Contents

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part HELECTRICAL INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope*

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

2 For the electrical installations of small ships, ships with restricted areas of service and fishing vessels as well as electrical installations of ships other than those to which Society approval are given, the application of the requirements in this Part may partly be modified in accordance with the requirements of **Chapter 6** except in cases where requirements are specified for the protection against shocks, fire and any 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 such due compliance with the requirements of this Part and that such electrical installations are deemed by the Society to be the equivalent of those specified in this Part.

1.1.3 Electrical Installations with Novel Design Features

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

1.1.4 (Deleted)

(Deleted)

1.1.5 Definitions

Terms used in this Part are defined as follows:

(1) "Hazardous areas" are those areas or the spaces where flammable or explosive substances are placed and where it is likely that flammable or explosive gases or vapours will be given of by these substances.
  (a) Zone 0: areas or spaces in which an explosive gas atmosphere is either continuously present or is present for long periods of time
  (b) Zone 1: areas or spaces in which an explosive gas atmosphere is likely to occur under normal conditions
  (c) Zone 2: areas or spaces in which an explosive gas atmosphere is likely to occur under abnormal conditions

(2) "Non-hazardous areas" are those areas or the spaces in which an explosive gas atmosphere is not expected to be present in quantities sufficient enough to require any special precautions be taken regarding the construction, installation and use of electrical apparatus.

(3) "Source of release" are those points or locations from which gases, vapours, mists or liquids may be released into the atmosphere so that an explosive gas atmosphere may be formed under normal operating conditions; for example, the seals of cargo pumps and cargo compressors, and the valves and flanges in cargo piping systems. Continuous fully welded parts are not considered as sources of release.

(4) "Selective tripping" are those arrangements such that only protective devices nearest to fault points are opened automatically in order to maintain power supplies to any remaining sound circuits, in the event of any faults in those circuit having protective

devices connected in a series.

(5) "Preference tripping" are those arrangements such that protective devices for unessential circuits are opened automatically in order to ensure power supplies for those services specified in 3.2.1-2, in cases where any one generator becomes overloaded or there are fears of overloading.

(6) "Normal operational and habitable conditions" are those conditions 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, etc. are in working order and functioning normally.

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

(8) "Main sources of electrical power" are those sources intended to supply electrical power to main switchboards for distribution to all services necessary for maintaining ships in normal operational and habitable conditions.

(9) "Main generating stations" are those spaces in which main sources of electrical power are situated.

(10) "Main switchboards" are those switchboards which are directly supplied by main sources of electrical power and are intended to distribute electrical energy to all ship services.

(11) "Emergency sources of electrical power" are those sources of electrical power, intended to supply emergency switchboards in any event of failure of supply from main sources of electrical power.

(12) "Emergency switchboards" are those switchboards which in any event of failure of main electrical power supply systems are directly supplied by emergency sources of electrical power or transitional sources of emergency power and are intended to distribute electrical energy to emergency services.

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

(14) "Semiconductor converters" are devices using semi conducting electronic elements to convert electric energy from one state to another. (*e.g.*, from *a.c.* to *d.c.*, *d.c.* to *a.c.*, *a.c.* to *a.c.* or *d.c.* to *d.c.*)

1.1.6 Drawings and Data*

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

(1) Drawings:

(a) Sectional assembly of generators, motors and electromagnetic slip couplings for electric propulsion equipment including their complete ratings, main dimensions, main materials used and weights

(b) Key diagrams and explanations of electric propulsion controlgears

(c) Sectional assembly of generators (main, auxiliary and emergency) of 100 *kW* (or *kVA*) and over, including their complete ratings, main dimensions, main materials used and weights

(d) Arrangement plans (including specifications of main parts such as circuit breakers, fuses, instruments and cables) and circuit diagrams of main switchboards and emergency switchboards

(e) Plans of arrangement of electrical equipment and of cable installation

(f) Diagrams of wiring systems including normal working currents, rated currents, prospective short-circuit currents in circuits, line drop of voltages, type of cables, cable sizes, ratings and settings of circuit breakers, ratings of fuses and switches, and breaking capacities of circuit breakers and fuses

(g) Semiconductor converters for power for electric propulsion and for electric generators (including dimensions, electric equipment particulars, sectional assembly)

(h) Sectional assembly drawings of windlass electric motors rated 100 *kW* and over, including their ratings, main dimensions, main materials used and weights

(2) Data:

(a) Explanations of electric propulsion systems

(b) Investigation tables of electrical power

(c) Lists of particulars for high voltage electrical equipment

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

any hazardous areas and lists of any electrical equipment installed in such hazardous areas

(e) For those ships carrying dangerous cargoes as specified in **19.3.2, Part R**, lists of any electrical equipment installed in such areas where such dangerous cargoes are loaded

(f) The following data in cases of ships where harmonic filters are installed on the main busbars of electrical distribution systems, except in cases where the filters are installed for single application frequency devices such as pump motors.

i) Total Harmonic Distortion (THD) calculation report

ii) Harmonic filter operation guide

1.1.7 Ambient Conditions*

1 The ambient conditions given in **Table H1.1** and **Table H1.2** are to be applied, unless otherwise specified, to the design, selection and arrangement of electrical installations in order to ensure their proper operation.

2 All electrical equipment is to be designed sufficiently enough to withstand any vibrations that occur under normal conditions.

3 Ambient temperatures for electrical equipment installed in environmentally controlled spaces are to comply with following requirements:

(1) Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment is to be suitable may be reduced from 45 °C and maintained at a value not less than 35 °C provided:

(a) The equipment is not for use for emergency services or automatic and remote control systems.

(b) Reduced ambient temperatures are to be controlled by at least two air conditioning units (including refrigerating units, hereinafter referred to as the same) which can work at a 45 °C ambient temperature. In the event of the loss of any one air conditioning unit, all remaining units are to be capable of maintaining such reduced ambient temperatures.

(c) The equipment is able to be initially set to work safety within a 45 °C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45 °C ambient temperature.

(d) If the temperature rise over the upper limit of these reduced ambient temperatures, audible and visual alarms are to be activated at continually manned spaces (e.g. navigation bridges or machinery control rooms).

(2) In accepting a lesser ambient temperature than 45 °C, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

(3) Air conditioning units used for cooling and maintaining the lesser ambient temperature are to be classed as one of the electrical installations necessary to provide normal operational conditions of propulsion and safety specified in **3.2.1-2**.

1.1.8 Maintenance Records of Batteries*

1 As for batteries fitted for use of the services necessary to provide normal operational conditions of propulsion and safety of the ship, maintenance records including at least the following information are to be kept on board.

