in the neutral wire, the resulting difference in voltage between the positive and neutral leads or the negative and neutral leads is not to exceed 2 % of the rated voltage between the positive and negative leads.

5. When *d.c.* generators are operated in parallel, the load on any generator is not to differ more than 10 % of its rated output of the largest machine from its proportionate share, based on the generator ratings, of the combined load, for any steady-state condition in the combined load between 20 % and 100 % of the sum of the rated outputs of all the machines. The starting point for the determination of the foregoing load distribution requirement is to be at 75 % load with each generator carrying its proportionate share.

6. The series field winding of each two-wire compound-wound generator is to be connected to the negative terminal.

7. Equalizer connections of *d.c.* generator are to have a cross sectional area not less than 50 % of that of the negative connection from the generator to the switchboard.

2.4.14 *A.C.* Generators

1. Each *a.c.* generator, except that of the self-excited compound-wound type, is to be provided with an automatic voltage regulator.

2. The overall voltage regulation of *a.c.* generators is to be such that at all loads from zero to full load at the rated power factor, the rated voltage is to be maintained under steady conditions within ± 2.5 %, except that for emergency generators the limits may be within ± 3.5 %.

3. When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor (see 2.4.15-3), the voltage is not to fall below 85 % nor exceed 120 % of the rated voltage. The voltage of the generator is then to be restored to within ± 3 % of the rated voltage in not more than 1.5 *seconds*. For emergency generator, its value may be increased to ± 4 % in not more than 5 *seconds*.

4. When *a.c.* generators are operated in parallel, each generator is to be stable in running within the limits of 20 % and 100 % total load, the *kW* load on any generator is not to differ from its proportionate share of the total load by more than 15 % of the rated output (*kW*) of the largest machine or 25 % of the rating of the individual machine.

5. When *a.c.* generators are operated in parallel, the reactive loads of the individual generator are not to differ from their proportionate share of the total reactive load by more than 10 % of the rated reactive output of the largest machine, or 25 % of the smallest machine where this value is less than the former.

2.4.15 Shop Tests

1. Rotating machines are to be tested in accordance with the requirements in this 2.4.15. However, the tests required by **-6**, **-7** and **-8** may be omitted subject to the Society s permission for each generator or motor which is produced in series having identical type with their unit. In addition, the tests required by **-5** may be omitted for each generator or motor which is of small capacity and produced in series having identical type with their unit.

2. No-load tests of the rotating machines are to be carried out. During the tests, the vibration of the machine and operation of the bearing lubrication system are to be within the order.

3. For generators, the voltage regulation tests are to be carried out and to comply with the requirements in 2.4.13-4, or 2.4.14-2 and -3. In the absence of precise information concerning the maximum values of the sudden loads when applying to the requirement of 2.4.14-3, 60 % of the rated current with a power factor of between 0.4 lagging and zero is to be suddenly switched on with the generator running at no load, and then switched off after steady-state conditions.

4. Rotating machines with commutators are to work with fixed brushes setting from no load to 50 % overload without harmful sparking.

5. Overcurrent or excess torque tests for rotating machines are to be carried out in accordance with 2.4.5 and the machines are to have capability to the tests.

6. Steady short-circuit tests for synchronous generators are to be carried out and to comply with the requirement in 2.4.6-2.

7. Overspeed tests for rotating machines are to be carried out and comply with the requirement in 2.4.7.

8. After the temperature reaches final steady one due to continuous running of the rotating machine by actual loading method at the rated output voltage, frequency and the duty for which the machine is rated, the temperature rises are to be measured and the values are not to exceed ones given in 2.4.3. Where considered acceptable by the Society, the test may be carried out in accordance with the procedure specified separately.

9. The high voltage specified in Table 2.5 is to be applied for one minute between the live parts and the frame of the rotating machines, with core and windings not under test connected to the frame. In the case of machines with rated voltage above 1 *kV* having both ends of each phase individually accessible, the test voltage is to be applied between each phase and the frame. Where the temperature rise test specified in **-8** is applied, the high voltage test is to be carried out after the test.

10. Immediately after the high voltage test specified in **-9**, the insulation resistance of the rotating machine is to be measured in accordance with Table 2.6 and the values are not to be less than values specified in Table 2.6.

During the measuring, the temperature of the rotating machines is to be near the operating temperature, or an appropriate method of calculation may be used.

11. The resistance of the machine winding is to be measured.

12. Upon completion of the above tests, machines which have sleeve bearings are to be opened and examined where deemed necessary by the Society.

Table 2.5 Testing Voltage

Item	Machine or part	Testing voltage (*rms*) (*V*)
1	Insulated windings of rotating machines of size less than 1 *kW* (or *KVA*), and of rated voltage less than 100 *V* with exception of those in items 3 to 6	2 *E*+500
2	Insulated windings of rotating machines with exception of those in item 1 and items 3 to 6	2 *E*+ 1,000 (Minimum 1,500)
3	Separately-excited field windings of *d.c*. machines	2 E_f+ 1,000 (Minimum 1,500)
4	Field windings of synchronous generators, synchronous motors and synchronous condensers a) $E_x \leq 500V$ $500V < E_x$ b) In cases where such machines are intended to be started with the field winding short-circuited or connected across a resistance of value less than ten time the resistance of the winding c) In cases where such machines are intended to be started with the field winding on open circuit or connected across a resistance of value equal to, or more than, ten times the resistance of the winding	$10E_x$ $(Minimum\ 1{,}500)$ $2E_x + 4{,}000$ $10E_x$ $(Minimum\ 1{,}500, Maximum\ 3{,}500)$ $2E_y + 1{,}000$ $(Minimum\ 1{,}500)$
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheostatic staring) a) In the case of non-reversing motors or motors reversible from standstill only. b) In the case of motors to be reversed or braked by reversing the primary supply while the motor is running	$2E_s + 1{,}000$ $4E_s + 1{,}000$
6	Exciters with the exception of: Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from field windings during starting; and separately excited field windings of exciters	$2E_i + 1{,}000$ $(Minimum\ 1{,}500)$

Note:

1 *E* : Rated voltage

E_f: Maximum rated voltage in field circuit

E_x: Rated field voltage

E_y: Induced terminal voltage between the terminals of field windings and starting rotor windings when applied the starting voltage to armature winding while the rotor is standstill and terminal voltage in such condition that the field windings or staring windings are started by connecting with the resistance.

E_s: Induced voltage between the terminals of secondary windings when the machine is at a standstill

E_i: Rated exciter voltage

2 For two-phase windings having one terminal in common, the voltage in the formula is to be the highest r.m.s. voltage arising between any two terminals during operation.

3 High voltage tests on machines having graded insulation may be as deemed appropriate by the Society.

4 For the semi-conductor rectifier of exciters, the requirements for semi-conductor rectifiers for power in 2.12 are to be applied.

Table 2.6 Minimum Values of Test Voltage and Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance ($M\Omega$)
$Un \leq 250$	2x*Un*	1
$250 < Un \leq 1{,}000$	500	1
$1{,}000 < Un \leq 7{,}200$	1,000	*Un*/1,000+1
$7{,}200 < Un$	5,000	*Un*/1,000+1

2.5 Switchboards, Section Boards and Distribution Boards

2.5.1 Location

Switchboards are to be installed in dry places away from the vicinity of steam, water and oil pipes as possible.

2.5.2 Safety Precautions to Operators

1. Switchboards are to be so arranged as to give easy access to each component without danger to personnel.

2. The sides and the rear and, where necessary, the front of switchboards are to be suitably guarded.

3. For voltage between poles, or to earth, exceeding 50 *V d.c.* or 50 *V a.c.* root mean square switchboards are to be of dead front type.

4. Insulated handrails are to be provided on the front and the rear faces of switchboards, and where necessary, insulated mats or gratings are to be provided on the floor of passageway.

5. Sufficient space for operation is to be provided in front of switchboards. Where necessary, space at the rear of switchboards is provided to permit operation and maintenance of disconnecting switches, switches, fuses and other parts, the passageway is to be more than 0.5 *m* in width.

6. Section boards and distribution boards are to have suitable protective enclosures depending on their location. If they are installed in such a location that they are readily accessible for persons other than those responsible operators, proper protection is to be arranged so that safety can be ensured in normal operation.

2.5.3 Construction and Materials

1. Busbars, circuit-breakers and other electrical appliances of main switchboards are to be so arranged that essential electrical equipment required to be installed in duplicate will not become unserviceable simultaneously by a single fault.

2. Where the main source of electrical power is necessary for propulsion of the ship, the main switchboard is to comply with the following requirements or to be of the performance equivalent thereto.

(1) A generator switchboard is to be provided for each generator, and the switchboards adjoining each other are to be partitioned by the walls of steel or flame-retardant material.

(2) The main busbars are to be subdivided into at least two parts which are to be normally connected by circuit breakers or other approved means. So far as is practicable, the connection of generating sets and other duplicated equipment are to be equally divided between the parts.

3. Cable entries of switchboards are to be so constructed that no ingress of water into the switchboard is permitted along the cables.

4. In case where the supply circuits having different voltages are installed in the same space of a switchboard, a section board or a distribution board, all appliances are to be so arranged that the cables of different rated voltages can be laid without coming to contact with each other within the board. The section boards and distribution boards for emergency distribution circuits are in principle to be provided independently.

5. The enclosures are to be of robust construction and their materials used are to be incombustible and non-hygroscopic.

6. Insulating materials are to be durable, flame-retardant and non-hygroscopic.

7. Wiring materials are to conform to the following requirements.

(1) Insulated wires for switchboards are to be those of flame-retardant and non-hygroscopic having a maximum permissible conductor temperature not less than 75°C.

(2) Ducts and straps for wiring are to be of flame-retardant materials.

(3) Insulated wires for control and instrument circuits are not to be bunched together with wires for main circuits and not to be in the same duct. However, if the rated voltages and maximum permissible temperatures of conductors are the same each other and no injurious effects are imposed by the main circuits, this requirement may not be applied.

8. Except where an isolation switch is provided, circuit breakers are to be such that repairing and replacing can be made without disconnecting them from the busbar connections and switching off the power source.

2.5.4 Busbars

1. Busbars are to be of copper of copper-surrounded aluminum alloy.

2. Busbar connections are to be so made as to inhibit corrosion and oxidization.

3. Busbars and busbar connections are to be so supported as to withstand the electromagnetic force resulted from short-circuiting.

4. Temperature rises of busbars, connecting conductors and their connections are not to exceed 45K at an ambient temperature of 45°C when carrying full load current.

5. Clearance distances between live parts of different polarity or between live parts and earthed metals are not to be less than the values given in **Table 2.7**.

Table 2.7 Minimum Clearance Distances for Busbars

Rated voltage between poles or phases (V)	Minimum clearance (mm)	
	Between phases or poles of live Parts	Between live parts and earthed metals
125 or less	13	13
over 125 to 250 inclusive	16	13
over 250 to 500 inclusive	23	23

2.5.5 Equalizer

1. The current rating of equalizer connections and equalizer switches is not to be less than a half of the rated full-load current of the generator.

2. The current rating of equalizer busbars is not to be less than a half of the rated full load current of the largest generator in the group.

2.5.6 Measuring Instruments for *d.c* Generators

Ship's service *d.c.* generator panels are at least to be provided with the instruments as given in **Table 2.8**.

Table 2.8 Instruments for d.c. Generator Panels

Operation	Instrument	Number required	
		2-wire system	3-wire system
Not parallel	Ammeter	1 for each generator (positive pole)	*2 for each generator (positive and negative poles)
	Voltmeter	1 for each generator	1 for each generator (voltage measurement between positive and negative poles or between positive or negative pole and neutral pole)
Parallel	Ammeter	1 for each generator (positive pole)	*2 for each generator (in case of compound winding, between equalizer and armature, and in case of shunt winding, for positive and negative poles)
	Voltmeter	2 busbars and each generator	2 (voltage measurement between busbar and positive and negative poles of each generator, or between positive pole and neutral pole)

Notes:

1 When employed neutral line earthed system, a zero centre ammeter for the earth line is to be added to the number marked with a * in the above table.

2 One of the voltmeters is to be capable of measuring shore supply voltage.

3 Where a control panel is provided for automatic control of generators, the instruments in the above table may be installed on the control panel, except that, if the control panel is installed outside engine room, the minimum number of instruments required to carry out single or parallel operation of generators is to be mounted on the switchboard.

2.5.7 Measuring Instruments for *a.c.* Generators

Ship's service *a.c.* generator panels are at least to be provided with the instruments as given in **Table 2.9**.

Table 2.9 Instruments for *a.c.* Generator Panels

Operations	Instruments	Number required
Not parallel	Ammeter	1 for each generator (current measurement of each phase)
	Voltmeter	1 for each generator (measurement of each line voltage)
	Wattmeter	1 for each generator (it may be omitted for 50*kVA* or less)
	Frequency meter	1 (frequency measurement of each generator)
	*Ammeter	1 for the exciting circuit of each generator
Parallel	Ammeter	1 for each generator (current measurement of each phase)
	Voltmeter	2 (measurement of busbar voltage and each line voltage of generators)
	Wattmeter	1 for each generator
	Frequency meter	2 (frequency measurement of each generator and busbar)
	Synchroscope and synchronizing lamps	1 set each In case where automatic synchroscopes are provided, either one of these may be omitted
	*Ammeter	1 for the exciting of each generator

Notes:

1 In the above table, the ammeter marked with a * is to be provided where necessary only.

2 One of the voltmeters is to be capable of measuring shore supply voltage.

3 Where a control panel is provided for automatic control of generators, the instruments given in the above table may be installed on the control panel, except that, if the control panel is installed outside engine room, the minimum number of instruments required to carry out single or parallel operation of generators is to be mounted on switchboard.

2.5.8 Instrument Scales

1. The upper limit of the scale of every voltmeter is to be approximately 120 % of the normal voltage of the circuit.

2. The upper limit of the scale of every ammeter is to be approximately 130 % of the normal rating of the circuit.

3. Ammeters for use with *d.c.* generators and wattmeters for use with *a.c.* generators which may operate in parallel are to be capable of indicating reverse current or reverse power up to 15 % respectively.

2.5.9 Transformers for Instruments

The secondary windings of transformers for instruments are to be earthed.

2.5.10 Shop Tests

1. Switchboards are to be tested and inspected in accordance with the requirements in this **2.5.10**. However, the test required by **-2** may be omitted subject to the Society s permission for each switchboard which is produced in series having the identical type with its first unit.

2. The temperature rises of switchboards are not to exceed the values given in **Table 2.10** under the specified current and/or rated voltage, except those provided in the relevant chapters of this part.

3. Functions of instruments, circuit breakers, switchgears, etc. on switchboards are to be confirmed normal.

4. Switchboards with all components are to withstand the high voltage by applying the following voltage at commercial frequency for 1 *minute* between all current-carrying parts connected together and earth and between current-carrying parts of opposite polarity or phase. Instruments and auxiliary apparatus may be disconnected during the high voltage test:

Rated voltage of 60*V* or below: 500 *V*

Rated voltage exceeding 60 *V*: 1,000 *V* + twice the rated voltage (minimum 1,500 *V*)

5. Immediately after high voltage test, the insulation resistance between all current-carrying parts connected and earth and between current-carrying parts of opposite polarity or phase are not to be less than 1*M* W when tested with *d.c.* voltage of at least 500 *V*.

Table 2.10 Limits of Temperature Rise of Electrical Appliances for Switch Boards (Based on ambient temperature 45°C)

Item and part			Limits of temperature rise (*K*)
Coils	Thermal class *A*		45
	Thermal class *E*		60
	Thermal class *B*		75
	Thermal class *F*		95
	Thermal class *H*		120
Contact pieces	Mass form	Cooper or copper alloy	40
		Silver or silver alloy	70
	Multilayer forms or Knife forms	Cooper or copper alloy	25
Terminals for external cables			45
Metallic resistors	Moulded-case type		245
	Those other than moulded-case type	For continuous service	295
		For intermittent service	345
	Exhaust (approx.. 25*mm* above the exhaust ports)		170

2.6 Circuit-breakers, Fuses and Electromagnetic Contactors

2.6.1 Circuit-breakers

1. Circuit-breakers are to comply with *IEC Publication* 60947-1 and 60947-2, or equivalent thereto, amended when necessary for ambient temperature, and also to comply with the requirements in **-2** and **-3**.

2. The construction of circuit-breakers is to comply with the followings:

(1) All circuit-breakers are to be of trip-free type and depending upon the field of their application, the trip attachments are to have a time-delay or an instantaneous overcurrent trip feature or both of them.