(1) Type and manufacturer's type designation

(2) Voltage and ampere-hour rating

(3) Location

(4) Equipment and/or system(s) served

(5) Maintenance/replacement cycle dates

(6) Date(s) of last maintenance and/or replacement

(7) For replacement batteries in storage, the date of manufacture and shelf life

(Note)

Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

Table H1.1 Ambient Temperatures

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

Table H1.2 Angle of Inclination

Installation Components	Athwartships[2]		Fore-and-aft [2]	
	Static inclination (List)	Dynamic inclination (Rolling)	Static inclination (Trim)	Dynamic inclination (Pitching)
Electrical installations excluding those items started below	15°	22.5°	5° [4]	7.5°
Emergency electrical installations, switch gears (circuit breakers, etc.), electric appliances and electronic appliances[1]	22.5° [3]	22.5° [3]	10°	10°

Notes:

1. No undesired switching operations or operational changes are to occur.
2. Athwartships and fore-and-aft inclinations may occur simultaneously.
3. In ships intended for the carriage of liquefied gases and of dangerous chemicals the emergency power supply is to also remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30°.
4. Where the length of the ship exceeds 100 *m*, the fore-and-aft static angle of inclination may be taken as follows:

   $\theta = 500/L$

   θ : The static angle of inclination (°)

   L : Length of the ship specified in **2.1.2, Part A** (*m*)

2 Procedures are to be put in place to ensure that where batteries are replaced that they are of an equivalent performance type.

3 Where vented type batteries replace valve-regulated sealed type batteries, it is to be ensured that the requirements specified in **2.11** are complied with.

(Note)

(1) A vented type battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

(2) A valve-regulated sealed type battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

1.2 Testing

1.2.1 Shop Tests*

1 The electrical equipment specified below is to be tested in accordance with the respective requirements in this Part at the place of manufacture or at other locations having adequate apparatus for testing and inspections. However, to implement the tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve other survey methods which it considers to be appropriate. In addition, tests for any equipment with small capacities as specified in **(4)** and **(5)** are to be conducted as deemed appropriate by the Society.

(1) Rotating machines for propulsion and their respective control equipment

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

(3) Main and emergency switchboards

(4) Motors for auxiliary machinery specified in **1.1.6-1(1)** to **1.1.6-1(3), Part D** (hereinafter referred to as "motors for essential services" in this Part)

(5) Controlgears for those motors specified in **(4)** above

(6) Transformers for power and lighting of single phase 1 *kVA* or more and three phase 5 *kVA* or more. However, those transformers used only for special services such as those ones for Suez Canal Search Lights, etc. are to be excluded

(7) Semiconductor converters for power of not less than 5 *kW* and their respective accessories that are used for supplying power to

the electrical equipment specified in **(1)** to **(3)** above

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

2 Any electrical equipment used for auxiliary machinery for specific use for those ships specified in **1.1.6-1(4)** and **1.1.6-1(5), Part D** as well as those deemed necessary by the Society are to be tested in accordance with the respective requirements in this Part.

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

4 Electrical equipment and cables shown in the following items **(1)** to **(6)** are to be subjected to type tests for each type of product. However, in cases where it is inadequate to deal with them under the requirements for type tests (e.g. those used only for specific ships or purposes with little possibility of continued use, or items for which the acquisition of individual test/inspection certificates is desired), tests and inspections of individual products may be accepted in place of type tests when requested by application.

(1) Fuses

(2) Circuit breakers

(3) Electromagnetic contactors

(4) Explosion-protected electrical equipment

(5) Cables for power, lighting and internal communications

(6) Semiconductor converters for power of not less than 5 *kW* that are used for the electrical equipment specified in **-1(4)** and **(5)** above

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

1.2.3 Additional Tests and Inspections

The Society may require, in cases where it deems necessary, tests and inspections other 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 voltages are not to exceed:

(1) 1,000 *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 which meets the requirements given in **2.17.**

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

3 Electrical equipment supplied from main and emergency switchboards is to be designed and manufactured so that it is capable of operating satisfactorily under the normally occurring voltage and frequency fluctuations. Unless otherwise specified, such electrical equipment is to operate satisfactorily under those fluctuations in voltage and frequency that are given in **Table H2.1**. Any special systems, *e.g.* electronic circuits, whose functions cannot operate satisfactorily, within the limits given in this table, are to be supplied by some suitable means, *i.e.* through some stabilized supply.

4 In cases where *a.c.* generators are driven at rated speeds, giving rated voltages and rated symmetrical loads, the Total Harmonic Distortion (THD) of distribution systems connected such generators is not to exceed values of 5 %. However, in cases where specially approved by the Society, the Total Harmonic Distortion (THD) may exceed the requirement values.

Table H2.1 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 charging and discharging characteristics, including voltage ripples from the charging devices, may be considered.

Note 4: The numerical values given in the table, excluding those values for time, mean percentages of rated values.

2.1.3 Construction, Materials, Installations, etc.*

1 Electric machinery parts which are required to possess strength are to be made of defect-free sound materials. Their proper fits and clearances are to be consistent with best maritime practices and experience.

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

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

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 likely to cause any bodily harm due to mechanical problems as well as suffer any damage caused by water, steam or oil. In cases where exposure to such risks is unavoidable, such equipment is to be so constructed so as to meet the specific conditions of the installation location.

7 No electrical installations 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 sufficiently safe distances from the magnetic compasses or are to be screened so that any interfering external magnetic fields do not exert negative affects, even when circuits are switched on and off.

9 Cables and apparatus for services required to be operable under fire conditions are to be arranged so 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.

11 Electrical equipment allowed in paint stores and adjacent areas are to be in accordance with **Table H2.2**. Switches, protective devices, motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and preferably are to be located in non-hazardous space.

12 Installation of electrical and electronic equipment in engine rooms protected by fixed water-based local application fire-fighting systems (FWBLAFFS) are to comply with following requirements (see **Fig. H2.1**):

(1) Electrical and electronic equipment enclosures located within areas protected by FWBLAFFS and those within adjacent areas exposed to direct spray are to have a degree of protection not less than IP44, except where evidence of suitability is submitted to and approved by the Society.

(2) The electrical and electronic equipment within adjacent areas not exposed to direct spray may have a lower degree of protection provided evidence of suitability for use in these areas is submitted taking into account the design and equipment layout, e.g. position of inlet ventilation openings, cooling airflow for the equipment is to be assured.

(3) Additional precautions may be required to be taken in respect of:

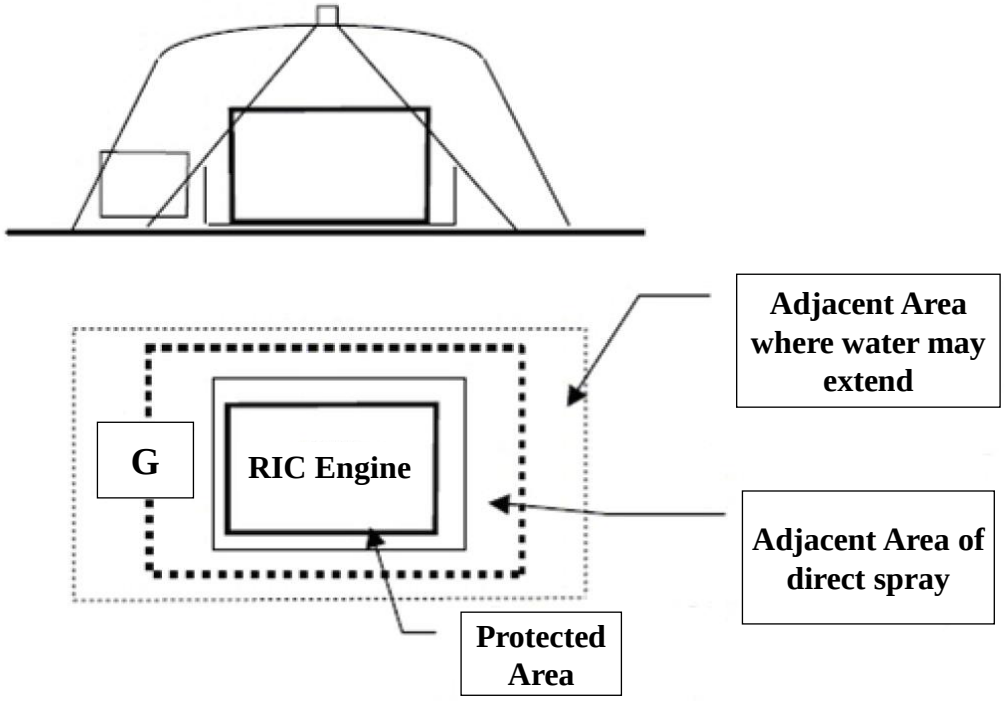
(a) Tracking as the result of water entering the equipment

(b) Potential damage as the result of residual salts from sea water systems

(c) High voltage installations

(d) Personnel protection against electric shock

Fig. H2.1 Areas Protected by Fixed Water-based Local Application Fire-fighting Systems, etc.



Notes:

1. Protected space: Is a machinery space where a FWBLAFFS is installed.
2. Protected areas: Areas within a protected space which is required to be protected by FWBLAFFS.
3. Adjacent areas:
   (a) Areas, other than protected areas, exposed to direct spray.
   (b) Areas, other than those specified in **(a)** above, where water may extend.

Table H2.2 Electrical Equipment Allowed in Paint Stores and Adjacent Areas

Areas		Permitted electrical installations
(a)	Paint stores	(1) The certified safe type equipment specified below at least with respect to gasses and vapours of group *II*B and of temperature class *T*3 as well as their associated cables - intrinsic safety type (*Exi*) - flameproof type (*Exd*) - pressurized type (*Exp*) - increased safety type (*Exe*) - special protection type (*Exs*) (2) Cables (through-runs or terminating cables) of armoured type or installed in metallic conduits are to be used. (3) Non-sparking type ventilation fans. Protection screens of not more than 13 *mm* square mesh are to be fitted in the inlet and outlet ventilation openings of the ducts fitted with such fans on the open deck.
(b)	Inlet and exhaust ventilation ducts	
(c)	Areas on open decks within 1 *m* of inlet and exhaust ventilation openings	(1) Electrical equipment and cables permitted for those areas specified in **(a)** and **(b)** (2) Electrical equipment with a type of protection '*n*' (*Exn*) (3) Electrical equipment of those types which ensure the absence of sparks or arcs and which no parts of such equipment haves operating temperatures which can cause the ignition of gases or vapours of those flammable liquids being stored as well as their associated cables (4) Electrical equipment with simplified pressurized enclosures or vapour proof enclosures (minimum degree of protection is IP55) and which no parts of such equipment have operating temperatures which can cause the ignition of gases or vapours of those flammable liquids being stored as well as their associated cables
(d)	Areas on open decks within 3 *m* of exhaust mechanical ventilation openings	
(e)	Enclosed spaces having direct openings (without closable openings, such as doors) into paint stores	These spaces may be considered as non-hazardous, provided that: (1) Doors to paint stores are gastight doors with self-closing devices; (2) Paint stores are provided with independent natural ventilation systems which are deemed appropriate by the Society; and, (3) Warning notices are fitted adjacent to paint store entrances stating that such stores contain flammable liquids.

Notes:

1. The paint stores and inlet and exhaust ventilation ducts are classified as Zone 1 and areas on open deck as Zone 2, as defined in *IEC* 60092-502:1999.
2. A watertight door may be considered as being gastight.

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. However, the following cases are excluded:

(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 which are 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 which are for use in confined or exceptionally damp spaces in cases where particular risks due to conductivity may exist.

3 In cases where earthing connections are necessary, earthing conductors are to be either of copper or other approved materials, and are to be properly protected against any damage as well as any erosion in cases where necessary. The size of these earthing

conductors is to be deemed appropriate by the Society according to the cross sectional areas of current-carrying conductors and the installation of earthing lines.

2.1.5 Clearances and Creepage Distances

1 Clearances and creepage distances between live parts and between live parts and earthed metals (hereinafter in this Part referred to as "clearances and creepage distances") are to be adequate for the working voltage with consideration given to the nature and service conditions of any insulating material.

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

2.2 System Design - General

2.2.1 Distribution Systems*

1 The following **(1)** to **(5)** distribution systems are considered as a standard:

(1) Two-wire direct currents

(2) Three-wire direct currents (three-wire insulated systems or three-wire mid-wire earthed systems)

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

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

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

2 Notwithstanding the requirements given in **-1** above, hull return distribution systems 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 currents do not flow directly through any dangerous spaces.

(3) Insulation monitoring systems, provided that circulation currents do not exceed 30 *mA* under any circumstances.

2.2.2 Insulation Monitoring Systems*

In cases where primary and secondary distribution systems with no connection to earth are used for power, heating or lighting, devices capable of continuously monitoring insulation levels to earth and of giving audible or visual indications of abnormally low insulation values are to be provided.

2.2.3 Unbalance of Loads

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

2 In the case of three-wire or four-wire three-phase alternating current systems, any load unbalance 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. In cases where it has been recognized that no practical hindrances exists, such circuits can be rated in accordance to diversity factor.

2 The diversity factor specified in **-1** above may be applied to calculations of cross sectional areas 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 arrangements are to be supplied by individual circuits without any use of common feeders, protective devices and controlgears.

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

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

4 Lighting circuits and motor circuits are to be arranged so that they are supplied independently from switchboards.

5 Final sub-circuits of ratings exceeding 16 *A* are not to supply more than one appliance.

2.2.6 Motor Circuits

Separate final sub-circuits are to be provided, as a rule, for every motor for essential service and for every motor with a rating of 1 *kW* or more.

2.2.7 Lighting Circuits*

1 Final sub-circuits used for lighting circuits are to be supplied separately from those for heating and power except in cases where such sub-circuits are used for cabin fans and electrical appliances for domestic use.

2 The number of lighting points supplied by final sub-circuits of ratings 16 *A* or less is not to exceed:

(1) 10 for those circuits up to 55 *V*

(2) 14 for those circuits from 56 *V* up to 120 *V*

(3) 24 for those circuits from 121 *V* up to 250 *V*

In cases where the number of lighting points and total load currents are invariable, a number of points greater than those specified above may be connected to final sub-circuits provided that aggregate load currents do not exceed 80 % of the ratings of protective devices in such circuits.