(2) The main contacts of the circuit-breakers are to be such as to have no undue burning or pitting. Arcing contacts except those of the moulded case circuit-breakers are to be readily renewable.

(3) Instantaneous trip devices other than those of electronic type having suitable testing arrangements are to be of a construction capable of tripping the associated breaker directly by short-circuit current.

(4) Circuit-breakers are to be such that no accidental opening and closing occur due to the vibration of a ship, and furthermore, no malfunction is caused by the list of an angle of 30°in any direction.

(5) The fused circuit-breakers of moulded-case type are to be so constructed that single phasing does not occur in the event of blowing of fuses and that the fuses can be readily replaced without the risk of accidental touch for the operating personnel to their live-parts.

(6) On each circuit-breaker the rated (operational) voltage and rated (thermal) current, and in addition rated breaking capacity, rated making current and rated short-time current are to be clearly indicated according to its kind. Each time-delay overcurrent trip device is to be indicated of its operating characteristics, except the moulded-case circuit-breakers.

3. Performance of circuit-breakers is to comply with the followings:

(1) The temperature rise in the connecting terminals of cables is not to exceed 45*K* at an ambient temperature of 45°*C* when 100 % of the rated current is carried there through.

(2) All circuit-breakers are, according to their kind, to be such as to be able to securely break the over-current not more than the rated braking capacity and safely make the circuit to carry the current not more than the rated making current under the circuit conditions specified in the standards referred to in **-1**.

(3) The time-delay over-current trip devices of circuit-breakers for generator circuits are to be such that the readjustment of the current setting does not cause remarkable change to the time-delay feature.

(4) The characteristics of the time-delay overcurrent trip devices are not to be affected excessively by ambient temperature.

2.6.2 Fuses

1. Fuses are to comply with *IEC Publication* 60269 or equivalent thereto, amended when necessary for ambient temperature, and also to comply with the requirements in **-2** and **-3**.

2. The construction of fuses is to comply with the followings:

(1) Fuses are to be of enclosed type and the construction is to be such that its enclosure is not broken nor burnt and the adjacent insulation is not deteriorated by flowing of fused metal or emitting of gases, when the fuse element has blown out.

(2) Fuses are to be readily replaceable with spares without the risk of causing electric shock or burn on setting fuses in and out.

(3) Each fuse is to be clearly indicated of its rated voltage and rated current, and in addition rated breaking capacity, fusing characteristics and current-limiting characteristics according to its kind. Such indication may be made in terms of value or symbol.

3. The performance of fuses and fuse-holders are to comply with the followings:

(1) The temperature rise in the connecting terminals of cables is not to exceed 45*K* at an ambient temperature of 45°*C* when the fuses and fuse-holders have been fitted to the normal working condition and 100 % of the rated current is carried there through.

(2) Fuses are to have the fusing characteristics corresponding to their kind, and under the circuit conditions specified in the standards referred to in **-1**, they are to be capable of breaking securely all currents whichever is below the rated breaking capacity and above the fusing current.

2.6.3 Electromagnetic Contactors

1. Electromagnetic contactors are to comply with *IEC publication* 60947-1 and 60947-4-1, or equivalent there to, amended when necessary for ambient temperature, and also to comply with the requirements in **-2** and **-3**.

2. The construction of electromagnetic contactors is to comply with the followings:

(1) Electromagnetic contactors are to be such that no accidental opening and closing occur due to the vibration of the ship, and furthermore, no malfunction is caused by the list of an angle of 30°in any direction.

(2) The contact pieces and magnetic coils are to be readily replaceable.

(3) Each electromagnetic contactor is to be clearly indicated of its rated operational voltage, rated capacity or full load current corresponding to rated capacity, rated operational voltage and frequency for control circuits, interruption current capacity and closed circuit current capacity. Such indication may be made in terms of value or symbol.

3. The performance of electromagnetic contactors is to comply with the followings:

(1) The temperature rise in the connecting terminals of cables is not to exceed 45*K* at an ambient temperature of 45°*C* when the full load current corresponding to the rated capacity is carried there through.

(2) Electromagnetic contactors are to have a suitable interruption current capacity and closed-circuit current capacity depending on their application.

(3) Electromagnetic contactors are not to accidentally open the circuit at a voltage exceeding 85 % of the rated voltage.

2.6.4 Overcurrent Relays for Motors

Overcurrent relays for motors are to have suitable characteristics in relation to the thermal capacities of motors.

2.7 Control Appliances

2.7.1 Clearance and Creepage Distances

1. The clearance and creepage distances of control appliances (*e.g.*, contactors, rheostats, control switches, limit switches, motor protection and control relays, terminal boards, appliances incorporating semi-conductors and their combinations) are to comply with the requirements in **-2** and **-3** depending on the degree of protection of enclosures of the appliances or the ambient condition in which the appliances are installed.

2. The minimum clearance and creepage distances of control appliances (*e.g.*, electromagnetic contactors, control switches, terminal boards) are not to be less than the values given in **Table 2.11** if the appliances are designed and constructed in consideration of the moisture, dust, etc. or are operated in the ambient condition not accompanying the extremely high humidity and heavy deposit of dusts.

3. The minimum clearance and creepage distances of small control appliances having rating current not exceeding 15 *A* may be shortened to the values as deemed appropriate by the Society, depending on the degree of protection of enclosures of the appliances or the ambient condition in which the appliances are installed.

4. The requirements in **-2** and **-3** may not apply to the followings:

(1) Clearance distances between contacts generating arc

(2) Appliances used in the secondary windings of induction motors

(3) Oil-immersed appliancess

(4) Cap and lamp-holder of indicator lamp

(5) Small switches in living quarters

(6) Filled portion of gas-filled appliance

Table 2.11 Minimum Clearances and Creepage Distances for Control Appliances

Rated insulating voltage (*V*) (d.c & a.c.)	Clearance (*mm*)						Creepage[3][4] (*mm*)					
	Less than 15 *A*[5]		15 *A* or over and 63 *A* or under[5]		Exceeding 63 *A*[5]		Less than 15 *A*[5]		15 *A* or over and 63 *A* or under[5]		Exceeding 63 *A*[5]	
	L-L[1]	*L-A*[2]	*L-L*[1]	*L-A*[2]	*L-L*[1]	*L-A*[2]	*a*	*b*	*a*	*b*	*a*	*b*
Not exceeding 60	2	3	2	3	3	5	2	3	2	3	3	4
Exceeding 60 and 250 or under	3	5	3	5	5	6	3	4	3	4	5	8
Exceeding 250 and 380 or under	4	6	4	6	6	8	4	6	4	6	6	10
Exceeding 380 and 500 or under	6	8	6	8	8	10	6	10	6	10	8	12

Notes:

1 "*L-L"* applies to clearances between bare live parts and between live part and earthed metal parts.

2 "*L-A"* applies to clearance between live part and insulated metal part which becomes live part due to insulation deterioration.

3 Creepage distance is to be determined by insulation thermal class and shape.

"a" applies to ceramic insulator (steatite and porcelain) and comparable other insulator which is particularly safe against leaked electricity provided with ribbed construction or vertical partitions proved to be equally effective as ceramic insulator through experiments having a tracking index greater than 140 *V, e.g.* phenol resins formed items.

"b" applies to other insulation materials.

4 In case where "*L-A"* is greater than the corresponding creepage *"a"* or *"b"* , the creepage distances between live parts and insulated metals which operator may readily touch and which becomes live parts by the deterioration of insulation are to be "*L-A"* or more.

5 Current value is to be expressed by the rated current-carrying value.

2.7.2 Ambient Conditions

1. Electrical appliances incorporating semi-conductors are to be suitable for proper operation at an ambient temperature of 55°C.

2. Control appliances are not to cause malfunctions such as undesired switching motions or change in status when they are inclined to an angle of 45°in any direction. However, electromagnetic contactors are to comply with **2.6.3-2(1)**.

2.8 Control gears for Motors and Magnetic Brakes

2.8.1 Controlgears for Motors

1. Controlgears for motors are to be durably constructed and provided with efficient means of starting, stopping, reversing and speed controlling of motors together with essential safety devices.

2. Controlgears for motors are to be provided with protective enclosures suitable for their location and to allow safe operation for the personnel.

3. All wearing parts of controlgears are to be readily replaceable and accessible for inspection and maintenance.

4. Motors above 0.5 *kW* are to be provided with the controlgears complying with the requirements in **-1**, **-2** and **-3** and in the followings:

(1) A means is to be provided to prevent undesired restarting after stoppage due to low voltage or complete loss of voltage. This requirement does not apply to motors continuous availability of which is essential to the safety of the ship and to motors with automatic operation.

(2) A primary means of isolation is to be provided so that all voltages may be cut off from the motor, except where a means of isolation (that provided at the switchboard, the section board, the distribution board, etc.) is adjacent to the motor.

(3) A means for automatic disconnection of the power supply is to be provided in the event of excess current due to mechanical overloading of the motor. This requirement does not apply to the motors for steering gears.

5. In case where the primary means of isolation is remote from the motor, either of the following means or the equivalent is to be provided:

(1) An additional means of isolation fitted adjacent to the motor is to be provided.

(2) Provision is made for locking the primary means of isolation in the off position.

6. When fuses are used to protect three-phase *a.c.* motor circuits, consideration is to be given to protect against single phasing.

7. In case where controlgears for motors of essential services installed in duplicate are built in a grouped starter panel, the busbars, appliances and others are to be so arranged that one fault on the appliances or the circuits do not render the motors for the same use unusable simultaneously.

8. Transformers for power supply to control circuits are to be provided to each motor or each group of motors incorporated in an apparatus.

9. Running indicators and overload alarms for motors for steering gears are to comply with the requirements in **15.2.7**, **Part 7**.

2.8.2 Magnetic Brakes

1. Electrical parts of magnetic brakes applied to watertight-type motors are to be watertight.

2. *D.C.* shunt-wound brakes are to release satisfactorily at 85 % of the rated voltage at the maximum working temperature, and *d.c.* compound-wound brakes at the same conditions as above are to release satisfactorily at 85 % of the starting current.

3. *D.C.* series-wound brakes are to release down at 40 % or more of the full-load current and in every case at the starting current and to set at 10 % or less of the full-load current.

4. *A.C.* magnetic brakes are to comply with the followings:

(1) *A.C.* magnetic brakes are to release satisfactorily at 80 % of the rated voltage at the working temperature.

(2) *A.C.* magnetic brakes are not to be noisy due to magnetic action in the working condition.

2.8.3 Temperature Rise

The temperature rises of controlgears for motors are not to exceed, under the specified current or rated voltage, the values given in **Table 2.12** except as separately specified in this Part.

Table 2.12 Limit of Temperature Rise of Controlgears for Motors (Based on ambient temperature 45°C)

Item and part				Limits of temperature rise (*K*)
Coils (air)	Thermal class *A*			60
	Thermal class *E*			75
	Thermal class *B*			85
	Thermal class *F*			110
	Thermal class *H*			135
	Thermal class *N*			155
Contact piece	Mass form	Continuous use over 8 *hours*	Cooper or copper alloy	40
			Silver or silver alloy	70
		Switch on & off me attempt or more in about 8 hours	Cooper or copper alloy	60
			Silver or silver alloy	70
	Multilayer form ok knife form		Cooper or copper alloy	35
Busbar and connecting conductor (bare or Thermal class *A* and higher)				60
Terminals for external cables				45
Metallic resistors	Moulded-case type			245
	Those other than moulded-case type		For continuous use	295
			For intermittent use	345
			For starter use	345
	Exhaust (approx. 25*mm* above exhaust port)			170

Notes:

1 Measurement of temperature of voltage coil is in principle to be made by resistance method only.

2 Where the insulation of single layer enamel windings is higher in class then that of the adjacent parts, the temperature rise associated with the class of insulation for the adjacent parts is to be applied.

3 For single layer bare windings, the temperature rise associated with the class of insulating material on the adjacent parts is to be applied.

4 Moulded-case type metal resistor means such a resistor as to be buried in the insulating so as no surface of metallic resistor to be exposed.

2.8.4 Shop Tests

1. Controlgears for motors are to be tested in accordance with the requirements in this 2.8.4. However, the test required by **-2** may be omitted subject to the Society s permission for each controlgear and magnetic brakes which is produced in series having identical type with its first unit.

2. Controlgears for motors are to undergo the temperature test under normal working condition, and then temperature rise of each is not to exceed the values given in **Table 2.12**.

3. Operations of instruments, switching gears, protective devices, etc. for controlgears for motors are to be verified.

4. Controlgears for motors with components are to withstand the high voltage by applying the following voltage at commercial frequency for 1 *minute* between all current-carrying parts of switchgears including control devices and earth and between poles or phases. Instruments and auxiliary apparatus may be disconnected during the high voltage test.

Rated voltage of 60 *V* or less: 500 *V*

Rated voltage exceeding 60 *V:* 1,000 *V* + twice the rated voltage (minimum 1,500 *V*)

5. Immediately after the high voltage test, the insulation resistance between all current-carrying parts connected and earth and between current-carrying parts of opposite polarity or phase are not to be less than 1*MΩ* when tested with *d.c.* voltage of at least 500 *V*.

2.9 Cables

2.9.1 General

Cables are to comply with *IEC Publication* 60092 or equivalent thereto. Installation of cables is to comply with the requirements in this **2.9**.

2.9.2 Choice of Cables

1. The rated voltage of any cable is not be lower than the nominal voltage of the circuit for which it is used.

2. Separate cables are, as a rule, to be used for a power supply circuit requiring individual short-circuit and overcurrent protection.

3. The maximum rated conductor temperature of materials used in cables is to be at least 10°C higher than the maximum ambient temperature likely to exist, or to be normally produced, in the space where the cable is installed.

2.9.3 Choice of Protective Coverings

Cables are to be protected by sheath and/or metal armour in accordance with the following:

(1) Cables fitted on weather decks, in bath rooms, cargo holds, machinery spaces, or any other location where water, oil or explosive gases may be present are to be sheathed.

(2) In permanently wet situations, metallic sheaths are to be used for cables with hygroscopic insulation.

(3) Cables fitted on weather decks, in cargo holds, in machinery spaces, etc. where they are likely to suffer from mechanical damages are to be metal armoured except where effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.14-3(4)** are provided.

2.9.4 Flame Retardancy

Cables, except special types of cables such as radio frequency cables, as a rule, are to be of flame retardant type.

2.9.5 Maximum Continuous Load

The maximum continuous load carried by a cable is not to exceed its current rating specified in 2.9.9. The diversity factor of the individual loads may be taken into account in estimating the maximum continuous load.

2.9.6 Voltage Drop

The voltage drop from the main or emergency switchboard busbars to any point in the installation except navigation lighting circuits, when the cables are carrying maximum current under normal conditions of service, is not to exceed 6 % of the nominal voltage. However, the voltage drop on the supply circuits from batteries with a voltage not exceeding 24 *V* may be permitted to 10 %.

2.9.7 Assessment of Lighting Load

In assessing the current rating of lighting circuits, every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 *W*, unless the fitting is so constructed as to take only a lamp rated at less than 60 *W*.

2.9.8 Current Rating for Short-time or Intermittent Load

Cables supplying motors used for cargo winches, windlass, capstan, etc. are to be suitably rated for their duty. In this case, consideration is to be taken of the voltage drop.

2.9.9 Current Rating of Cables

The current rating of cables is to comply with the following **(1)** to **(5)**.

(1) The current rating of cables for continuous services is not to exceed the values given in Table 2.13.

(2) The current rating of cables for short-time services (30 *minutes* or 60 *minutes*) may be increased by multiplying the value given in Table 2.13 by the following correction factor.

Correction factor: $\sqrt{1.12/(1-\exp(-ts/0.245/d^{1.35}))}$

ts: 30 or 60 (*min*)

d: overall diameter of the finished cable (*mm*)

(3) The current rating of cables for intermittent services (for periods of 10 *minutes*, of which 4 *minutes* are with a constant load and 6 *minutes* without load) may be increased by multiplying the value given in Table 2.13 by the following correction factor.

Correction factor: $\sqrt{\frac{1-\exp(-10/0.245/d^{1.35}}{1-\exp(-4/0.245/d^{1.35}}}$

d: overall diameter of the finished cable (*mm*)

The current rating for other intermittent ratings is to be deemed appropriate by the Society.

(4) Where more than 6 cables belonging to the same circuit are bunched together, a correction factor of 0.85 is to be applied.