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

4 In spaces such as compartments where main engines or boilers are located, 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 arranged so that the failure of any one circuit will not leave these spaces in darkness. One of these circuits may be an emergency lighting circuit.

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

2.2.8 Circuits for Internal Communication Systems and Navigational Aids*

1 Essential internal communication and signal systems as well as 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 arranged so that no induced interference is caused.

3 No switches are to be provided for feeder circuits of general alarm devices, except for operating switches. In cases where circuit breakers are used, suitable means are to be taken to prevent such breakers from being kept in "off" positions.

2.2.9 Circuits for Radio Installations

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 separate final sub-circuits. However, up to 10 small electric heaters of an aggregate current rating not exceeding 16 *A* may be connected to a single final sub-circuit.

2 Electric heating and cooking equipment are to be controlled by multipole linked switches mounted in the vicinity of the equipment. However, small electric heaters connected to final sub-circuits of ratings not exceeding 16 *A* may be controlled by a single-pole switch.

2.2.11 Circuits for Shore Connections*

1 In cases where arrangements are made for the supply of electricity from sources on shore, connection boxes are to be installed in suitable positions. In cases where shore connection cables can be easily drawn into switchboards and put safely into service, such connection boxes may be omitted provided that those protective devices and checking devices specified in **-2** below are equipped on switchboards.

2 Connection boxes are to contain terminals to facilitate satisfactory connections and circuit-breakers or isolating switches with fuses. Means are to be provided for checking phase sequences (for three-phase alternating currents) or polarity (for direct currents).

3 In cases where power is supplied from three-wire neutral earthed systems, earth terminals are to be provided for connecting hulls to appropriate earths in addition to those specified in **-2** above.

4 At connection boxes, notices are to be provided giving information on the systems of supply and nominal voltages (and frequencies if *a.c.*) of such systems as well as those procedures for carrying out connections.

5 Cables between connection boxes and switchboards are to be permanently fixed and pilot lamps for sources and switches or circuit-breakers are to be provided on switchboards.

2.2.12 Disconnecting Switches of Circuits*

1 Power circuits and lighting circuits terminating in cargo holds or coal bunkers are to be provided with multipole linked switches situated outside these spaces. Provisions are to be made for locking in "off" positions any switches or switch boxes for these lighting circuits.

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

2.2.13 Remote Stopping of Ventilating Fans and Pumps*

1 Remote stopping of ventilating fans and pumps is to comply with the requirements given in **5.2.1-2** and from **5.2.2-2** to **5.2.2-4, Part R**.

2 In cases where fuses are used to protect a remote stopping circuit specified in **5.2.1-2** and **5.2.2-2** through **-4**, **Part R** 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 overcurrents including short-circuits. Any protective devices used are to be capable of breaking any faulty circuits, thus preventing any other circuits from suffering damage or catching fire as well as to continuously serve those other circuits as far as possible.

2.3.2 Protection against Overload

1 Overcurrent trip characteristics of circuit-breakers and fusing characteristics of fuses are to be chosen suitably after 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 settings of overload protection devices for each circuit are to be permanently indicated at the location of such protection devices. In addition, current-carrying capacities of each circuit are to be indicated.

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

2.3.3 Protection against Short-circuit*

1 Breaking capacities of protective devices are to be not less than the maximum values of short circuit currents which can flow at installation points at the instant of constant separation.

2 Making capacities of circuit-breakers or switches intended to be capable of being closed, if necessary, on short-circuits, are not to be less than the maximum value of short-circuit currents at installation points. With respect to alternating currents, this maximum value corresponds to those peak values allowing for maximum asymmetry.

3 In cases where the rated breaking capacities and/or the rated making capacities of short-circuit protection are not in compliance with the requirements given in **-1** and **-2** above, fuses or circuit-breakers having breaking capacities not less than any prospective short-circuit currents are to be provided at power source sides of foregoing short-circuit protection. In such cases, circuit-breakers for generators are not to be used for this purpose. In addition, those circuit-breakers connected to load sides are not to be excessively damaged and are to be capable of further service in the following cases:

(1) In cases where short-circuit currents are broken by back-up circuit-breakers or fuses.

(2) In cases where circuit-breakers connected to load sides are closed on short-circuit currents while any back-up circuit-breakers or fuses breaks the current.

4 In cases where an absence of precise data regarding rotating machines makes it very difficult to anticipate short-circuit currents in machine terminals, the following **(1)** or **(2)** are to be used to determine the presence of short-circuit currents. In addition, in cases where motors are as loads, short-circuit currents of such motors are to be added to the short-circuit currents of generators:

(1) *D.C.* systems

Ten times the sum of the rated currents of any generators which are connected (including spares).

Six times the sum of the rated currents of any motors simultaneously in service.

(2) *A.C.* systems

Ten times the sum of the rated currents of any generators which are connected (including spares).

Three times the sum of the rated currents of 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.* systems: at least one line or phase

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

(3) Three-phase, three-wire systems: one each for two phases

(4) Three-phase, four-wire systems: one each for each phase

3 Fuses, non-linked switches or non-linked circuit-breakers are not to be inserted into earthed conductors and neutral lines.

2.3.5 Protection of Generators*

1 Generators are to be protected against short-circuits and overcurrents by multipole circuit-breakers arranged to simultaneously open all insulated poles, or in the case of generators less than 50 *kW* not arranged to run in parallel, may be protected by multipole-linked switches with fuses or circuit-breakers in each insulated pole. Such 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 requirements given in **-1** above, instantaneous reverse-current protections operating at fixed values of reverse-currents within the limits of 2 % to 15 % of the rated currents of generators are to be provided. However, this requirement does not apply to reverse-currents generated from load sides, *e.g.* cargo winch motors, etc.

3 For *a.c.* generators arranged to operate in parallel, in addition to the requirements given in **-1** above, reverse-power protection with time delay selected and set within the limits of 2 % to 15 % of full loads to values fixed in accordance with the characteristics of prime movers, are to be provided.

2.3.6 Load Shedding*

1 To protect main generators against overloads, means are to be provided to disconnect any unessential loads automatically. In such cases, these means may consist of two or more stage trippings.

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

2.3.7 Protection of Feeder Circuits*

1 Supply circuits to section boards, distribution boards, grouped starters, etc. are to be protected against overload and short-circuit by multi-pole circuit-breakers or fuses. In cases where fuses are used, switches complying with the requirements given in **2.14.3** are to be provided at power source sides of such fuses.

2 Each insulated pole of final sub-circuits is to be protected against short-circuit and overload by circuit-breakers or fuses. In cases where fuses are used, switches complying with the requirements given in **2.14.3** are, as a rule, to be provided at power source sides of such fuses. In addition, for the protection of the supply circuits of steering gears, the requirements given in **15.2.7, Part D** are to apply.

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

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

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

2.3.8 Protection of Power and Lighting Transformers

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

2 In cases where transformers are arranged to operate in parallel, means of isolation are to be provided on secondary circuits.

2.3.9 Protection of Electric Motors

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

2 Protective devices are to have delay characteristics to enable motors to start.

3 In cases where motors are used for intermittent services, current settings and delays are to be chosen in relation to the load

factors of such motors.

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. Pilot lamps installed as integral parts of other items of equipment need not be individually protected provided that any damage to pilot lamp circuits does not cause any failures in the power supplies of essential equipment.

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

3 Fuses in circuits such as those of automatic voltage regulators in cases where any loss of voltage might have serious consequences may be omitted. However, if omitted, proper means are to be provided to prevent any risk of fire in unprotected parts of such installations.

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 such batteries. Emergency batteries supplying essential services may have short-circuit protection only.

2.3.13 Harmonic Filters

1 Where harmonic filters are installed on the main busbars of electrical distribution systems, except when the harmonic filters are installed for single application frequency drives such as pump motors, the ship is to be fitted with facilities to continuously monitor the Total Harmonic Distortion (THD) values experienced by the main busbars as well as to alert the crew in cases where the value exceeds the upper limits given in **2.1.2-4**. The Total harmonic distortion (THD) value is to be recorded in the engine log book, but this reading may be logged electronically in cases where the engine room is provided with systems which automatically log such values.

2 The protection arrangements for harmonic filters specified in **-1** are to comply with the following requirements:

(1) Arrangements are to be provided to alert in the event of activation of the protection of a harmonic filter circuit.

(2) The protection of a harmonic filter circuit is to be arranged in conformity with the following requirements:

(a) A harmonic filter is to be arranged as a three-phase unit with individual protection provided for each phase. The activation of the protection arrangement for a single phase is to result in automatic disconnection of the entire filter.

(b) A current unbalance detection system independent of the overcurrent protection is to be provided to alert the crew in the case of current unbalance.

(3) Consideration is to be given to additional protection for individual capacitor elements, such as relief valves or overpressure disconnectors, in order to protect against damage from rupturing. This consideration is to take into account the type of capacitors used.

2.4 Rotating Machines

2.4.1 Prime Movers Driving Generators

Prime movers driving generators are to be constructed in accordance with the requirements given in **Part D**.

2.4.2 Characteristics of Governors

Characteristics of governors for prime movers driving generators are to comply with the requirements specified in **2.4.1-5, Part D**.

2.4.3 Limits of Temperature Rise*

Temperature rise of rotating machines are not to exceed those values given in **Table H2.3**, in cases where they are operated continuously at rated loads or operated intermittently according to their duties. Temperature rise of static exciters for *a.c.* generators are to comply with the requirements given in **2.5.10(1)**.

2.4.4 Modification of Limits of Temperature Rise*

1 In cases where ambient temperatures exceed 45 °C, limits of temperature rise are to be decreased by the difference from those values given in **Table H2.3**.

2 In cases where temperatures of primary coolants do not exceed 45 °C, limits of temperature rise may be increased in those cases where deemed appropriate by the Society.

3 In cases where ambient temperatures do not exceed 45 °C, limits of temperature may be increased by the difference from those value given by **Table H2.3**. In such cases, ambient temperatures are not to be set below 40 °C.

Table H2.3 Limits of Temperature Rise for Rotating Machines (Based on an Ambient Temperature of 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 of 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 which 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 field 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.														

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
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 to exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over their complete operating range														
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. In cases where the Super Position Method is applied to windings of machines rated 200 *kW* (or *kVA*) or less with Thermal Classes A, E, B and F, marked with *1, the limits for temperature rise given for the Resistance Method may be exceeded by 5 *K*
2. Also includes multiple layer windings marked with *2 provided that their under layers are each in contact with the circulating primary coolant.
3. Limits for temperature rise of "windings indirectly cooled by hydrogen" and "directly cooled windings and their coolants" are specified in reference to relevant tables in *IEC*60034-1:2017.
4. T = Thermometer Method, R = Resistance Method, E.T.D. = Embedded Temperature Detector

2.4.5 Overload and Overcurrent Capability*

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

(1) Overcurrent capability

(a) *A.C.* generators

150 % of rated current for 30 *seconds*

(b) *A.C.* motors

150 % of rated current for 2 *minutes*.

However, in the case of *A.C.* motors having rated outputs exceeding 315 *kW* or rated voltages exceeding 1 *kV*, the load and time of overcurrent capability may be increased or decreased in consideration of use conditions and the like.

(c) *D.C.* generators

150 % of rated current

Rated output (*kW*) / Rated rotating speed (*rpm*) ≤ 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.* motors

160 % of rated torque for 15 *seconds*

(b) Polyphase synchronous motors

i) Synchronous (wound rotor) induction motors

135 % of rated torque for 15 *seconds*

ii) Synchronous (cylindrical rotor) induction motors

135 % of rated torque for 15 *seconds*

iii) Synchronous (salient pole) induction motors

150 % of rated torque for 15 *seconds*

2.4.6 Short-circuit Scaling*

1 Ship service generators are to be capable of withstanding the mechanical and thermal effects of any faulty currents for the duration of any time delay which may be fitted in tripping devices for selective tripping.

2 Generators and their excitation systems are to be capable of maintaining currents of at least three times their rated full-load currents for durations of at least 2 *seconds* or for those durations of any time delays which may be fitted in tripping devices for selective tripping.

2.4.7 Overspeed Capability

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

(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 designated by the manufacturer

(d) Permanent-magnet excited motors

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

(e) Generators

120 % of the rated speed

2.4.8 Shaft Currents

In cases where there is a fear of harmful currents circulation between the shafts and bearings, suitable means are to be provided to prevent such from occurring.

2.4.9 Precaution to the Effect of Condensation of Moisture

In cases where there is a fear of deterioration of insulations due to condensation of moisture within rotating machines, suitable means are to be provided to prevent such from occurring.

2.4.10 Air Coolers

In cases where air coolers are provided for rotating machines, they are to be arranged so that there is no fear of any water ingress into such machines due to any leakage or condensation in the air coolers.

2.4.11 Shafts of Rotating Machine*

1 The shaft materials for electric propulsion motors of 100 *kW* and over and for main engine driven generators, in cases where such shafts are part of propulsion shafting, are to be in compliance with the requirements given in **Part K**.

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

3 In cases where welding is applied to shafts and other torque members of rotating machines, the plans are subject to Society approval.

4 The shafts of generators are to comply with the following requirements:

(1) The diameters of generator shafts, in the length from those sections in cases where rotors are fixed to the shaft ends of prime movers, are not to be less than those values obtained from the formula specified in **6.2.2, Part D**.

In such cases, the values H, N_0 and F_1 used in that formula 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 H2.4**

However, in cases where bearings are arranged on both sides of generators, the diameter of shafts around those couplings on prime movers may be reduced gradually to 0.93 times those diameters obtained from the aforementioned formula.

(2) Due consideration is given to the amount of any bending of shafts so that their diameters are designed to maintain necessary air

gaps between stators and rotors within their working ranges.