(5) Where the ambient temperature is different from that specified in **(1)** to **(3)**, the correction factor in **Table 2.14** may be applied.

Table 2.13 Current Rating of Cable (for continuous services) (Based on ambient temperature 45°C)

Nominal sectional area of conductor (mm^2)	Current rating in amperes											
	PVC insulation (general purpose) (70° C)			*PVC* insulation (heat resisting) (75° C)			*EP* rubber insulation and Cross-linked polyethylene Insulation (90°C)			Silicon rubber insulation and Mineral insulation (95°C)		
	1 core	2 cores	3 cores	1 core	2 cores	3 cores	1 core	2 cores	3 cores	1 core	2 cores	3 cores
1.5	12	13	11	17	14	12	23	20	16	26	22	18
2.5	17	18	15	24	20	17	30	26	21	32	27	22
4	22	25	20	32	27	22	40	34	28	43	37	30
6	29	31	26	41	35	29	52	44	36	55	47	39
10	51	43	36	57	48	40	72	61	50	76	65	53
16	68	58	48	76	65	53	96	82	67	102	87	71
25	90	77	63	100	85	70	127	108	89	135	115	95
35	111	94	78	125	106	88	157	133	110	166	141	116
50	138	117	97	150	128	105	196	167	137	208	177	146
70	171	145	120	190	162	133	242	206	169	256	218	179
95	207	176	145	230	196	161	293	249	205	310	264	217
120	239	203	167	270	230	189	339	288	237	359	305	251
150	275	234	193	310	264	217	389	331	272	412	350	288
185	313	266	219	350	298	245	444	377	311	470	400	329
240	369	314	258	415	353	291	522	444	365	533	470	387
300	424	360	297	475	404	333	601	511	3421	636	541	445

Table 2.14 Correction Factor for Various Ambient Temperatures

Maximum rated conductor temperature of insulation	Correction factor									
	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
70°C	1.10	1.00	0.89	0.77	0.63	-	-	-	-	-
75°C	1.08	1.00	0.91	0.82	0.71	0.58	-	-	-	-
90°C	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47	-
95°C	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

2.9.10 Installation of Cables

1. Cable runs are to be, as far as possible, straight and accessible.

2. The installation of cables across expansion joints in the ship's structure is to be avoided as far as possible. Where such installation is unavoidable, a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable.

3. Where a duplicate supply is required, the two cables are to follow different routes which are to be as far apart as practicable.

4. Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where such bunching is unavoidable, the cables are to be operated so that no cable may reach a temperature higher than that permitted for the lowest temperature-rated cable in the group.

5. Cables having a protective covering which may damage the covering of other cables are not to be bunched together with those other cables.

6. When installing cables, the minimum inside radius of bend is to be in accordance with the followings:

(1) Armoured rubber insulated and *PVC* insulated cables: 6*d*

(2) Unarmoured rubber insulated and *PVC* insulated cables: 4*d* ($d \leq 25mm$) or 6*d* ($d > 25mm$)

(3) Mineral insulated cables: 6*d*

(*d*: overall diameter of the finished cable (*mm*))

7. Intrinsically safe circuits are to be installed complying with the followings;

(1) The cables for intrinsically safe circuits associated with intrinsically safe type electrical equipment are to be of exclusive use, being installed separately from cables for general circuits.

(2) Intrinsically safe circuits associated with different intrinsically safe type electrical equipment are, as a rule, to be wired individually using different cables. Where it is necessary to use a multi-core cable in common, a cable which has shields by each core or each pair of cores is to be used, having such shields earthed effectively.

However, intrinsically safe circuits associated with category "*ia*" intrinsically safe type electrical equipment are not to be contained in a cable associated with category "*ib*" intrinsically safe type electrical equipment.

2.9.11 Precaution against Fire

1. Cables are to be so installed as not to impair original flame retardant properties.

2. All cables for power, lighting, internal communications, signals and navigational aids of essential and emergency services are to be so far as practicable routed clear of machinery spaces of category *A* and their casings, galleys, laundries and other high fire risk areas. Cables connecting fire pumps to the emergency switchboard is to be of a fire resistant type when they pass through high fire risk areas. All such cables are to be so far as practicable run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

3. The interconnecting cables between a generators and the main switchboard is to be routed clear fuel oil purifier spaces, above the other generator engines and fuel oil purifiers except in the following **(1)** to **(3)**

(1) Subdivided into at least two groups separated throughout their length as widely as practicable,

(2) Fire resistant cables which have passed the test specified in *IEC publication* 60331, or

(3) Protected by means deemed appropriate by the Society.

2.9.12 Cables in Hazardous Areas

Where cables which are installed in hazardous areas introduce the risk of fire or explosion in the event of an electrical fault in such areas, proper protections against such risks are to be provided.

2.9.13 Earthing of Metallic Coverings

1. Metallic coverings of cables are to be effectively earthed at the both ends unless otherwise stated in this part. In final sub-circuits, however, earthing may be at the supply end only. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

2. Effective means are to be taken to ensure that all metallic coverings of cables are made electrically continuous throughout their length.

3. Lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of electrical equipment.

2.9.14 Supports and Fixing of Cables

1. Cables and wires are to be so supported and secured that they may not be injured by chafing or other mechanical damage.

2. Distances between supporting and fixing points are to be suitably chosen according to the type of cable and the probability of vibration, and are not to exceed 40 *cm*. With respect to horizontal cable runs, except that along weather decks, where the cables are laid on cable supports in the form of hanger ladders, etc., the spacing between the fixing points may be up to 90 *cm* provided that there are supports with maximum spacing of 40 *cm*. Cable runs where cables are installed in ducts or pipes are to be deemed appropriate by the Society.

3. Clips, supports and accessories are to comply with the followings:

(1) Clips are to be robust and are to have surface areas so large and shaped that the cables remain tight without their coverings being damaged.

(2) Clips, supports and accessories are to be corrosion-resistant material or to be suitably corrosion inhibited before erection.

(3) Non-metallic clips are to be in accordance with the followings:

  (a) They are to be of flame-retardant material

  (b) They are to be arranged so as to prevent any cables from becoming slack in the event of a fire except in cases where they are laid horizontally on support.

(4) Non-metallic supports are to be in accordance with the followings:

  (a) to be of those passed the test otherwise specified by the Society,

  (b) to be sufficiently endurable under possible surrounding circumstances,

  (c) to be suitable for ambient temperature,

(d) to be electrically conductive if they are used in dangerous spaces,

(e) to be protected against UV light if they are used on open decks,

(f) to be fixed with a support spacing not to be greater than that at the test referred to in **(1)** or 2 *m*, whichever is the less, and

(g) to be supplemented by metallic fixings to prevent the supports and cables from falling in the event of a fire.

2.9.15 Penetration of Bulkheads and Decks

1. Penetration of bulkheads and decks, which are required to have some degree of strength and tightness, is to be so carried out by means of cable glands or boxes as to ensure that the strength and tightness are not impaired.

2. Where cables pass through non-watertight bulkheads or steel structures, the holes are to be bushed with suitable materials in order to avoid damage to cables. If the thickness of the steel is sufficient ($\geq 6mm$) and there is no risk of damage to cables, adequately rounded edges may be accepted as the equivalent of bushing.

3. The choice of the materials for glands and bushings is to be such that there is no risk of corrosion.

4. Penetration through bulkheads and decks, which are to have some degree of fire integrity, is to be so effected as to ensure that the fire integrity is not impaired.

2.9.16 Mechanical Protection of Cables

1. Cables without metal armour exposed to risk of mechanical damage are to be protected by means of effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.14-3(4).**

2. Cables in cargo holds and other spaces where there is exceptional risk of mechanical damage are to be protected by means of effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.14-3(4)**, even if armoured.

2.9.17 Installation of Cables in Pipes and Conduits

1. Metallic or electrically conductive non-metallic pipes and conduits are to be effectively earthed and are to be mechanically and electrically continuous across joints.

2. The internal radius of the bend of pipes and conduits is not to be less than the values specified (*See* **2.9.10-6**).

Where, however, pipes exceed 64 *mm* in diameter, the internal radius of the bend is not to be less than twice a diameter of the pipes.

3. Drawing-in factor (ratio of the sum of the cross-sectional areas of the cables to the internal cross-sectional area of the pipe) is not to exceed 0.4.

4. Horizontal pipes or conduits are to have suitable drainage.

5. Where pipe arrangement is long, expansion joints are to be provided where necessary.

2.9.18 Cables in Refrigerated Spaces

Cables installed in refrigerated spaces are to comply with the following:

(1) *PVC* insulated cables, when used, are to be capable of withstanding the low temperatures of the refrigerated spaces.

(2) Cables are to have lead sheath or cold-resisting impervious sheath.

(3) Cables are not to be, as a rule, embedded in structural heat insulation.

(4) Where cables have to pass through structural heat insulation, they are to be installed at right angle to such insulation and are to be protected by a pipe, preferably fitted with a watertight stuffing tube at each end.

(5) Cables are to be installed with sufficient spaces behind the face of the chamber or air duct casings and are to be supported by plating, hangers or cleats. If cables have corrosion-proof layer covering armour, they may be placed directly on the face of the chamber or air duct.

2.9.19 Cables for Alternating Current

Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20*A*, the following requirements **(1)** to **(8)** are to apply:

(1) Cables are to be either non-armoured or armoured with non-magnetic materials. In this case, the armour is to be earthed at single point.

(2) Where installed in a pipe or conduit, cables belonging to the same circuit are to be installed in the same pipe or conduit unless the metallic pipe or conduit is of non-magnetic material.

(3) Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

(4) Where two or three single-core cables forming respectively single-phase circuits or three-phase circuits are installed, the cables are to, as far as possible, be in contact with one another. In any case, the distance between adjacent cables is not to be greater than the diameter of the cable.

(5) Where single-core cables of current rating greater than 250 *A* are run along steel bulkheads, the cables are to be run apart from the steel bulkheads, as far as practicable.

(6) Where single-core cables having a sectional area of 185 mm^2 or over and exceeding 30 *m* in length are used, the phases are to be transposed at regular intervals of approximately 15 *m* in order to obtain the same degree of impedance of circuits, unless the cables are installed in trefoil formation.

(7) In case of circuits involving 2 or more single-core cables running in parallel per phase, all cables are to have the same length and the same sectional area.

(8) Magnetic material is not to be placed between single-core cables of a group. Where cables pass through steel plates, all cables of the same circuit are to pass through a plate or gland so constructed that the distance between the cables and the magnetic material is not less than 75*mm*, unless the cables are installed in trefoil formation.

2.9.20 Terminals, Joints and Branches of Cables

1. Cables are to be jointed by terminals. Soldering fluxes containing corrosive substances are not to be used.

2. Terminals are to have sufficient contacting surface and pressure.

3. The length of soldered parts of copper tube terminals and other terminals is not to be less than 1.5 times the diameter of conductors.

4. Cables not having a moisture-resistant insulation (*e.g.* mineral insulation) are to have their ends effectively sealed against ingress of moisture.

5. Terminals and joints (including branches) of all cables are to be so made as to retain the original electrical, mechanical, flame-retardant and, where necessary, fire-resisting properties of the cable.

6. Terminals and conductors are to be of dimensions adequate for the cable rating.

2.10 Transformers for Power and Lighting

2.10.1 Scope

Transformers rated at 1 *kVA* or more for single phase and at 5 *kVA* or more for three-phase are to comply with the requirements in this **2.10**.

2.10.2 Construction

1. Transformers in accommodation spaces are to be of dry, naturally cooled type. In machinery spaces they may be of oil-immersed, naturally cooled type.

2. Transformers except those for motor starting are to be double wound (two separate windings).

3. Oil-immersed transformers rated at 10 *kVA* or more are to be provided with oil gauges and drain cocks or plugs, and those rated at 75 *kVA* or more with thermometers in addition.

4. All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of short-circuit at the terminals of any winding for 2 *seconds*.

5. Transformers are to have current limiting devices as needed in order to prevent excessive voltage drop on the system caused by current inrush when the transformers are switched on.

2.10.3 Temperature Rise

Temperature rise of transformers is not to exceed the values given in **Table 2.15** during continuous operation at the rated output, where, however, the ambient temperature is not more than 40°C, it may be increased by the difference from the values in the table.

Table 2.15 Limit of Temperature Rise of Transformers (Based on ambient temperature 45°C)

Part		Limit of temperature rise (°C)					
		Measuring Method	Class *A* insulation	Class *E* insulation	Class *B* insulation	Class *F* insulation	Class *H* insulation
Windings	Dry type transformer	Resistance method	55	70	75	95	120
	Oil-immersed transformer	Resistance method	60	-	-	-	-
Oil		Thermometer method	45				
Core		Thermometer method	Not exert injurious effect on adjacent insulation				

2.10.4 Voltage Regulation

Voltage regulation of transformers is not to exceed the following values at full load and 100 % power factor:

Single phase 5 *kVA* or more, and three-phase 15 *kVA* or more: 2.5 %

Single phase less than 5 *kVA*, and three-phase less than 15 *kVA*: 5 %

2.10.5 Shop Tests

1. Transformers are to be tested in accordance with the requirements in this **2.10.5**. However, the test required by **-2** may be omitted subject to the Society s permission for each transformer which is produced in series having identical type with its first unit.

2. Temperature rises of transformers under the rated full load are not to exceed the values given in **2.10.3**.

3. Transformers are to undergo the voltage regulation test and comply with the requirements in **2.10.4** except that it may be permissible to obtain from calculation.

4. After the temperature test, transformers are to withstand the high voltage by applying *a.c.* 1000 *V* plus twice the maximum line voltage of commercial frequency, between windings and between winding and earth for 1 *minute*.

The test voltage in this test is to be at least 1500 *V*.

5. Transformers are to withstand for the duration of the test given by the following formula, when twice the normal voltage induced on the winding at any frequency between 100 and 500 *Hz*, but the duration of the test is to be at least 15 *seconds* and not over 60 *seconds*:

$$Testing\ time\ (second) = 60 \times \frac{2 \times Rated\ frequency}{Test\ frequency}$$

2.11 Accumulator Batteries

2.11.1 General

1. The requirements in this 2.11 apply to permanently installed secondary batteries of vented type. Vented type secondary battery means one in which the electrolyte can be replaced and which may release gas while operating on charge and overcharge.

2. Proposals for the use of other types of secondary batteries are to be as deemed appropriate by the Society.

3. Accumulator batteries are to have performance suitable for intended services.

2.11.2 Construction

Cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to ship's motions and to prevent emission of acid or alkaline spray.

2.11.3 Location

1. Alkaline batteries and lead acid batteries are not to be installed in the same compartment.

2. Large batteries are to be installed in compartment assigned to them only. They may be installed in a box on deck if adequately ventilated and provided with means to prevent ingress of water.

3. Engine starting batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery room, they are to be installed at the place where adequate ventilation is ensured.

4. Batteries are not to be placed in the living quarters.

2.11.4 Installation Procedures and Protection of Corrosion

1. Batteries are to be arranged to permit ready access for replacing, inspection, testing, replenishing and cleaning.

2. Cells or crates are to be placed on non-absorbent isolating supports. They are to be fitted to prevent any movement due to ship's motions.

3. In case where acid is used as the electrolyte, a tray of acid resisting materials is to be provided below the cells unless the deck below is similarly protected.

4. The interior of battery compartment including the shelves is to be coated with corrosion-resistant paint.

5. The interior of ventilating ducts and impellers of ventilating fans are to be coated with corrosion-resistant paint unless ducts and fans are made of corrosion-resisting material.

2.11.5 Ventilation

1. Battery compartments are to be adequately ventilated by an independent ventilating system.

2. In case where natural ventilation is employed, the ventilation ducts are to be run directly from the top of the battery compartment to the open air above, with no part of the ducts more than 45°from the vertical.

If natural ventilation is impracticable, mechanical exhaust-ventilation is to be provided. The electric motors for the ventilating fans are not to be placed inside the ducts. Ventilating fans are to be so constructed and to be of such a material as to render sparking impossible in the event of the impeller touching the fan casing.

2.11.6 Electrical Installations in Battery Compartment

1. Switches, fuses and other electrical installations liable to cause an arc are not to be installed in battery compartments.

2. Lighting fittings provided within battery compartments are to comply with the requirements in 2.16 and to be suitable for use in explosive atmosphere classified into gases and vapours group *IIC* and temperature class *T*1 as specified in *IEC Publication* 60079, or equivalent thereto.