(3) In case where generators are driven by reciprocating internal combustion engines, tortional vibrations of shafting are to comply with those relevant requirements given in **Chapter 8, Part D**.

Table H2.4 Values of F_1

Bearing arrangements of rotating machines	Generators driven by steam or gas turbines, as well as those generators driven by reciprocating internal combustion engines through slip type couplings (Note)	Generator driven by reciprocating internal combustion engines other than those mentioned in the left-hand column
In cases where bearings are arranged at both sides of rotating machines	110	115
In cases where no bearings are arranged at prime movers or load sides of rotating machines	120	125

Note: Slip type couplings in this case refer to hydraulic couplings, electro-magnetic couplings or their equivalent.

2.4.12 Clearances and Creepage Distances inside Terminal Boxes

1 Clearances and creepage distances inside terminal boxes of rotating machines are not to be less than the values given in **Table H2.5**. Furthermore, the clearances and creepage distances for the terminal boxes of rotating machines with rated voltages exceeding 500 *V* are to be adequate for the working voltage and to give consideration to the specifications of the terminal boxes.

2 The requirements specified in **-1** above are not to be applied in cases where insulating barriers are used and also they are not to be applied to small motors such as controlling motors, synchros, etc.

Table H2.5 Minimum Clearances and Creepage Distances inside Terminal Boxes of Rotating Machines

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** below 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 resistors are to be either:

(1) Shunt-wound generators; or

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

3 Field regulators for *d.c.* generators are to be capable of adjusting the voltage of generators 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 loads and full loads at any temperature within their working range.

4 The overall voltage regulation of *d.c.* generators is to be in accordance with the following requirements and rotating speeds are to be adjusted to those rated speeds at full loads:

(1) Shunt-wound generators

After temperature testing, in cases where voltages are set at full loads, steady voltages at no loads are not to exceed 115 % of their full-load values, and voltages obtained at any load values are not to exceed their no-load values.

(2) Compound-wound generators

After temperature testing, in cases where voltages at 20 % loads are adjusted within ± 1 % of their rated voltages, those voltages at full loads are to be within ± 1.5 % of their rated voltages. In addition, the averages of the ascending and descending

load/voltage curves between 20 % loads and full loads are not to vary by more than 3 % from their rated voltages.

Note: For compound-wound generators operated in parallel, drops in voltage may be acceptable up to 4 % of their rated voltages in cases where such loads are gradually increased from 20 % loads to full loads.

(3) Three-wire generators

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

5 In cases where *d.c.* generators are operated in parallel, loads on generators are not to differ by more than ± 10 % of the rated output of the largest machine from its proportionate share, based on generator ratings, of combined loads, for steady-state conditions in those combined loads between 20 % and 100 % of the sums of rated outputs of all machines. In such cases, starting points for the determination of foregoing load distribution requirements are to be at 75 % loads with each generator carrying its proportionate share.

6 Series field windings of each two-wire compound-wound generator are to be connected to negative terminals.

7 Equalizer connections of *d.c.* generators are to have cross sectional areas not less than 50 % of that of any negative connections from generators to switchboards.

2.4.14 *A.C.* Generators

1 Each *a.c.* generator, except self-excited compound-wound types, are to be provided with automatic voltage regulators.

2 The overall voltage regulation of *a.c.* generators is to be such that at all loads from zero to full loads at rated power factors, the rated voltages are to be maintained under steady conditions within ± 2.5 %. However, in the case of emergency generators such voltage limits may be within ± 3.5 %.

3 In cases where generators are driven at rated speeds, giving rated voltages and they are subjected to sudden changes of symmetrical loads within the limits of specified currents and power factors (see **2.4.15(4)**), voltages are not to fall below 85 % nor exceed 120 % of the rated voltages. Voltages of such generators are then to be restored to within ± 3 % of their rated voltage in a period of not more than 1.5 *seconds*. However, in the case of emergency generators, such voltage values may be increased to ± 4% in a period of not more than 5 *seconds*.

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

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

6 Rating plates which comply with the requirements in **1.3.10 of Part D** are to be installed on *A.C.* generating sets; in this context, "generating sets" means those systems which are composed of alternators, reciprocating internal combustion engines, couplings, etc.

2.4.15 Shop Tests*

Rotating machines are to be tested in the following **(1)** to **(13)** in accordance with **Table H2.6**. In addition, all tests are to be carried out in accordance with *IEC* 60092-301:1980/AMD2:1995. However, those tests required by **(5)** and **(7)** below 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. Furthermore, those tests required by **(6)** below may be omitted for each generator or motor which is of small capacity and which is produced in a series of identical types with their unit.

(1) Visual examinations of rotating machines are to be carried out. Such visual examinations are to ensure, as far as is practicable, that rotating machines comply with their technical documentation (e.g. design drawings, specifications).

(2) Immediately after those high voltage tests specified in **(9)** have been performed, the insulation resistance of such rotating machines is to be measured in accordance with **Table H2.8** and all values are not to be less than any of those specified in **Table H2.8**. In addition, during such measuring, temperatures of rotating machines are to be near operating temperature. However, in cases where this is difficult, appropriate methods of calculation may be used instead.

(3) Machine winding resistance is to be measured. The resistances of the machine windings are to be measured and recorded using either an appropriate bridge method, or a voltage and current method.

(4) In the case of generators, voltage regulation tests are to be carried out and comply with the requirements given in **2.4.13-4**, or

2.4.14-2 and **-3**. In the absence of precise information concerning the maximum values of any sudden loads when applyingthe requirement given in **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 attaining steady-state conditions. However, the voltage regulation during transient conditions may be calculated values based upon the test records of identical type generators subject to the Society's permission.

(5) After rotating machines are run continuously under actual load methods at their rated output voltages, frequencies, and those duties for which they are being rated until their temperatures have reached a steady state, the temperature rise of each part is to be measured and is not to exceed the value given in **2.4.3** (see *IEC* 60034-1:2017). In cases where it is considered to be acceptable by the Society, such tests may be carried out in accordance with separately specified procedures.

(6) Overcurrent or excess torque tests for rotating machines are to be carried out in accordance with **2.4.5,** and such machines are to have the capability to withstand such tests (see *IEC* 60034-1:2017).

(7) Steady short-circuit tests for synchronous generators are to be carried out and comply with the requirements given in **2.4.6-2**. However, the duration of a steady short-circuit may be of any time delay which will be fitted in the tripping device for selective tripping where precise data showing such time delay is available in accordance with the following **(a)** and **(b)**. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through tests of identical types of the same model.

(a) In order to provide sufficient information to the party responsible for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short-circuit current upon a sudden short-circuit occurring when excited and running at nominal speed.

(b) The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based upon physical testing.

(8) Overspeed tests for rotating machines are to be carried out and comply with the requirements given in **2.4.7** (see *IEC* 60034-1:2017). Such tests, however, are not applicable to squirrel cage motors.