3. Cables other than those for batteries and electrical installations specified in **-2** are, as a rule, not to be installed in battery compartments except where installation in other locations is impracticable.

2.11.7 Charging Facilities

1. Suitable charging facilities are to be provided. Battery charging facilities by means of *d.c.* generator and series resister are to be provided with protection against reversal of current when the charging voltage is 20 % of the line voltage or higher.

2. For floating service or for any other conditions where the load is connected to the battery while it is on charge, the maximum battery voltage under any conditions of charge is not to exceed the safe value of any connected apparatus. A voltage regulator or other means of voltage control may be provided for this purpose.

2.12 Semi-conductor Converters for Power

2.12.1 General

1. The requirements in this 2.12 are to apply to the semi-conductor rectifiers for power (hereinafter referred to as “converters”) not less than 5 *kW*.

2. Converters are to be in accordance with all applicable requirements given in this Part, and standards are, as far as practicable, to be deemed appropriate by the Society.

2.12.2 Construction and Location

1. Semiconductor valve units, semiconductor stacks or semiconductor elements are to be arranged so that they can be removed from equipment without dismantling the complete unit.

2. Effective means are to be provided in convertors to prevent any accumulation of moisture and condensation unless such convertors are located in air-conditioned spaces.

3. Transformers for converters are to be of two separate windings.

4. In case where semiconductor elements are connected in series or parallel, they are to be arranged so that voltage or currents for each element will become equal as far as practicable.

5. Converters are to be installed with effective cooling devices in order to maintain temperature rises of semiconductor elements or semiconductor stacks below allowable levels. In such cases, such equipment is to be installed in such manner that coolant circulation is not impeded and the temperature of the air at inlets to air-cooled semiconductor elements or semiconductor stacks does not exceed allowable values.

6. Converters are to be separated from resistors, steam pipes or other sources of radiant heat as far as practicable.

2.12.3 Protective Devices, etc.

1. Where forced cooling is provided, the converters are to be arranged so that they cannot remain loaded unless effective cooling is maintained.

2. Where necessary, means are to be provided to guard against transient over-voltage caused by switching and breaking of the circuits and *d.c.* voltage rise due to regenerative power.

3. Protecting fuses for semiconductor elements are to be co-ordinated with the character of semiconductor elements as far as practicable.

4. Over voltages in those supply systems to which convertors are connected are to be limited by suitable devices to prevent any damage.

5. Semiconductor elements and filter circuits are to be protected by fuses, etc.

2.12.4 Shop Tests

1. Converters and their accessories are to be tested in accordance with the requirements in this **2.12.4**. The test required by **-2**, however, may be omitted subject to the Society s permission for each product which is produced in series having identical type with its first unit.

2. Temperature rise test for converters and their accessories is to be carried out under normal working conditions, and temperature rise for the interiors of converters is not to exceed manufacturer specified values and the temperature rise for the exteriors of converters (e.g.the connecting parts of busbars and cables for switchboards as well as coils ,contactors and resistors) is not to exceed those values specified in the requirements in **2.8.3**.Furthemore, temperature test methods for semiconductor element connections are to be as deemed appropriate by the Society.

3. Instruments, switching devices and protective devices are to be checked under operating conditions.

4. Converters are to withstand the high voltages by applying the following *a.c.* voltage for one *minute* between semiconductor elements or live parts of accessories charged with main circuit potential and earths.

Testing voltage (V) = $1.5EP_i$ + 1000 (minimum 2,000 V)

EP_i : Peak reverse voltage

Where *d.c.* voltage is less than 100 V, minimum testing voltage may be 1,500 V. Semiconductor elements are to be short-circuited before such test.

5. High voltage test between live parts and earth for accessories charged with auxiliary circuit potential is to be in accordance with the requirements in **2.8.4-4**.

6. After the high voltage test, insulation resistance between live parts of rectifiers and their accessories and earth is not to be less than $1M\,\Omega$ when tested with *d.c.* voltage of at least 500 *V*.

2.13 Lighting Fittings

2.13.1 General

Lighting fittings are to comply with the requirements in this 2.13.

2.13.2 Construction

1. Rating of lampholders is to be in accordance with *IEC Publication* 60092 or other standards as deemed appropriate by the Society.

2. Lampholders are to be constructed of non-hydroscopic and flame-retarding or incombustible materials.

3. Large lampholders are to be provided with means for locking the lamp in the holder.

4. Enclosures are to be composed of metal, glass or synthetic resins having a sufficient mechanical, thermal and chemical resistivity and to have a suitable degree of protection depending on their location. Synthetic resin enclosures which support current-carrying parts are to be flame retardant.

5. Terminal boxes and leading-in parts of cables are to be of construction suitable for marine application. Consideration is to be given so that the insulation of cables may not be deteriorated at early stage due to the temperature rise on terminals and other parts.

6. The internal wiring of lighting fitting is to be use wiring which takes into account the effects of ultraviolet rays and heat in order to prevent the early –stage degradation of the cable insulation cover.

7. Lighting fittings installed in engine room or similar other spaces which are exposed to the risk of mechanical damage are to be provided with suitable grilled metallic guards to protect their lamps and glass globe against such damage.

2.13.3 Arrangement

Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring, and to prevent surrounding material from becoming excessively hot.

2.13.4 Fluorescent Lighting Fittings

1. Reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are liable to be subjected high temperatures.

2. Every capacitor of $0.5\mu F$ or more is to be provided with a protective leak or other protective means which reduces the voltage of the capacitor to not more than 50 *V* within 1 *minute* after disconnection from the supply sources.

3. Transformers are to be installed as close as practicable to the associated discharge lamps.

2.14 Wiring Accessories

2.14.1 General

1. Enclosures are to be of metal or flame-retardant material.

2. Insulating materials of live parts is to be of flame-retardant and non-hygroscopic material.

2.14.2 Temperature Rises

The temperature rise of live parts is not to exceed 30*K*.

2.14.3 Switches

Switches are to be capable of breaking and making safely a load current equal to 150 % of their rated currents at their rated voltages.

2.14.4 Socket-outlets and Plugs

Socket-outlets and plugs are to comply with the followings:

(1) Socket-outlets and plugs are to be such that they cannot be readily short-circuited whether the plug is in or out.

(2) It is to be impossible to insert only one pin of the plug in to the socket-outlet.

(3) Socket-outlets of rated current exceeding 15 *A* are to be provided with a switch so interlocked that the plug cannot be inserted or withdrawn when the switch is in the “on” position.

(4) Where distribution systems of different voltages are in use, socket-outlets and plugs are to be of such design that an incorrect connection cannot be made.

(5) Where socket-outlets with earthing contacts are required, the socket-outlets and plugs are to be provided with additional contact for earthing the casings or frames of appliances. The earthing contacts are to make contact in advance of the live contact pins when inserting the plug.

2.15 Heating and Cooking Equipment

2.15.1 Construction

1. Heating elements are to be suitably protected.

2. Space heaters are to be so constructed as to reduce fire risks to a minimum, and no such space heaters are to be fitted with an element so exposed that closing, curtains or other similar materials can be scorched or set on fire by heat from the element.

2.15.2 Installation

Space heating appliances are to be so mounted that there will be no risk of dangerous heating of decks, bulkheads or other surroundings.

2.16 Explosion-protected Electrical Equipment

2.16.1 General

Explosion-protected electrical equipment is to be in accordance with the standard deemed appropriate by the Society or equivalent thereto and also to comply with the requirements in this 2.16.

2.16.2 Selection of Explosion-protected Construction

The explosion-protected construction used for electrical equipment on board ships is to be selected from the followings.

(1) Flameproof type
(2) Increased safety type
(3) Intrinsically safe type
(a) Category "*ia*" intrinsically safe type
(b) Category "*ib*" intrinsically safe type
(4) Pressurized protected type
(5) Encapsulation type
(6) Powder filling type
(7) Oil immersion type

2.16.3 Materials

1. Materials for explosion-protected construction are to have an adequate electrical, mechanical, thermal and chemical resistance against the environmental condition and flammable gases or vapours (hereinafter referred to as "gases") at the location of the electrical equipment concerned.

2. Enclosures and outer fittings of portable appliances are to be of materials which minimize the risk of spark by friction, or to have a non-metallic strong cover with hanging strap.

3. Insulating compounds and sealing compounds used for integral parts of explosion-protected construction are to be such that no harmful expansion, contraction, softening or crack is found during in service. And the insulating compounds applied to bare live-parts are to be flame-retardant.

2.16.4 Construction

1. The glazed ports of lighting fittings and the inspection windows of other electrical apparatus of flameproof type, increased safety type and pressurized protected type are, as a rule, to be provided with robust metallic guards.

2. In case where a gasket is used with a view to give watertightness to the explosion-protected electrical equipment installed on weather decks and other similar spaces, gaskets are is to be so fitted as not to impair, the explosion-proof characteristics due to its deterioration or breakage.

3. Leading-in parts of cables are to be of a construction suitable for ship cables. Consideration is to be given so that the cables can be surely fixed at the leading-in part, except where the cables are installed in steel conduits.

4. Electrical equipment associated with intrinsically safe circuits and located in hazardous areas are in principle to be of totally enclosed construction.

5. The type of explosion-protected electrical equipment, the kind of gases for which the equipment is designed and other items deemed necessary by the Society are to be clearly indicated on a surface of the equipment.

2.16.5 Special Requirement

Explosion-protected electrical equipment is to be in accordance with the requirements otherwise specified by the Society for each explosion-protected construction specified in 2.16.2.

2.17 High Voltage Electrical Installations

2.17.1 General

1. The requirements in this 2.17 are to be applied to high voltage electrical installations with system voltage above *a.c.* 500 *V* up to *a.c.* 15,000 *V*.

2. The high voltage electrical installations are to meet the requirements in this 2.17 and also those in other applicable chapters of this part.

2.17.2 Distribution

1. The following distribution systems are considered as a standard:

(1) Three-phase, three-wire, insulated system.

(2) Three-phase, three-wire, neutral earthed system.

- (a) High-impedance earthing
- (b) Low-impedance earthing
- (c) Direct earthing

2. For three-wire insulated system, high voltage equipment is to withstand the transient over-voltages which may arise from earth-faults.

3. For three-wire neutral earthed system, high voltage equipment is to withstand earth-fault currents. Where means are provided for limiting earth-fault currents, this is not to influence selective tripping of the fault circuit.

4. For three-wire neutral earthed system, it is to be assured that at least one source neutral to ground connection is available whenever the system is in the energized mode.

5. All earthing resistors are to be connected to the hull. Earthing method is to be considered in order to eliminate possible interference with radio, radar and communication circuits.

2.17.3 Construction and Location

1. High voltage electrical equipment is to be manufactured in accordance with standards deemed appropriate by the Society, whose ambient temperature may be subject to consideration by the Table **1.1** when necessary, and to comply with the requirements in this **2.17.3**.

2. High voltage electrical equipment is to be protected so that the operators are not accidentally able to come in contact with the live parts of the equipment.

3. High voltage electrical equipment or entrances to key-locked spaces in which the equipment are installed are to be marked in an easily visible place so as to identify them as high voltage electrical installations.

4. High voltage electrical equipment is to be of construction to facilitate leading of cables, preparation of cable ends, and connection of cables, and also to prevent any accidental contact between high and low voltage circuits.

5. For rotating machines, transformers and reactors, effective means is to be provided to prevent the accumulation of moisture and condensation within the machines especially when they are idle for appreciable periods.

6. When generators are run with neutrals interconnected, such generators are to be suitably designed to avoid excessive circulating currents.

7. For generators used in three-wire neutral earthed system, means of disconnection is to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

8. To ensure safety of operation, a passageway that has a width of at least $1m$ is to be arranged in front of each high voltage switchboard. Where access to the rear of a switchboard is needed for purposes of operation or maintenance, a passageway of sufficient width allowing such access is to be provided.

9. For generators with cooling systems that use auxiliary power, interlocks are to be provided. These interlocks are to disconnect the generator for all other systems in either of the following cases:

(1) In cases where the auxiliary power fails.

(2) In cases where temperature detectors, which sound an alarm when the generator stator windings reach their maximum rated temperature, indicate a temperature of 110% of the maximum rated temperature.

10. Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit.

11. Where rotating machines are provided with water-air heat exchangers, they are to be of the double tube type. A visual and audible alarm in a normally attended position is to be given to monitor cooling water leakage.

12. Higher voltage terminals are never to be combined with lower voltage terminals in the same box, unless measures are taken to ensure that access to lower voltage terminals can be obtained without danger.

13. The degree of protection applying to enclosures of high voltage electrical equipment are to be deemed appropriate by the Society.

14. High voltage switchboards and control boards are to be of an enclosed type and the high voltage sections are to be equipped with doors that are either locked by key or some other equivalent means.

15. Earthing conductors are to be provided for high voltage electrical equipment. These conductors are to be properly connected to the earthing system of the equipment and satisfy the following:

(1) be made of copper.

(2) the cross-section area is to be at least 35 mm^2.

(3) the current density does not exceed 150 A/mm^2 when an earth fault occurs.

16. High voltage switchboards are to comply with the requirements in **2.5.3-1** and **2.5.3-2** of this chapter regardless of the power to the propulsion system being fed or not. In this case, for a neutral earthed system, means of earthing are to be provided for each section. If two separate switchboards are provided and interconnected by cables, a circuit breaker is to be provided at each end of the cables.

17. Each high voltage circuit in high voltage switch boards and control boards is to be fitted with means of earthing and short-circuiting for safe maintenance work. An adequate number of portable earthing and short-circuiting devices may be used as an alternative method.

18. In high voltage switchboards and control boards, an adequate separation is to be provided between lower voltage circuits and higher voltage circuits, in order to prevent the operators from touching the live parts of higher voltage circuits accidentally.

19. Circuit-breakers are to be of the withdrawable type or with equivalent means or arrangements permitting safe maintenance while the busbars are live.

20. Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities at both in-service and withdrawn positions. For safe maintenance, withdrawable circuit breakers, switches and fixed disconnectors are to be capable of being locked by key or some other equivalent means.

21. The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that the live contacts are automatically covered at the withdrawn position.

22. If electrical energy or physical energy is required for the operation of circuit breakers, switches and the like, a store supply of such energy is to be provided for at least two operations of all the components. If stored electrical energy sources are necessary for the tripping due to overload, short-circuit or under-voltage, alarms which activate upon discontinuity in the release circuits and power supply failures are to be provided.

23. The air clearances (phase-to-phase, pole-to-pole and phase-to-earth) of the non-insulated busbars of high voltage switchboards and control boards, and the air clearances of high voltage control equipment are not to be less than the values given in **Table 2.16**. When difficulty arises in meeting the above requirements, the measures deemed appropriate by the Society are to be adopted.

24. The air clearances of high voltage electrical equipment other than the equipment specified in **-23** and the creepage distances of all high voltage electrical equipment are not to be less than the values deemed appropriate by the Society.

25. Control circuits are to be separated from main circuits by partitions insulated with flame-retardant material.

26. The secondary winding of current and voltage transformers for control circuits is to be earthed. In this case, the earthing conductor is to be of copper and have a minimum cross-section area of 4 mm^2.

27. For forced-ventilated transformers, the running condition of the ventilators and the temperature of the cooling air are to be monitored.

28. For transformers using a heat exchanger equipped with a closed circuit cooling method, the temperature sensors are to be provided so as to monitor the cooling air temperature. transformers, particularly those employing a water forced-cooled system, are also to be provided with leakage monitoring devices and fitted so that leakage-water and condensed moisture are kept away from the transformer windings.

Table 2.16 Minimum Air Clearances

Rated voltage (*V*)	Non-insuated busbars (*mm*)	High voltage control equipment (*mm*)
Above 500 and 1,000 or below	35	20
Above 1,000 and 3,600 or below	55	30
Above 3,600 and 7,200 or below	90	60
Above 7,200 and 12,000 or below	120	100
Above 12,000	160	--

2.17.4 Protective Devices, etc.

1. Fuses are not to be used for overload protection.

2. In order to protect a generator from any internal malfunctions and from any electrical failures between the generator and its circuit breakers, differential protection relays are to be provided.

3. Excitation systems of generators are to be so designed that faulty generator can be de-excited automatically.

4. In order to prevent any problems of over voltage, protective devices are to be provided for the temperature sensor circuits of the windings that are fitted to rotating machines.