(9) The high voltage levels specified in **Table H2.7** are to be applied for a period of 1 *minute* between live parts and frames of rotating machines, with those cores and windings not undergoing testing connected to such frames (see *IEC* 60034-1:2017). In the cases of machines with rated voltages above 1 *kV*, tests are to be carried out in accordance with the requirements given in **2.17.6-4**. Furthermore, where those temperature rise tests specified in **(5)** above are applied, high voltage tests are to be carried out after the test.

(10) No-load tests of rotating machines are to be carried out. Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency when used as a motor, or are to be driven by a suitable means and excited to give rated terminal voltage when used as a generator. During such tests, machine vibrations and bearing lubrication system operations are to be checked and confirmed to be in good order.

(11) Verification of degree of protection (IP) is to be as specified in *IEC* 60034-5:2000+AMD1:2006.

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

(13) Rotating machines with commutators are to work with fixed brushes settings from no loads to 50 % overloads without any harmful sparking.

Table H2.6 Tests for Rotating Machines

No.	Tests	Generators		Motors	
		First generator produced in a series of identical type units (1)	Other generators produced in a series of identical type units(2)	First motor produced in a series of identical type units(1)	Other motors produced in a series of identical type units(2)
1	Examination of the technical documentation, as appropriate and visual examination	x	x	x	x
2	Insulation resistance measurement	x	x	x	x
3	Winding resistance measurement	x	x	x	x
4	Verification of the voltage regulation system(7)	x	x(3)		
5	Rated load test and temperature rise measurements	x	x(8)	x	x(8)
6	Overload/overcurrent test	x	x(4)	x	x(4)
7	Verification of steady short circuit conditions(5)	x	x(8)		
8	Overspeed test	x	x	x(6)	x(6)
9	High voltage tests	x	x	x	x
10	No-load test	x	x	x	x
11	Verification of degree of protection	x		x	
12	Verification of bearings	x	x	x	x

Notes:

(1) Type tests on prototype machine or tests on at least the first batch of machines.

(2) The report of machines produced as part of a series of identical type units are to contain the manufacturer's serial number of the machine which has been type tested and the corresponding test results.

(3) Only functional tests of voltage regulator systems.

(4) Only applicable to machines with rated outputs above of 100 *kW* used for essential services.

(5) Verification of steady short circuit condition applies to synchronous generators only.

(6) Not applicable to squirrel cage motors.

(7) Not applicable to *D.C.* generators.

(8) Tests may be omitted subject to Society approval for each rotating machine which is produced in series of identical type units.

Table H2.7 Testing Voltages

Item	Machine or part	Testing voltage (*rms*) (*V*)
1	Insulated windings of rotating machines of sizes less than 1 *kW* (or *kVA*), and of rated voltages less than 100 *V* with the exception of those in items 3 to 6	2 *E* + 500
2	Insulated windings of rotating machines with the 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) $E_x \leq 500$ *V* 500 *V* < 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 times 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	 10 E_x (Minimum 1,500) 2 E_x + 4,000 10 E_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 starting) 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	 2 E_s + 1,000 4 E_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	2 E_i + 1,000 (Minimum 1,500)

Notes:

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 in cases where starting voltages are applied to armature windings while rotors are at a standstill and terminal voltages in cases where field windings or staring windings are started by connecting with such resistance
   E_s : Induced voltage between the terminals of secondary windings in cases where the machine is at a standstill
   E_i : Rated exciter voltage
2. In the case of 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. In the case of semiconductor elements for exciters, the requirements given in **2.12** are to be applied.

Table H2.8 Minimum Values of Test Voltages and Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance (*MΩ*)
$Un \leq 250$	2 × *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 and be located as far away as possible from any steam pipes, water pipes, oil pipes and other similar pipes.

2.5.2 Precautions for Operator Safety*

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

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

3 In cases where the voltage between poles or to earths exceeds 50 *V d.c.* or 50 *V a.c.* root mean square, switchboards are to be of a dead front type.

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

5 Sufficient space for operation is to be provided in front of switchboards. In addition, in cases where it is necessary for the operation and the maintenance of any disconnecting switches, switches, fuses and other parts, passageways of more than 0.5 *m* in width are to be provided at the rear of switchboards.

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

2.5.3 Construction and Materials*

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

2 In cases where main sources of electrical power are necessary for ship propulsion, main switchboards are to comply with the following requirements or are to be equivalent in performance thereto:

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

(2) 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 it is practicable, any connection of generating sets and other duplicated equipment are to be equally divided among such parts.

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

4 In cases where supply circuits having different voltages are installed in the same spaces as switchboards, section boards or distribution boards, all appliances are to be arranged so that the cables of different rated voltages can be laid without coming to contact with each other within such boards. 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 any 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 flame-retardant and non-hygroscopic which have appropriate maximum permissible conductor temperatures of not less than 75 °C.

(2) Ducts and straps for wiring are to be made 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 and it has been recognized that no harmful effects will be caused by the main circuits, this requirement may be omitted.

8 Except in cases where isolation switches are provided, circuit breakers are to be such that any repairing and replacing of them can be made without disconnecting them from busbar connections and switching off power sources.

2.5.4 Busbars*

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

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

3 Busbars and busbar connections are to be supported so as to withstand any electromagnetic forces resulting from short-circuiting.

4 Temperature rises of busbars, connecting conductors and their connections are not to exceed 45 *K* at ambient temperatures of 45 °C in cases where they are carrying full-load currents. However, in cases where deemed appropriate by the Society, these requirements do not apply.

5 Air clearances (phase-to-phase, pole-to-pole and phase-to-earth) of non-insulated busbars are not to be less than the values given in **Table H2.9**.

Table H2.9 Minimum Air Clearances for Busbars

Rated voltage (*V*)	Air clearance (*mm*)
250 or less	15
over 250 to 690 inclusive	20
over 690 to 1,000 inclusive	25

2.5.5 Equalizers

1 Current ratings of equalizer connections and equalizer switches are not to be less than half the rated full-load current of generators.

2 Current ratings of equalizer busbars are not to be less than half the rated full-load current of the largest generator in the group.

2.5.6 Measuring Instruments for *d.c.* Generators

Ship service *d.c.* generator panels are to be at least provided with the instruments given in **Table H2.10**.

Table H2.10 Instruments for *d.c.* Generator Panels

Operations	Instruments	Number required	
		2-wire systems	3-wire systems
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 the case of compound winding, between equalizers and armatures, and in the case of shunt winding, for positive and negative poles)
	Voltmeter	2 busbars and each generator	2 (voltage measurement between busbars and positive and negative poles of each generator, or between positive poles and neutral poles)

Notes:

1. In cases where neutral line earthed systems are employed, zero centre ammeters for such earth lines are to be added to those numbers marked with a * in the above table.
2. One of the voltmeters is to be capable of measuring shore supply voltages.
3. In cases where control panels are provided for automatic control of generators, the instruments in the above table may be installed on such control panels. However, in cases where such control panels are installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operations of generators is to be mounted on switchboards.