5. Circuit-breakers are generally to be used for short-circuit protection at the primary side of transformers.

6. When transformers are arranged in parallel, tripping of the protective device at the primary side is to be followed automatically by tripping of the switch connected at the secondary side.

7. Oil immersed transformers are to be provided with the following alarms and safety devices.

(1) Alarms for low oil level and high oil temperature

(2) Stopping or load reducing devices for low oil level and high oil temperature

(3) Stopping devices for high gas pressure

8. When a single consumer, such as bow thruster or others, is supplied directly at a higher voltage via step-up transformer, the transformer may be protected at the lower-voltage side.

9. Protective measures are to be taken to prevent any problems of short circuit in both the primary and secondary sides of voltage-transformers used for control circuits. However, these protective measures may be omitted in cases where any power loss causes a critical condition in any related system.

10. Low voltage circuits fed through step-down transformers from high voltage circuits are to be protected so that there is no chance of any overlapping between the high voltage and low voltage circuits.

11. A device capable of indicating any earth fault in the system by means of a visual and audible alarm is to be provided.

12. In low impedance neutral earthed systems or direct neutral earthed systems, a provision is to be made to disconnect the faulty circuits automatically. High impedance neutral earthed systems, where outgoing feeders are not isolated in case of an earth fault, are to be capable of withstanding the transitional over voltage caused by the earth fault.

2.17.5 Cables

1. High voltage cables are to have a metallic sheath or a metallic armour. Where the high voltage cables having neither metallic sheath nor metallic armour are used, they are to be protected by metallic ducts or pipes or electrically conductive non-metallic ones complying with the requirements specified in **2.9.14-3(4)** through their length. These ducts or pipes are to be ensured of their electrical continuity with earthing.

2. High voltage cables associated with different voltages are not to be run in the same duct or pipe. These cables may be run on the same tray if they are fixed by individual clips and isolated each other at a distance of at least the air clearance of non-insulated busbars (for the higher voltage cable) given in the **Table 2.16**.

3. High voltage cables are to be installed as far apart from lower voltage cables as possible and to be laid in a place not liable to mechanical damage. These cables are not to be run on or in the same tray, duct or pipe.

4. Where practicable, high voltage cables are not to be run through accommodation spaces. In case where these cables are necessarily run through accommodation spaces, they are to be installed for their entire length in enclosed cable pipes.

5. The terminal ends of high voltage cables and the connecting parts for high voltage cables are to be made of materials that will not negatively impact the overall integrity of the cable as well as be sufficiently protected by insulation in order to prevent, as much as is practically possible, any electrical accidents.

6. When the conductors inside of a terminal box are not insulated, sufficiently insulated shields are to be provided to ensure proper phase-to-phase and phase-to-earth separation.

7. High voltage cables are to be appropriately marked or color-coded to ensure easy identification.

2.17.6 Testing

1. High voltage electrical equipment and cables are to be tested in accordance with all applicable requirements of **Part 6**. High voltage test, however, is also to comply with the following requirements in this **2.17.6**.

2. Internal arc fault tests on high voltage switchboards, in accordance with the standards deemed appropriate by the Society, are to be carried out at the place of manufacturer, etc. However, the subsequent testing of identical units of the same series may be omitted subject to the approval of the Society.

3. The following high voltage tests on high voltage electrical equipment and cables are to be carried out at the place of manufacturer, etc.:

(1) Test voltages for high voltage switchboards and control boards of the following values.
Rated voltages above 500*V* and 1,000*V* or below: twice the rated voltage + 1,000*V*
Rated voltages above 1,000*V* and 3,600*V* or below: 10,000*V*
Rated voltages above 3,600*V* and 7,200*V* or below: 20,000*V*
Rated voltages above 7,200*V* and 12,000*V* or below: 28,000*V*
Rated voltages above 12,000*V*: 38,000*V*

(2) Test voltages for high voltage transformers of the following values.
Maximum voltages above 500*V* and 1,100*V* or below: 3,000*V*
Maximum voltages above 1,100*V* and 3,600*V* or below: 10,000*V*
Maximum voltages above 3,600*V* and 7,200*V* or below: 20,000*V*
Maximum voltages above 7,200*V* and 12,000*V* or below: 28,000*V*
Maximum voltages above 12,000*V*: 38,000*V*

(3) At least five impulses are to be applied to the stator coils for high voltage rotating machines. The peak value of the test voltage is $\sqrt{6}$ times the rated voltage.

(4) Test voltages for high voltage cables of the following values.
Rated voltages above 500*V* and 1,000*V* or below: 3,500*V*
Rated voltages above 1,000*V* and 3,600*V* or below: 6,500*V*
Rated voltages above 3,600*V* and 7,200*V* or below: 12,500*V*
Rated voltages above 7,200*V* and 12,000*V* or below: 21,000*V*
Rated voltages above 12,000*V*: 30,500*V*

4. High voltage cables, after installation on board, are to be confirmed as having no abnormalities by testing them with the voltage in direct current (*d.c.*) equal to 4.2 times the rated voltage for a period of 15 *minutes*. However, in certain cases, alternative testing procedures, in lieu of that specified above, may be accepted by the Society.

2.18 Tests after Installation on Board

2.18.1 Insulation Resistance Test

1. For each circuit of electric propulsion, auxiliary power and lighting, insulation resistance between each conductor and earth and, if applicable, between conductors is to be measured and its value is to be less than the value specified in **Table 2.17**.

2. Insulation resistance of internal communication circuits is to comply with the following **(1)** and **(2)**. In this case, any or all appliances connected thereto may be disconnected.

(1) For each circuit of 100 *V* and above, insulation resistance between each conductor and earth, if applicable, between conductors is to be measured and its value is to be less than 1 *M*Ω.

(2) For circuits below 100 *V*, the insulation resistance is to be at least 1/ 3*M*Ω.

3. The insulation resistance of each generator and motor under working temperature is to be the value specified in **Table 2.6**.

Table 2.17 Minimum Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance (*MΩ*)
$Un \leq 250$	2 x *Un*	1
$250 < Un \leq 1{,}000$	500	1
$1{,}000 < Un \leq 7{,}200$	1,000	*Un*/1,000+1
$7{,}200 < Un$	5,000	*Un*/1,000+1

Note:

During the above test, any or all electric heaters, small appliances and the like connected may be disconnected from the circuit.

2.18.2 Performance Tests

1. Generators are to be tested in accordance with the following requirements **(1)** to **(3)**. During these tests, governor characteristics, voltage regulation and load balance are to be satisfied the requirements of **2.4.2**, **2.4.13** and **2.4.14**:

(1) The operation of overspeed trip and other safety devices is to be demonstrated.

(2) Tests are to be made to demonstrate that voltage regulation and parallel operation are satisfactory.

(3) All generating sets are to be run at full rated load for duration sufficient to demonstrate that temperature rises, communication, absence of vibration and others are satisfactory.

2. All switches, circuit-breakers and associated equipment on the switchboard are to be operated on load to demonstrate suitability, and also section boxes and distribution boxes are to be tested as above.

3. Motors are to be tested in accordance with the following requirements **(1)** to **(3)**:

(1) Motors and their controlgears are to be examined under working condition that wiring, capacity, speed and operation are satisfactory.

(2) Each motor driving auxiliary machinery is to be run to demonstrate that operating characteristics are satisfactory.

(3) All motors driving cargo winches and windlasses are to hoist and lower their specified load.

4. Lighting system is to be tested in accordance with the following requirements **(1)** and **(2)**:

(1) All circuits are to be tested to demonstrate that the lighting fittings, branch boxes, switches, socket-outlets and other accessories are connected effectively and function satisfactorily.

(2) Emergency lighting circuits are to be tested in the same manner specified in **(1)**.

5. Electric heaters, electric cooking ranges and the like are to be tested to demonstrate that the heating elements function satisfactorily.

6. Each internal communication system is to be thoroughly tested to demonstrate its suitable and specified functioning. particular attention is to be paid to the tests of operation of the ship's essential electrical communication systems which include engine order telegraphs, helm indicators, fire alarms, emergency signals, Morse signal lamps, a navigation light indicator panel and telephones.

2.18.3 Voltage Drop

During above tests, it is to be ascertained that the voltage drop of feeder circuits does not exceed values specified in **2.9.6**.

Chapter 3 DESIGN OF INSTALLATIONS

3.1 General

3.1.1 General

This chapter specifies the requirements for the design of installations of main source of electrical power, emergency source of electrical power and other electrical installations on board ships.

3.1.2 Design and Construction

Electrical installations are to comply with the followings:

(1) All electrical auxiliary service necessary for maintaining the ship in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power;

(2) Electrical services essential for safety will be ensured under various emergency conditions; and

(3) The safety of passengers, crew and ship from electrical hazards will be ensured.

3.2 Main Source of Electrical Power and Lighting Systems

3.2.1 Main Source of Electrical Power

1. A main source of electrical power of sufficient capacity to supply all those services specified in **3.1.2(1)** is to be provided. This main source of electrical power is to consist of at least two generating sets.

2. The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability is also to be ensured which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

3. Where the main source of electrical power is necessary for propulsion and steering of the ship, the system is to be so arranged that the electrical supply to 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. The arrangements of the ship's main source of electrical power are to be such that the services referred to the requirement in **3.1.2(1)** can be maintained regardless of the speed and direction of the propulsion machinery or shafting.

5. The generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets are to be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by the requirements in **3.3.2-2(1)** to **(4)**.

3.2.2 Number and Ratings of Transformers

Where transformers constitute an essential part of the electrical supply system required by 3.2.1, the system is to be so arranged as to ensure the same continuity of the supply as is stated in 3.2.1.

3.2.3 Lighting Systems

1. A main electric lighting system supplied from the main source of electrical power is to be provided in spaces or compartments where crew and personnel use and normally work on duty.

2. The main electric lighting system is to be so arranged as not to be impaired in the event of a fire or other causality in spaces containing the emergency source of electrical power, associated transforming equipment, the emergency switchboard and the emergency lighting switchboard.

3. Emergency lighting is to provide sufficient illumination necessary for the safety;

(1) At every muster and embarkation station as required by the *Paragraph 4, Regulation 11, Chapter III, the Annex to SOLAS Convention;*

(2) In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks;

(3) In the machinery spaces and main generating stations including their control positions;

(4) In all control stations, machinery control rooms, and at each main and emergency switchboard;

(5) At all stowage positions for firemen s outfit;

(6) At the steering gear;

(7) At the fire pump referred to in 3.3.2-2(5), at the sprinkler pump, if any, and at the emergency bilge pump, if any, and at the starting positions of their motors; and

(8) In cargo pump rooms for tankers intended for the carriage in bulk of liquid cargoes or dangerous chemicals having a flash point not exceeding 60°C other than liquefied gasses.

4. The emergency electric lighting systems specified in **-3**, the emergency electric lighting systems required by the *Paragraph 7, Regulation 16, Chapter III, the Annex to SOLAS Convention***,** as well as navigation lights and other lights specified in 3.3.2-2(3) are to be so arranged as not to be impaired in the event of a fire or other causality in spaces containing the main source of electrical power, associated transforming equipment, the main switchboard and the main lighting switchboard.

3.2.4 Location of Main Switchboard

The main switchboard and main generating stations are to be located in a same space. However, main switchboards may be separated from generators by an environmental enclosure, such as may be provided by a machinery control rooms situated within the main boundaries of the spaces.

3.3 Emergency Source of Electrical Power

3.3.1 General

1. A self-contained emergency source of electrical power is to be provided.

2. The emergency source of electrical power, associated transforming equipment, the transitional source of emergency electrical power, the emergency switchboard and the emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead, except where permitted by the Society in exceptional circumstances.

3. The location of the emergency source of electrical power, associated transforming equipment, the transitional source of emergency electrical power, the emergency switchboard and the emergency lighting switchboard are to be such as to ensure to the satisfaction of the Society that a fire or other casualty in the space containing the main source of electrical power, associated transforming equipment, and the main switchboard, or in any machinery space of category *A* will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, the transitional source of emergency electrical power and the emergency switchboard is not to be contiguous to the boundaries of machinery spaces of category *A* or to those spaces containing the main source of electrical power, associated transforming equipment and the main switchboard.

4. Provided that suitable measures are taken for safeguarding the independent emergency operation under all circumstances, the emergency generator may be used exceptionally and for short periods to supply to non-emergency circuits.

3.3.2 Capacity of Emergency Source of Power

1. The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously.

2. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(1) For a period of 3 *hours*, the emergency lighting specified in **3.2.3-3(1)** and the emergency lighting required by the *Paragraph 7, Regulation 16, Chapter III, the Annex to SOLAS Convention*

(2) For a period of 18 *hours*, the emergency lighting specified in **3.2.3-3(2)** to **(8)**

(3) For a period of 18 *hours*, the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force and lights required by the National Regulations of the country to which the ship is registered.

(4) For a period of 18 *hours*:

(a) All internal communication equipment as required in an emergency;

(b) VHF radio installations, MF radio installations, *INMARSAT* Ship Earth Stations and MF/HF radio installations as required *by Chapter IV, the Annex to SOLAS Convention* and installed in the ship. Where, however, these radio installations are installed in duplicate, it is not necessary to consider duplicated installations are operated simultaneously in determining capacity of the emergency source of electrical power.

(c) The navigational aids, which requires electrical sources, as required by *Regulation 19 and 20, Chapter V, the Annex to SOLAS Convention.* Where such provision is unreasonable or impracticable this requirement may be waived for ships of less than 5,000 gross tonnage;

(d) The fire detection and fire alarm system; and

(e) Intermittent operation of the daylight signaling lamp, the ship's whistle, the manual fire alarms, and all internal signals that are required in an emergency; unless such services have an independent supply for the period of 18 *hours* from an accumulator battery suitably located for use in an emergency.

(5) For a period of 18 *hours*, the fire pump so designed as to depend upon the emergency generator by the requirements in **10.2.2-3, Part 6**.

(6) For the period of time required by **15.2.6, Part 7**, the steering gear where it is required to be so supplied by that requirement.

(7) For a period of 30 *minutes*, indications showing whether the closing means are opened or closed and audible alarms showing the closing means are operating as required by **1.3.1, Part 3**, and indications showing whether the closing means are opened or closed as required by **1.3.2, Part 3** and **30.2.1, Part 2** of the Rules if they are operated by electrical Power.

(8) For the period of 3 *hours*, intermittent operation of means to bring the stabilizer wings inboard and indicators to show the position of them, as required *by Paragraph 9, Regulation 16, Chapter III, the Annex to SOLAS Convention.*

(9) For the period of 3 *hours*, intermittent operation of the secondary launching appliances of the free-fall lifeboat as required by *Paragraph 6.1.4.7, Chapter VI of the International Life-Saving Appliances (LSA) Code.*

(10) In a ship engaged regularly in voyages of short duration, the Society if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 18 *hours* period specified in **(2)** to **(5)** but not less than 12 *hours*.

3. Where electrical source is necessary to restore propulsion, the capacity of the emergency source of power shall be sufficient to restore propulsion to the ship from a dead ship condition within 30 *minutes* after blackout.

3.3.3 Kind and Performance of Emergency Source of Electrical Power

The emergency source of electrical power is to be a generator or an accumulator battery or an uninterruptible power system, which is to comply with the following:

(1) Where the emergency source of electrical power is a generator, it is to comply with the following:

(a) The emergency generator is to be driven by a suitable prime mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C;

(b) The emergency generator is to be started automatically upon failure of the main source of electrical power supply unless a transitional source of emergency electrical power in accordance with **(c)** is provided; where the emergency generator is automatically started, it is to be automatically

connected to the emergency switchboard; those services referred to the requirements in 3.3.4 are then to be connected automatically to the emergency generator;

(c) A transitional source of emergency electrical power as specified in 3.3.4 is to be provided unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 *seconds*.

(2) Where the emergency source of electrical power is an accumulator battery it is to be capable of:

(a) Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

(b) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

(c) Immediately supplying at least those services specified in paragraph 3.3.4.

(3) Where the emergency generator is an interruptible power system, the requirements are as deemed appropriate by the Society.

3.3.4 Transitional Source of Emergency Electrical Power

The transitional source of emergency electrical power where required by 3.3.3(1)(c) is to consist of an accumulator battery suitably located for use in an emergency which is to:

(1) Operate without recharging while maintaining the voltage of the battery through the discharge period within 12% above or below its nominal voltage; and

(2) Be of sufficient capacity and be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

(a) The lighting required by 3.3.2-2(1) to **(3)**. For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

(b) All services required by 3.3.2-2(4)(a), **(d)** and **(e)** unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

3.3.5 Location, etc. of Emergency Source of Electrical Power

1. The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

2. Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3. No accumulator battery fitted in accordance with this 3.3 is to be installed in the same space as the emergency switchboard.

4. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of electrical power referred to the requirements in **3.3.3(2)** or **3.3.4** are being discharged.

5. An interconnector feeder connecting the emergency switchboard and the main switchboard is to be:

(1) Adequately protected at the main switchboard against overload and short circuit;

(2) Disconnected automatically at the emergency switchboard upon failure of the main source of electrical power ; and

(3) Protected at the emergency switchboard at least against short circuit where the system is arranged for feedback operation. In addition, the emergency switchboard is to be supplied during normal operation from the main switchboard.

6. Arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power shall be available automatically to the emergency circuits.

3.3.6 Provision for the Testing

Emergency electrical system is to be provided with measures for periodic testing. The periodic testing is to include the testing of automatic starting arrangements.

3.4 Starting Arrangement for Emergency Generating Sets

3.4.1 General

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

2. Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society with a stored energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy is to be provided for an additional three starts within 30 *minutes* unless manual starting can be demonstrated to be effective.

3. The stored energy is to be maintained at all times, as follows:

(1) Electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

(2) Compressed air starting systems may be maintained by the main or auxiliary compressed air reservoirs through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

(3) All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency

generating set. This does not preclude the supply to the air reservoir of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

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

5. When manual starting is not practicable, the starting arrangements are to comply with the requirements **-2** and **-3**, except that starting may be manually initiated.

3.5 Steering Gear

3.5.1 General

See **Chapter 15**, **Part**.

3.6 Navigation Lights, Other Lights, Internal Signals, etc.

3.6.1 Navigation Lights

1. Navigation lights are to be connected separately to the navigation light indicator panel.

2. Each navigation light is to be controlled and protected in each insulated pole by a switch with fuses or a circuit breaker fitted on the navigation light indicator panel.

3. The navigation light indicator panel is to be power supplied by a separate circuit from the main switchboard or the secondary busbar of transformers connected to it and from the emergency switchboard or the secondary busbar of transformers connected to it respectively. The circuits are to be separated throughout their length as widely as practicable.

4. Switches and fuses are not to be provided on the feeder circuits of navigation lights, except the switchboards and indicator panel.

5. The navigation light indicator panel is to be placed in an accessible position on the navigation bridge.

3.6.2 Not Under Command Lights and Anchor Lights

Not under command lights and anchor lights are to be power supplied from both main source of electrical power and emergency source of electrical power.

3.6.3 Signal Lights

Signal lights are to be power supplied from both main source of electrical power and emergency source of electrical power.

3.6.4 General Emergency Alarm Systems

General emergency alarm system specified in the Regulation 51 and public address system or other suitable means of communication specified in the *Paragraph 4.2, Regulation 6, Chapter III, the Annex to SOLAS Convention* are to be power supplied from both main source of electrical power and emergency source of electrical power.

3.6.5 On-board Communications

On-board communication specified in the *Paragraph 4.1, Regulation 6, Chapter III, the Annex to SOLAS Convention* is to be power supplied from the electrical source(s) suitably located for use in an emergency.

3.7 Lightning Conductors

3.7.1 General

Lightning conductors are to be fitted on each mast of ships having wooden masts or topmasts.

3.7.2 Construction

1. Lightning conductors are to be composed of continuous copper tape or rope having a section not less than 75 mm^2 which is riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 12 *mm* in diameter, projecting at least 150 *mm* above the top of the mast. At the lower end, this copper tape or rope is to be securely clamped to the nearest metal forming part of the ship.

2. Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided.

All clamps used are to be of brass or copper, preferably of the serrated contact type, and effectively locked. No connection is to be dependent on a soldered joint.

3. The resistance of lightning conductor between the mast top and the point on the earth plate or hull is not to exceed 0.02 Ω.

3.8 Spare parts, Tools and Instruments

3.8.1 Spare parts

1. For the rotating machines and controlgears intended for electric propulsion plant, the articles of spare parts specified in **Table 3.1**, **Table 3.3** and **Table 3.5** are to be supplied.

2. For ship's service generators, motors important use and their controlgears and switchboards, the articles of spare parts specified in **Table 3.1** to **Table 3.5**, so far as applicable, are recommended to be supplied as a standard.

3. The number required in **-1** and **-2** is the number of spare parts for total identical installation per ship.

4. For steering gear motors and motor-generators, if no stand-by machine is installed, the spare parts in Table 3.2 are to be supplied in addition to the spare parts for motors enumerated in Table 3.1.

5. Where the voltage of emergency lighting circuits are different from that of general service, 1 for each 2 of lamps are to be supplied as the spare.

3.8.2 Testing Instruments

For ships having electrical installations of 50 *kW* and above, 500 *V* insulation resistance meter is to be supplied in order that the insulation may be tested at regular intervals. In addition, the following portable instruments are to be provided:

(1) One portable voltmeter, *a.c*. or *d.c*. or both as required.

One portable ammeter, *a.c*. or *d.c*. or both as required, with shunts or current transformers as required

Table 3.1 Spare parts for Generators, Exciters and Motors

Spare parts	Number required
Bearing or bearing linings including oil ring	1 for each 4 or less
Brushholders	1 for each 10 or less
Brushholders springs	1 for each 4 or less
Brushes	1 for each 1
Field coils for *d.c*. machines except for uninsulated inter-pole coils	1 for each 10 or less
Resistors for field rheostat and discharge resistors for generators and exciters	*See* Table 3.5
Armatures of cargo winch d.c. motors	1 for each 6 or more motors
Stators of cargo winch *a.c*. cage-rotor motors	1 for each 6 or more motors
Rotors of cargo winch *a.c*. would-rotor motors	1 for each 6 or more motors
Slip-rings for electric propulsion machines	1 for each kind and size

3.8.3 Disassembling Tools

Where special tools are required to adjust or disassemble the equipment, one set of each tool is to be provided.

3.8.4 Storage and Packing

All spare parts, instruments and tools are to be packed in suitable wooden boxes or corrosion-protected steel boxes and to be marked with the contents on the surface of boxes and to be placed in suitable places. Where lockers are provided to store these spare parts, individual boxes may be omitted.

Table 3.2 Additional Spare parts for Steering Gear Motors without Stand-by Motor or Motor-generator

Spare parts	Number required
Armatures of *d.c.* motors and motorgenerator	1 for each size (complete with shaft and coupling)
Stators of *a.c.* cage-rotor motors	1 for each size
Rotors of *a.c.* would-rotors motor	1 for each size (complete with shaft and coupling)

Table 3.3 Spare Parts for Control Gear

Spare parts	Number required
Contact pieces (arcing or wear parts)	1 set for each 2 sets of less
Springs	1 for each 4 or less
Operating and shunt coils	1 for each 10 or less
Resistors of each kind and size	1 for each 10 or less
Fuses and their elements	See **Table 3.5**
Lamp lenses and bulbs	See **Table 3.5**

Table 3.4 Spare Parts for Brakes

Spare parts	Number required
Shoe lining and rivets	1 set for each 4 or less
Springs	1 for each 4 or less
Coils	1 for each 10 or less

Table 3.5 Spare Parts for Switchboards, Section Boards and Distribution Boards

Spare parts	Number required
Fuses (non-renewable)	1 for each, but need not exceed 20 in total
Fuses (renewable)	1 for each 10, but need not exceed 10 in total
Fuse elements of renewable fuses	1 for each
Arcing contacts	1 for each, but need not exceed 10 in total
Springs	1 for each, but need not exceed 10 in total
Complete trip element assembly, where interchangeable tripelements are used for moulded case thermal type circuit-breakers	1 for each 10 identical trip element or less
Complete moulded case thermal type circuit-breakers, where non-erchangeable trip elements are used	1 for each group of 10 identical breakers or less
Potential coils	1 for each rating and type
Resistors	1 for each rating and type
Lenses of pilot and signal lamps	1 for each 10 identical lenses or less
Lamps of pilot and signal lamps	1 for each

Chapter 4 ADDITIONAL REQUIREMENTS FOR SHIPS CARRYING SPECIAL CARGOES

4.1 General

4.1.1 Scope

Electrical installations for ships or cargo spaces carrying special cargoes as specified in the following **(1)** to **(4)** are to comply with the requirements in this chapter, in addition to the requirements in other relevant chapters in this part.

(1) Tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk

(2) Enclosed cargo holds for motor vehicles with fuel in their tanks for their own propulsion and enclosed compartments adjoining an enclosed cargo hold

(3) Coal carriers

(4) Ships carrying dangerous godos

4.2 Tankers, Ships Carrying Liquefied Gases in Bulk and Ships Carrying Dangerous Chemicals in Bulk

4.2.1 General

Electrical equipment for tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk is to comply with all applicable requirements in this part and the requirements in **Chapter 4, PART 9 of the Rules**.

4.2.2 Distribution System

1. Notwithstanding the requirement in 2.2.1-1, the distribution system is to be one of the following.

(1) Two-wire insulated *d.c.* system

(2) Single-phase two-wire insulated *a.c.* system

(3) Three-phase three-wire insulated *a.c.* system

2. Notwithstanding the requirement in **-1**, a hull return distribution system may be used for the systems listed in 2.2.1-2(1) to **(3)**.

3. Notwithstanding the requirement in **-1**, an earthed distribution system may be used for the following systems.

(1) Intrinsically safe circuits

(2) Power supplies, control circuits and instrumentation circuits where technical or safety reasons demanded to the earthed systems, provided that the current in the hull is limited to not more than 5*A* in both normal and fault conditions

(3) Locally earthed systems for limited use or a.c. power networks of 1,000*V* root mean square line voltages and over, provided that any arising earthing current does not flow directly through any hazardous areas

4. The neutral or earth conductor required for protection against electric shock is not to be connected together with a single conductor in a hazardous area.

4.2.3 Hazardous Areas

1. Hazardous areas for tankers are to be categorized in accordance with the requirements in **4.3.1**, **4.4.1** and **4.5.1**.

2. Hazardous areas for ships carrying dangerous chemicals in bulk are to be categorized in accordance with the requirements in **4.3.1**, **4.4.1**, **4.5.1** and **4.6.1**.

3. Hazardous areas for ships carrying liquefied gases in bulk are to be categorized in accordance with the requirements in **4.7.1**.

4. Areas and spaces not mentioned in **-1** to **-3**, but considered to present risks of the presence of an explosive gas atmosphere, are to be categorized as hazardous areas in accordance with the requirements otherwise specified by the Society.

5. Access doors or other openings are not to be provided in the following boundaries except where required for operational purposes and safety reasons on ships. Where access doors or other openings are provided, the areas connected to the boundaries are to be categorized as hazardous areas in accordance with the requirements otherwise specified by the Society.

(1) The boundary between Zone 1 and Zone 2

(2) The boundary between hazardous areas and non-hazardous areas

4.2.4 Electrical Installations in Hazardous Areas

1. Electrical installations are not to be installed in hazardous areas unless essential for operational purposes or safety reasons on ships. However, where the following electrical installations are installed necessarily, the requirements do not apply.

(1) Zone 0

- (a) Category "*ia*" intrinsically safe type electrical equipment including simple electrical apparatus (thermocouples, switching devices, etc.) and associated cables
- (b) Submerged cargo pump motors and their supply cables (In this case, the motors are to be automatically stopped off with alarms by at least two independent detecting method which are pump delivery low pressure, lower current of motors or low liquid level.)

(2) Zone 1

- (a) Electrical installations specified in **(1)**
- (b) Category "*ib*" intrinsically safe type electrical equipment including simple electrical apparatus (thermocouples, switching devices, etc.) and associated cables
- (c) Flameproof type or pressurized type electrical equipment and associated cables
- (d) Increased safety type, encapsulated type, powder filling type or oil immersion type electrical equipment and associated cable

(e) Hull fittings (terminals or shell-plating penetrations for anodes or electrodes of an impressed current cathodic protection system, or transducers such as those for depth-sounding or log systems) and associated cables

(f) Through runs of cables

(3) Zone 2

(a) Electrical installations specified in **(2)**

(b) Other electrical equipments deemed appropriate by the Society and associated cables

2. Where electrical equipment are installed in hazardous areas in accordance with the requirement **-1**, the equipment are to be confirmed that it is safely usable in the explosive gas atmosphere concerned.

3. Aerials and associated riggings are to be sited well clear of gas or vapour outlets.

4. As a rule, no portable electrical equipment is to be located in harzarous areas. Where it is unavoidable to locate the equipment in hazardous areas, it is subject to the approval of the Society.

5. Cables are to be one of the following. Where corrosion may be expected, a *PVC* or chroloprene sheath is to be applied over armour or metallic sheath of cables for corrosion protection.

(1) Mineral insulated and copper sheathed

(2) Lead alloy sheathed and metal armoured

(3) Non-metallic sheathed and metal armoured

6. Installation of cables is to comply with the followings:

(1) Cables are to be installed as close to the hull centre line as practicable.

(2) Cables are to be installed sufficiently distant from decks, bulkheads, tanks and various kinds of pipes.

(3) Cables are, as a rule, to be protected against mechanical damage. Especially, cables installed on open decks are to be protected by metallic casings or non-metallic casings complying with the requirements specified in **2.9.14-3(4)**. Further, the cables and their supports are to be fitted in such a manner as to withstand expansion, contraction and other effects of the hull structure.

(4) The penetration part of the cables or cable pipes through decks and bulkheads of the hazardous areas is to be constructed so as to maintain gas-tightness and liquid-tightness as the case may require.

(5) When mineral insulated cables are used, special precautions are to be taken to ensure sound terminations.

(6) Cables are to be connected to explosion-protected electrical equipment only by means of a gland or equivalent device.

(7) Where cable joints are used, it is subject to the approval of the Society. In this case, cable joints are permitted to be in zones 1 and 2. Especially for intrinsically-safe circuits, they are permitted to be in zone 0.

(8) Where cables are immersed in cargos, the construction of the cables is to be such as to withstand the substances to which they can be exposed, or the cables are to be enclosed in casings, e.g. metallic pipes, which is capable of withstanding such substances.

(9) Where cables run through cargo pump room entrances, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

7. Metallic coverings of power and lighting cables as listed below are to be earthed at least at both end. Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20*A*, metallic coverings of cables are to be earthed at single point. In this case, the non-earthing point is not to be located in hazardous areas.

(1) Cables passing through hazardous areas

(2) Cables connected to equipment installed in hazardous areas

8. Electrical circuits path through Zone 0 are to be made the following measures.

(1) The circuits other than intrinsically-safe circuits are to be disconnected automatically in the event of an abnormally low level of insulation resistance and high level of leakage current.

(2) The protective systems are to be arranged so that manual intervention is necessary for the reconnection of the circuit after disconnection as the result of a short circuit, overload or earth-fault condition.

9. Where flame-proof type electrical motors for cargo handling equipment are installed in cargo pump room or cargo compressor room, the motors is to be arranged so that it is easy to approach them and make sure to carry out the maintenance and survey for them.

4.2.5 Lighting in Hazardous Areas

1. Where hazardous areas are lit by the lighting fittings located in adjacent non-hazardous areas through glazed ports fitted in the bulkheads or decks, these glazed ports are to be so constructed as not to impair the water-tight, gastight, fireproof and strength integrity of the bulkheads and decks. Due consideration is to be given to the ventilation of the lighting fittings so that the excessive temperature rise is not caused on the glazed ports.

2. The lighting fittings installed in cargo pump room and cargo compressor room are to be divided between at least two branch circuits.

3. All switches and protective devices related with the circuits specified in **-2** are to interrupt all poles or phases and to be located in non-hazardous areas.

4.2.6 Ventilation in Hazardous Areas

1. Ventilators installed in cargo pump room or cargo compressor room are to be arranged in order that discontinuities of ventilation are not expected to occur for long periods and accumulation of gas or vapour is not occurred. In case of failure of the ventilation, an alarm is to be activated in a continually manned space, e.g. the navigation bridge or the machinery control room, in addition to the cargo pump room and cargo compressor room.

2. Electric motors for the ventilators specified in **-1** are to be placed outside the ventilation ducts.

3. The ventilators specified in **-1** are not to produce a source of ignition.

4. In tankers, notwithstanding the requirement in **4.5.4-1(1)**, **Part 6**, the air change ratio of the ventilation in cargo pump room is to be at least 30 per hour, based upon the gross volume of the space. However, when deemed appropriate by the Society, these requirements do not apply.

4.2.7 Maintenance for Explosion-protected Electrical Equipment

Maintenance deemed appropriate by the Society for explosion-protected electrical equipment in hazardous areas are to be periodically carried out by experienced personnel who are sufficiently trained about it. The documentations for the maintenance are to be kept on board.

4.3 Tankers and Ships Carrying Dangerous Chemicals in Bulk Having a Flashpoint Not Exceeding 60°C.

4.3.1 Classification of Hazardous Areas

The areas or spaces in tankers and ships carrying dangerous chemicals in bulk having a flashpoint not exceeding 60°C are to be classified in Zone 0, 1 and 2 as follows.

(1) Zone 0

(a) Cargo tanks and slop tanks

(b) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks

(c) Interior of cargo pipes

(2) Zone 1

(a) Void spaces adjacent to integral cargo tanks

(b) Hold spaces containing independent cargo tanks

(c) Cofferdams and segregated ballast tanks adjacent to cargo tanks (fuel oil tanks, lubricating oil tanks, etc. are regarded as a cofferdam, the same being referred hereinafter.)

(d) Cargo pump rooms

(e) Enclosed or semi-enclosed spaces (means spaces separated by decks and bulkheads where the condition of ventilation is significantly different from that of exposed spaces of ships) immediately above cargo tanks or having bulkheads above and in line with cargo tank bulkheads

(f) Spaces other than cofferdams and segregated ballast tanks, adjacent to and below the top of a cargo tank (for example, trunks, passage-ways, holds, the same being referred hereinafter.)

(g) Areas on open deck or semi-enclosed spaces on open deck, within a sphere of 3*m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets (for example, cargo tank hatches, sight ports, tank cleaning openings, sounding pipe openings, etc., the same being referred hereinafter.), cargo manifold valve, cargo valve, cargo pipe flange and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variation

(h) Areas on open deck or semi-enclosed spaces on open deck, within a vertical cylinder of unlimited height and 6*m* radius from the outlet centre, and within a hemisphere of 6*m* radius below the outlet which permits the flow of large volumes of gas or vapour during loading, discharging or ballasting

(i) Areas on open deck or semi-enclosed spaces on open deck, within 1.5*m* from cargo pump room entrances, within a sphere of 1.5*m* radius from of cargo pump room ventilation inlet and openings specified in **(2)**

(j) Areas on open deck within spillage coamings surrounding cargo manifold valves and 3*m* beyond these, up to a height of 2.4*m* above the deck

(k) Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank block, the same being referred hereinafter.) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3*m* fore and aft on open deck, up to a height of 2.4*m* above the deck

(l) Compartments for cargo hoses

(m) Enclosed or semi-enclosed spaces in which pipes containing cargos are located

(3) Zone 2

(a) Areas on open deck or semi-enclosed spaces on open deck, within 1.5*m* surrounding the areas specified in (except the hazardous areas otherwise specified in the Rules, the same being referred hereinafter.)

(b) Spaces within 4*m* surrounding the areas specified in **(2)(h)**

(c) Spaces forming an air-lock between the areas specified in **(2)** and non-hazardous areas

(d) Areas on open deck within spillage coamings intended to keep spillages clear of accommodation and service spaces and 3*m* beyond these, up to a height of 2.4*m* above the deck

(e) Areas on open deck over all cargo tanks where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3*m* fore and aft on open deck, up to a height of 2.4*m* above the deck

(f) Spaces forward of open deck specified in **(e)** and **(2)(k)**, below the level of the open deck, and having openings at a level less than 0.5*m* above the open deck (except where the openings are situated at least 5*m* from the foremost cargo tank and at least 10*m* measured horizontally from any cargo tank outlet or gas or vapour outlet, and the spaces are mechanically ventilated, the same being referred hereinafter.)

(g) Ballast pump room adjacent to cargo tanks

4.4 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoint Exceeding 60°C and their Cargos are Heated more than Temperature which is 15°C lower than the Flashpoint

4.4.1 Classification of Hazardous Areas

The areas or spaces in tankers and ships carrying dangerous chemicals in bulk having a flashpoint exceeding 60°C and their cargos are heated more than temperature which is 15°C lower than the flashpoint are to be classified in accordance with the requirements specified in **4.3.1**.

4.5 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoint Exceeding 60°C and their Cargos are not Heated or Heated less than Temperature which is 15°C lower than the Flashpoint

4.5.1 Classification of Hazardous Areas

The areas or spaces in tankers and ships carrying dangerous chemicals in bulk having a flashpoint exceeding 60°C and their cargos are not heated or heated less than temperature which is 15°C lower than the flashpoint are to be classified in Zone 2 as follows.

(1) Cargo tanks and slop tanks

(2) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks

(3) Interior of cargo pipes

4.6 Ships Carrying Dangerous Chemicals in Bulk Reacting with other Products to Evolve Flammable Gases

4.6.1 Classification of Hazardous Areas

The areas or spaces in ships carrying dangerous chemicals in bulk reacting with other products to evolve flammable gases are to be classified in Zone 1 and 2 as follows.

(1) Zone 1

- (a) Cargo tanks and slop tanks
- (b) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks
- (c) Interior of cargo pipes
- (d) Cargo pump rooms
- (e) Compartments for cargo hoses

(2) Zone 2

- (a) Areas on open deck or semi-enclosed spaces on open deck, within 1.5*m* surrounding the areas specified in **(1)**
- (b) Void spaces adjacent to integral cargo tanks
- (c) Hold spaces containing independent cargo tanks
- (d) Cofferdams and segregated ballast tanks adjacent to cargo tanks
- (e) Enclosed or semi-enclosed spaces immediately above cargo tanks or having bulkheads above and in line with cargo tank bulkheads
- (f) Spaces other than cofferdams and segregated ballast tanks, adjacent to and below the top of a cargo tank
- (g) Enclosed or semi-enclosed spaces in which pipes containing cargos are located
- (h) Areas on open deck or semi-enclosed spaces on open deck, within a sphere of 1.5*m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets, cargo manifold valve, cargo valve,

cargo pipe flange and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variation

(i) Areas on open deck within spillage coamings surrounding cargo manifold valves and 1.5*m* beyond these,up to a height of 1.5*m* above the deck

(j) Areas on open deck or semi-enclosed spaces on open deck, within a vertical cylinder of unlimited height and 3*m* radius from the outlet centre, and within a hemisphere of 3*m* radius below the outlet which permits the flow of large volumes of gas or vapour during loading, discharging or ballasting

4.7 Ships Carrying Liquefied Gases in Bulk

4.7.1 Classification of Hazardous Areas

The areas or spaces in ships carrying liquefied gases in bulk are to be classified in Zone 0, 1 and 2 as follows.

(1) Zone 0

(a) Cargo tanks and slop tanks

(b) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks

(c) Interior of cargo pipes

(d) Hold spaces containing independent cargo tanks requiring a secondary barrier

(2) Zone 1

(a) Void spaces adjacent to integral cargo tanks

(b) Hold spaces containing independent cargo tanks not requiring a secondary barrier

(c) Cofferdams and segregated ballast tanks adjacent to cargo tanks

(d) Spaces separated from hold spaces specified in **(1)(d)** by a single gastight boundary

(e) Cargo pump rooms and cargo compressor rooms

(f) Enclosed or semi-enclosed spaces immediately above cargo tanks or having bulkheads above and in line with cargo tank bulkheads

(g) Spaces other than cofferdams and segregated ballast tanks, adjacent to and below the top of a cargo tank

(h) Areas on open deck or semi-enclosed spaces on open deck, within a sphere of 3 *m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets, cargo manifold valve, cargo valve, cargo pipe flange and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variation

(i) Areas on open deck or semi-enclosed spaces on open deck, within a vertical cylinder of unlimited height and 6*m* radius from the outlet centre, and within a hemisphere of 6*m* radius below the outlet which permits the flow of large volumes of gas or vapour during loading, discharging or ballasting

(j) Areas on open deck or semi-enclosed spaces on open deck, within 1.5*m* from cargo pump room entrances, within a sphere of 1.5*m* radius from of cargo pump room ventilation inlet and openings specified in **(2)**

(k) Areas on open deck within spillage coamings surrounding cargo manifold valves and 3*m* beyond these, up to a height of 2.4*m* above the deck

(l) Areas on open deck over all cargo tanks where structures are restricting the natural ventilation and to the full breadth of the ship plus 3*m* fore and aft on open deck, up to a height of 2.4*m* above the deck

(m) Compartments for cargo hoses

(n) Enclosed or semi-enclosed spaces in which pipes containing cargos are located

(3) Zone 2

(a) Areas on open deck or semi-enclosed spaces on open deck, within 1.5*m* surrounding the areas specified in **(2).**

(b) Spaces within 4*m* surrounding the areas specified in **(2)(i)**

(c) Spaces forming an air-lock between the areas specified in **(2)** and non-hazardous areas

(d) Areas on open deck within spillage coamings intended to keep spillages clear of accommodation and service spaces and 3*m* beyond these, up to a height of 2.4*m* above the deck

(e) Areas on open deck over all cargo tanks where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3*m* fore and aft on open deck, up to a height of 2.4*m* above the deck

(f) Spaces forward of open deck specified in **(e)** and **(2)(l)**, below the level of the open deck, and having openings at a level less than 0.5*m* above the open deck

(g) Spaces within 2.4*m* of the outer surface of cargo tanks where the surface is exposed to the weather

4.8 Enclosed Cargo Holds for Carrying Motor Vehicles with Fuel in Their Tanks for Their Own Propulsion and Enclosed Compartments Adjoining the Cargo Holds, etc.

4.8.1 Electrical Installations in Enclosed Cargo Holds, etc.

Enclosed cargo holds for carrying motor vehicles with fuel in their tanks for their own propulsion, etc. are to comply with the requirements in **20.3**, **Part 6**.

4.9 Coal Carriers

4.9.1 Electrical Installations in Cargo Holds

1. Electrical installations are not to be installed in spaces or areas listed in the following **(1)** to **(3)** unless essential for operational purposes.

(1) Cargo holds

(2) Enclosed spaces adjacent to a cargo hold having a non gastight or watertight door, hatch, and the like into the cargo hold

(3) Areas within 3 *m* of any cargo hold mechanical exhaust ventilation outlet

2. Where installation of electrical installations in such spaces is unavoidable, it is to comply with requirements in the following **(1)** to **(4)**.

(1) Electrical installations are to be of explosion-protected type as deemed appropriate by the Society and to have an enclosure for safely operation in coal dust. And electrical installations are to be installed so as to be kept free from mechanical damage. However, electrical installations suitable for the location and the purpose of service, and considered by the Society equivalent with regard to the safety to explosion-protected type electrical installations may be used.

(2) Switches and soket-outlets are not to be installed except those connected to intrinsically safe circuits.

(3) The cables passing through the cargo holds are to be led in gastight heavy gauge steel pipes, and the both ends of the pipes are to be sealed using cable glands or the like at the boundaries of cargo holds. The cables led to electrical equipment installed in the cargo holds are to be protected by metallic casings or non-metallic casings complying with the requirements specified in **2.9.14-3(4)**, and those casings are to be sealed using cable glands or the like at the boundaries of cargo holds.

(4) Mechanical exhaust ventilation fans fitted in ducts of cargo holds are to be of non-sparking type.

3. Notwithstanding the requirements in **-1** and **-2**, electrical installations installed in spaces and areas listed in **-1(1)** to **(3)** of a bulk carrier which sometimes carries coal and they are not used during coal carrying are to comply with requirements in the following **(1)** and **(2)**.

(1) Electrical equipment is to have an enclosure less liable to permit the ingress of coal dust.

(2) Electrical installations are to be installed so as to be kept free from mechanical damage. In addition, feeder circuits for the equipment are to be provided with multipole linked switch situated outside the spaces or areas specified in **-1(1)** to **(3)** and accessible, so devised as to have the equipment usually locked with the switch in off position.

4.10 Special Requirements for Ships Carrying Dangerous Goods

4.10.1 General

Electrical installations for ships carrying dangerous goods are to comply with the requirements in **Chapter 19**, **Part 6** as well as the relevant requirements in this part.

Chapter 5 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS

5.1 General

5.1.1 Scope

1. Electrical installations for ships which rely solely on propulsion motors for their propulsion (hereinafter referred to as electric propulsion ships in this chapter) are to meet the relevant requirements specified in this part, and in addition to those in this chapter.

2. Semiconductor convertors for propulsion motors are to be complied with the requirements of **-1** and those as deemed necessary by the Society.

3. Machinery for electric propulsion ships is to meet the relevant requirements in **PART 7of the Rules**, and in addition to those in this chapter.

5.1.2 Additional Requirements for the Prime Movers driving Propulsion Generators

1. When manoeuvring from propeller speed ahead to astern with the ship making ahead, the prime mover driving a propulsion generator is generally to provide a control system being capable of absorbing or limiting the regenerated power without tripping of overspeed protection devices specified in **2.4.1-2**, **3.3.1-1** or **4.3.1-1, Part 7**. Further, the prime mover and the generator are to be so constructed to withstand the revolution up to the setting revolution of the overspeed protection devices.

2. Characteristics of governors on the prime movers are to be as deemed appropriate by the Society, excluding the case where the propulsion generator is also used as a main generator.

3. When engine speeds are regulated to control the propeller speed, the governors are to be capable of being controlled remotely, as well as locally. However, when deemed appropriate by the Society, these requirements do not apply.

4. When *d.c*. generators to be separately driven are connected in series electrically, means are to be provided to prevent reverse running of the generator in the event of failure of driving power.

5.2 Propulsion Electrical Equipment and Cables

5.2.1 General

Excessive electromagnetic interference of propulsion electrical equipment are not observed at any normal manoeuvring.

5.1.2 General Requirements for Propulsion Motors

1. Propulsion motors are to have performance specified in the following **(1)** to **(3)**.

(1) Torque available for manoeuvring a ship is to be capable of stopping or reversing of the ship in a reasonable time when the ship is running at maximum service speed

(2) Adequate torque margin is to be provided in *a.c.* propulsion systems to guard against the motor to be pulled out of synchronism during rough weather and at the time of turning operation in a multiple-screw ship

(3) Motors are not to produce any harmful torsional vibration within a normal range of rotational speeds

2. Lubrication of the bearings of propulsion motors is to be effective at all operational speed including creep speed.

When a forced lubrication system is used, the system is to be provided with alarm devices which give visible and audible alarming in the event of failure of lubricating oil supply or appreciable reduction in lubricating oil pressure, and also with devices to stop the operation of the motors automatically by lower pressure after the function of the alarm.

3. For *d.c.* motors liable to over the speed specified in 2.4.7 due to propeller missing or propeller racing, overspeed protection devices are to be provided, and the rotors are to be suitably constructed to prevent damage due to excessive overspeed.

4. Where arrangements permit a propulsion motor to be connected to the generating plant having a continuous rating greater than the motor rating, means are to be provided to prevent continuous operation at the overload or over torque conditions not permitted to the motors and shafting.

5. The propulsion motor shaft is to conform to the requirements in 2.4.11. In this case, the diameter of the rotor shaft in the length from the section where rotor is fixed to the shaft end of propeller side is to conform to the requirements in 2.4.11-4(1). The value of F_1 is to comply with the value specified either in **(1)** or **(2)** below.

(1) When the motor has bearings at both ends: 110

(2) When the motor has no bearings at its propeller side: 20

5.2.3 Construction and Arrangement of Propulsion Rotating Machines

1. Means are to be provided to prevent the accumulation of bilgewater under the propulsion motors, the generators, the exciters or the electromagnetic slip-couplings (hereinafter referred to as the propulsion rotating machines in this chapter).

2. Slip rings and commutators of propulsion rotating machines are to be suitably arranged to be maintained easily. For purpose of inspection and repair is to be made for easy access to each kind of coils and bearing. When the Society considers necessary, the propulsion rotating machines are to have construction that permits removal and replacement of their field windings.

3. Temperature sensors for monitoring and alarming are to be provided for a stator winding of *a.c.* machines or an interpole winding of *d.c.* machines with exceed 500 *kW*.

4. Propulsion rotating machines provided with forced ventilation systems, air ducts or air filters are to have thermometers for measuring cooling air temperatures.

5. Effective means are to be provided in rotating machines to prevent accumulation of moisture and condensation.

6. The lubrication of bearing is to be effective at all operational speeds including creep speeds. In cases where forced lubrication systems for bearing are used, such systems are to be provided with alarm devices which give visible and audible alarms in the event for any failure of lubricating oil supplies or any appreciable reduction in lubricating oil pressure. In addition, devices to automatically stop the operation of motors after such alarm have sounded are to be provided as well.

7. Bearing are to be provided with monitoring systems for bearing temperatures and with alarm systems responsible for detecting excessive bearing temperatures.

8. In order to protect generator circuits from electrical failures located on the generator side of generator breaker, differential current protection devices are to be provided for propulsion generators with exceed 1,500*KW* (or *kVA*).

5.2.4 Temperature Rise of Rotating Machines

When variable speed propulsion rotating machines are fitted with an integral fan and have to be operated at speeds below the rated speed with full-load torque, full-load current, full-load excitation or the like, temperature limits according to **Table 2.2** of **2.4.3** are not exceeded.

5.2.5 Propulsion Semiconductor Convertors

1. Propulsion semiconductor convertors are to be designed to withstand any overcurrents which may be generated during turning and astern motions of ships (under conditions specified in **1.3.2**, **Part 7**).

2. In cases where semiconductor elements are cooled by forced ventilation, etc., the following preventive measures are to be provided to respond to any failure of such cooling systems:

(1) Output reduction or decupling measures for propulsion semiconductor convertors, and

(2) In cases where semiconductor elements are connected in parallel, divided into groups, and provided with independent group cooling systems, measures to separate the concerned group from others.

3. Forced cooled propulsion semiconductor convertors are to be provided with means for monitoring effective forced cooling, and alarming in the event of any cooling system failure.

4. In cases where propulsion semiconductor convertors are cooled by the forced ventilation of coolant, alarms are to be given in the event of any coolant leakage.

5. In case where the sensors which detects speeds and rotor positions of propulsion motors are provided, alarms are to be connected to such sensors and respond in cases of the sensors failure.

6. Semiconductor elements and protective fuses for filter circuits installed in propulsion semiconductor convertors are to be monitored at all times.

5.2.6 Propulsion Transformers

1. Propulsion transformers are to be provided with means for monitoring winding temperatures.

2. In cases where the temperature rise for the windings of propulsion transformers exceed design allowance values, means of decreasing propulsion power are to be provided.

3. In cases where liquid cooled transformers are used as propulsion transformers, the following requirements (1) to (3) are to apply:

(1) Means of monitoring liquid temperatures are to be provided. In addition, prealarms are to be actuated before maximum permissible temperature is attained. In cases where the maximum permissible temperature limit is reached, transformers are to be switched off.

(2) Means of monitoring liquid filling levels by two separate sensors are to be provided. In addition, prealarms are to be actuated before liquid levels below permissible levels. In cases where liquid levels fall below permissible levels, supplies for transformers are to be switched off

(3) Gas-actuated protection devices are to be provided.

4. Forced ventilated propulsion transformers are to be provided with means of monitoring the operation condition of ventilation devices and cooling air temperatures.

5. Propulsion transformers with closed circuit cooling methods for heat exchangers are to be provided with thermometers for monitoring cooling air temperatures. Especially, in cases where water cooling methods are adopted, additional leakage monitoring systems are to be provided and located so that any leakage water is kept away from the windings

6. Propulsion transformers are to be protected from short circuit at their secondary also.

5.2.7 Measuring Instruments

Measuring instruments specified below are to be installed on the control panels of propulsion motors or local control position:

(1) Voltmeters for propulsion motors (only in the case of variable speed control)

(2) Ammeters for propulsion motors (Ammeters for field current and armatures in the case of d.c. motors, Ammeters for main circuits in the case of a.c. motors)

5.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits

5.3.1 Composition of Electrical Equipment for Propulsion and Auxiliary Machinery for Propulsion

1. Means are to be provided to ensure that the installation or equipment mentioned in the following **(1)** to **(5)** are to be capable of starting the propulsion motors and obtaining a navigable speed for the ship even though one of those becomes inoperative.

(1) Sources of electrical power for propulsion

(2) Transformers for propulsion

(3) Semiconductor convertors (or propulsion motor control devices)

(4) Propulsion motors (including cooling systems and Lubricating system)

(5) Other installations and equipment which the Society deems necessary

2. Where the source of electrical power for propulsion correspond to **(1)** and **(2)** below, they may be used for the main source of electrical power specified in 3.2.1.

(1) When one set of the source of electrical power for propulsion is out of operation, the capacity specified in 3.2.1-2 is secured by the remaining the source of electrical power for propulsion, which at the same time has a capacity sufficient to give a navigable speed for the ship.

(2) At the time of load fluctuations and braking of the propeller or at the time of changing the rotational speed of the propulsion generator in order to control the propulsion motors, the variations of the voltage and frequency are to comply with the requirements in 2.1.2-3.

5.3.2 Electrical Power Supply Circuits

1. Electrical equipment or installations, in duplicate, in accordance with the requirements in 5.3.1-1 are to be supplied with electrical power by mutually independent circuits.

2. Propulsion system having two or more generators or motors respectively on one propeller shaft, is to be so arranged that any unit of them can be taken out of service and isolated electrically.

3. Safety measures specified in the following **(1)** to **(6)** are to be taken for the electrical power supply circuits.

(1) Overcurrent protective devices, if any, in the main circuits are to be sufficiently high so that there is no possibility of their operating due to overcurrent caused by manoeuvring condition in rough weather, turning operation or the operation specified in 1.3.2, Part 7.

(2) Means for earth leakage detection are to be installed on the electrical power supply circuit to the propulsion motor.

(3) Excluding a brushless exciting circuit and an exciting circuit of a rotating machine of less than 500 *kW*, an earth leakage detection is to be installed at an insulated exciting circuit.

(4) It is to be provided with means of suppressing voltage rises in cases where switches in excitation circuits are opened.

(5) In excitation circuits, there is to be no overload protection causing the openning of any circuits.

4 In cases where generators are running in parallel and one of them is tripping, power supply systems are to be provided with suitable means of load reductions to protect the remaining generators against unacceptable load steps.

Chapter 6 SPECIAL REQUIREMENTS FOR SHIPS WITH RESTRICTED SERVICE, SMALL SHIPS AND FISHING VESSELS

6.1 General

6.1.1 Scope

The requirements in this chapter apply to electrical installations of ships or vessels listed below in place of the relevant requirements of this part.

(1) Ships with class notations "*Coasting Service*" , "*Smooth Water Service*" , "*Harbour Service*" or equivalent thereto which are not engaged in international voyage and ships with such a class notation with a gross tonnage less than 500 *tons* which are engaged in international voyages

(2) Ships with a gross tonnage less than 500 *tons*

(3) Ships with class notations "*Coasting Service*" , "*Smooth Water Service* ", "*Harbour Service*" or equivalent thereto with a gross tonnage of 500 *tons* or more which are engaged in international voyages

(4) Ships with a gross tonnage of 500 *tons* or more which are not engaged in international voyage

(5) Fishing vessels which are not engaged in international voyages

(6) Fishing vessels with a gross tonnage less than 500 *tons* which are engaged in international voyages

(7) Fishing vessels with a gross tonnage of 500 *tons* or more which are engaged in international voyages

6.2 Electrical Installations of Ships Specified in 6.1.1(1)

6.2.1 General

For ships specified in **6.1.1(1)**, the requirements of this 6.2 may be applied.

6.2.2 Ambient Conditions

In Table 1.1 of 1.1.7, air temperature of 40°C and sea water temperature of 27°C may be applied in place of air temperature of 45°C and sea water temperature of 32°C except for ships which are navigating tropical areas.

6.2.3 Distribution Systems

The requirements of 2.2.1-2 may not apply to ships with a gross tonnage less than 1,600 *tons* (except tankers, carriers of liquefied gases in bulk and carriers of dangerous chemicals in bulk).

6.2.4 Insulation Monitoring System

In applying the requirements of 2.2.2, insulation monitoring system may be replaced with other earth indicating systems for ships with a gross tonnage less than 1,600 *tons* (except tankers, carriers of liquefied gases in bulk and carriers of dangerous chemicals in bulk).

6.2.5 Lighting Circuits

In 2.2.7-4, the requirements that in spaces such as compartments where the main propulsion machinery or boilers are provided, large machinery rooms, large galleys, corridors, stairways leading to boat decks and public rooms, lighting is to be supplied from at least two circuits may be limited to spaces where the main propulsion machinery or boilers are provided. Further, one of circuits may be reserve lighting circuit.

6.2.6 Construction and Materials of Main Switchboard

1. The requirements of 2.5.3-1 may not apply.

2. The requirements of 2.5.3-2 may not apply except ships intended to be registered as ships provided with operation systems for unattended machinery spaces (hereinafter referred to as **M0** ships in this chapter)

6.2.7 Measuring Instruments for *d.c.* Generator

In 2.5.6, in case where there are two or more *d.c*. generators which are not operated in parallel, one ammeter and one voltmeter may be permitted provided that one portable voltmeter and one portable ammeter specified in 3.8.2 are located on board.

6.2.8 Measuring Instruments for *a.c.* Generator

In 2.5.7, in case where there are two or more *a.c.* generators which are not operated in parallel, one ammeter and one voltmeter may be permitted provided that one portable voltmeter and one portable ammeter specified in 3.8.2 are located on board.

6.2.9 Controlgears for Motors

The requirements of 2.8.1-7 and -8 may not apply. However, for ships with a gross tonnage of 500 *tons* or more, a grouped starter panel is to be divided into two parts, *i.e*. one part for No.1 motors and the other part for No.2 motors.

6.2.10 Precaution against Fire

The requirements of 2.9.11 may not apply.

6.2.11 Main Source of Electrical Power

1. Notwithstanding the requirements of 3.2.1-1 to -3, except **M0** ships, the number of main source of electrical power may be made one. However, in case where no other generator is provided, accumulator batteries with a capacity sufficient to supply electrical power to the lighting system, signalling system, communication equipment, etc., which are necessary for ensuring the safety are to be provided as a reserve source of electrical power.

2. In **M0** ships, the requirements for minimum comfortable conditions of habitability specified in 3.2.1-2 may not apply.

3. The requirements of 3.2.1-3 may not apply except **M0** ships.

6.2.12 Number of Transformers

In ships other than **M0** ships, if an emergency source of electrical power or a reserve source of electrical power (accumulator batteries) is provided in a capacity sufficient to feed the lighting system, signalling system, communication system, etc., the requirements of 3.2.2 may not apply.

6.2.13 Lighting Systems

The requirements of 3.2.3-2 and -4 may not apply. Further, in applying the requirements of 3.2.3-3 the ships are to be provided with reserve lighting systems at the following places.

(1) Launching station of life rafts and outboard side in the vicinity

(2) All corridors, stairs and exits

(3) Machinery space and the place where the reserve source of electrical power is installed

(4) Control station of main engine

6.2.14 Location of Main Switchboard

The requirements of 3.2.4 may not apply.

6.2.15 Emergency Source of Electrical Power

The requirements of 3.3 may not apply.

6.2.16 Starting Arrangement for Emergency Generating Sets

The requirements of 3.4 may not apply.

6.2.17 Power Supply to Navigation Lights

Notwithstanding the requirements of 3.6.1-3, power feeding to a navigation light indicator panel is to be supplied by a separate circuit from a main switchboard and a reserve source of electrical power or a lighting distribution panel provided on the navigation bridge (limited to the case where two or more generating sets are provided). However, for ships with a gross tonnage less than 500 *tons*, only one circuit from the main switchboard supplied from the main source of electrical power and the reserve source of electrical power may be accepted.

6.2.18 Power Supply to Not Under Command Lights, Anchor Lights and Signalling Lights

Notwithstanding the requirements of 3.6.2 and 3.6.3, the power supply to not under command lights, anchor lights and signalling lights may be from a main source of electrical power and an independent reserve source of electrical power.

6.2.19 Power Supply to General Alarm Systems

Notwithstanding the requirements of 3.6.4, the emergency source of electrical power may be of an independent reserve source of electrical power.

6.2.20 Spare parts

The requirements of 3.8.1-4 may not apply to ships which have an effective manually operated auxiliary steering gear.

6.3 Electrical Installations of Ships Specified in 6.1.1(2)

6.3.1 General

For ships specified in **6.1.1(2)**, the requirements of 6.2.3 to 6.2.6, 6.2.10, 6.2.11-3, 6.2.13, 6.2.14, 6.2.16, 6.2.18 and 6.2.19, and additionally the following requirements may be complied with.

6.3.2 Control Gears for Motors

The requirements of 2.8.1-7 and -8 may not apply.

6.3.3 Main Source of Electrical Power

1. The requirements for minimum comfortable conditions of habitability specified in 3.2.1-2 may not apply.

2. In the requirements of 3.2.1-3, the reliability of the ship's main source of electrical power may be modified for ships other than **M0** ships.

6.3.4 Emergency Source of Electrical Power

The requirements of 3.3 may not apply. However, that a reserve source of electrical power simultaneously to the following loads at least for 3 *hours* (continuously 30 *minutes* for signalling equipment and alarming devices of intermittent services) is to be provided.

(1) All internal communications required in an emergency

(2) Navigation lights, not under command lights, anchor lights and signalling lights

(3) The lighting systems at locations indicated in 6.2.13

6.3.5 Power Supply to Navigation Lights

Notwithstanding the requirements of 3.6.1-3, power feeding to a navigation light indicator panel may be supplied by one circuit from a main switchboard supplied from a main source of electrical power and a reserve source of electrical power.

6.4 Electrical Installations of Ships Specified in 6.1.1(3)

6.4.1 General

For ships specified in **6.1.1(3)**, the requirements of 6.2.2, 6.2.3, 6.2.7 to 6.2.9 and 6.2.20, and additionally the following requirements may be complied with.

6.4.2 Capacity of Emergency Source of Power

The requirements of **3.3.2-2(8)** may be complied with.

6.5 Electrical Installations of Ships Specified in 6.1.1(4)

6.5.1 General

For ships specified in **6.1.1(4)**, the requirements of **6.2.4**, **6.2.5**, **6.2.10**, **6.2.14** and **6.3.3** may be complied with.

6.6 Electrical Installations of Vessels Specified in 6.1.1(5)

6.6.1 General

For vessels specified in **6.1.1(5)**, the requirements of **6.2.2** to **6.2.20** may be complied with.

6.7 Electrical Installations of Vessels Specified in 6.1.1(6)

6.7.1 General

For vessels specified in **6.1.1(6)**, the requirements of **6.2.3** to **6.2.8**, **6.2.10**, **6.2.11-3**, **6.2.14**, **6.2.16**, **6.2.18**, **6.2.19**, **6.3.2**, **6.3.3 -1** and **6.3.5**, and additionally the following requirements may be complied with.

6.7.2 Main Source of Electrical Power

The requirements of **3.2.1-3** and **-4** may not apply to a generating set driven by main propulsion machinery as one of two generating sets consisting main source of electrical power of ships other than **M0** ships.

6.7.3 Lighting Systems

The requirements of **3.2.3-2** and **-4** may not apply. Further, in applying the requirements of **3.2.3-3** the vessels are to be provided with reserve lighting systems at the following places.

(1) Launching station of life rafts and outboard side in the vicinity
(2) All corridors, stairs and exits
(3) Machinery space and the place where the reserve source of electrical power is installed
(4) Control station of main engine
(5) Spaces where the catch are processed

6.7.4 Emergency Source of Electrical Power

The requirements of **3.3** may not apply. However, that a reserve source of electrical power simultaneously to the following loads at least for 3 *hours* (continuously 30 *minutes* for signalling equipment and alarming devices of intermittent services) is to be provided.

(1) All internal communications required in an emergency

(2) Navigation lights, not under command lights, anchor lights and signalling lights

(3) The lighting systems at locations indicated in **6.7.3**

6.8 Electrical Installations of Vessels Specified in 6.1.1(7)

6.8.1 General

For vessels specified in **6.1.1(7)**, the requirements of **6.2.5**, **6.2.7** to **6.2.9** and **6.7.2**, and additionally the following requirements may be complied with.

6.8.2 Emergency Source of Electrical Power

In applying the requirements of **3.3.2-2**, the following requirements may apply in place of the requirements of **3.3.2-2(1)** to **(8)**.

(1) For a period of 3 *hours*, the emergency lighting specified in **3.2.3-3**.

(2) For a period of 3 *hours*, the navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force and lights required by National Regulations of the country to which the ship is registered.

(3) For a period of 30 *minutes* (continuous operation), the signalling lights and the ship's whistle.