2.5.7 Measuring Instruments for *a.c.* Generators

Ship service *a.c.* generator panels are at least to be provided with the instruments given in **Table H2.11**.

2.5.8 Instrument Scales

1 The upper limits of the scale of voltmeters are to be approximately 120 % of the normal voltage of their respective circuits.

2 The upper limits of the scale of ammeters are to be approximately 130 % of the normal rating of their respective circuits.

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 currents or reverse power up to 15 % respectively.

2.5.9 Transformers for Instruments

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

Table H2.11 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 cases where automatic synchroscopes are provided, either one of these may be omitted
	*Ammeter	1 for the exciting circuit of each generator

Notes:

1. In the above table, ammeters marked with a * are to be provided only in those cases where necessary.
2. One of the voltmeters is to be capable of measuring shore supply voltages.
3. In cases where control panels are provided for automatic control of generators, those instruments given in the above table may be installed on such control panels. However, in cases where such control panels are installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operations of generators is to be mounted on switchboards.

2.5.10 Shop Tests

Switchboards are to be tested and inspected in accordance with the requirements given in the following **(1)** to **(4)**. However, those tests required by **(1)** below 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.

(1) Temperature rises of switchboards are not to exceed those values given in **Table H2.12** under the specified currents and/or rated voltages, except in those cases specified in the chapters of this Part.

(2) Functions of instruments, circuit breakers, switchgears, etc. on switchboards are to be confirmed as normal.

(3) Switchboards as well as all components are to be able to withstand high voltages by applying the following voltages at commercial frequencies for a period of 1 *minute* between all current-carrying parts connected together and earths as well as between current-carrying parts of opposite polarities or phases. Instruments and auxiliary apparatus may be disconnected during these high voltage tests:

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*)

(4) Immediately after such high voltage tests have been performed, the insulation resistance between all current-carrying parts connected, earths and between current-carrying parts of opposite polarities or phases is not to be less than 1 *MΩ* when tested with *d.c.* voltages of at least 500 *V*.

Table H2.12 Limits of Temperature Rise of Electrical Appliances for Switch Boards

(Based on Ambient Temperatures of 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 forms	Copper or copper alloys	40
		Silver or silver alloys	70
	Multilayer forms or Knife forms	Copper or copper alloys	25
Terminals for external cables			45
Metallic resistors	Moulded-case types		245
	Those other than moulded-case types	For continuous service	295
		For intermittent service	345
	Exhaust (approx. 25 *mm* above 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 any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3** below.

2 The construction of circuit-breakers is to comply with the following **(1)** to **(6)**:

(1) All circuit-breakers are to be trip-free types and depending upon the field of their application, trip attachments are to have time-delays or instantaneous overcurrent trip features or both.

(2) Main contacts of circuit-breakers are to be such as to have no undue burning or pitting. Arcing contacts, except those of moulded case circuit-breakers, are to be easily replaceable.

(3) Instantaneous trip devices other than those electronic types having suitable testing arrangements are to be of constructions capable of tripping associated breakers directly by short-circuit currents.

(4) Circuit-breakers are to be such that no accidental opening and closing occur due to ship vibrations; furthermore, there are to be no malfunctions caused by an inclination in any direction under the conditions given in **Table H1.2**.

(5) Fused circuit-breakers of moulded-case types are to be constructed so that single phasing does not occur in the event of blowing of fuses and that the fuses can be easily replaced without any risk of operating personnel accidentally touching any live-parts.

(6) Rated (operational) voltages, rated (thermal) currents, etc. as well as rated breaking capacities, rated making currents and rated short-time currents are to be clearly indicated on each circuit-breaker according to their type. In addition, each time-delay overcurrent trip device is to have its operating characteristics indicated except for moulded-case circuit-breakers.

3 Circuit-breaker performance is to comply with the following **(1)** to **(4)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45 *K* at ambient temperatures of 45 °C in cases where 100 % of rated currents are carried therethrough.

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

(3) Time-delay over-current trip devices of circuit-breakers for generator circuits are to be such that any readjustment of current settings does not cause any remarkable changes in such time-delay features.

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

2.6.2 Fuses

1 Fuses are to comply with *IEC Publication* 60269, or any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3** below.

2 The construction of fuses is to comply with the following **(1)** to **(3)**:

(1) Fuses are to be enclosed types and their construction is to be such that such enclosures are neither broken nor burnt and any adjacent insulation cannot be damaged by any flowing of fused metal or emitting of gases in cases where fuse elements blow out.

(2) Fuses are to be easily replaceable with spares without any risk of electric shock or burning to any personnel replacing such fuses.

(3) Rated voltages, rated currents, etc. are to be clearly indicated on each fuse. In addition, rated breaking capacities, fusing characteristics and current-limiting characteristics according to its kind are also to be indicated. All such indications are to be clearly made using either values or symbols.

3 The performance of fuses and fuse-holders are to comply with the following **(1)** and **(2)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45 *K* at ambient temperatures of 45 °C in cases where fuses are fitted to fuse-holders; furthermore, 100 % of rated currents are carried therethrough.

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

2.6.3 Electromagnetic Contactors

1 Electromagnetic contactors are to comply with *IEC publications* 60947-1 and 60947-4-1, or any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3**.

2 The construction of electromagnetic contactors is to comply with the following **(1)** to **(3)**:

(1) Electromagnetic contactors are to be such that no accidental opening and closing occur due to ship vibrations; furthermore, there are to be no malfunctions caused by an inclination in any direction under the conditions given in **Table H1.2**.

(2) Contact pieces and magnetic coils are to be easily replaceable.

(3) Rated operational voltages, rated capacities or full-load currents corresponding to rated capacities, etc. as well as rated operational voltages and frequencies for control circuits, interruption current capacities and closed circuit current capacities are to be indicated on each electromagnetic contactor. Such indications are to be clearly made in either values or symbols.

3 The performance of electromagnetic contactors is to comply with the following **(1)** to **(3)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45 *K* at ambient temperatures of 45 °C in cases where full-load currents corresponding to rated capacities are carried therethrough.

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

(3) Electromagnetic contactors are not to accidentally open circuits at voltages exceeding 85 % of rated voltages.

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 Clearances and Creepage Distances

1 Clearances and creepage distances of control appliances (*e.g.*, contactors, rheostats, control switches, limit switches, motor protection and control relays, terminal boards, appliances incorporating semiconductors and their combinations) are to comply with the requirements given in **-2** and **-3** below depending on the degree of protection of enclosures of such appliances or those ambient conditions in which such appliances are installed.

2 Minimum clearances and creepage distances of control appliances (*e.g.*, electromagnetic contactors, control switches, terminal boards) are not to be less than those values given in **Table H2.13** if such appliances are designed and constructed in consideration of

moisture, dust, etc. or if they are operated in ambient conditions not affected by extremely high humidity and heavy deposit of dusts.

3 Minimum clearances and creepage distances of small control appliances having rating currents not exceeding 16 *A* may be shortened to values deemed appropriate by the Society, depending on the degree of protection of the enclosures of such appliances or those ambient conditions in which such appliances are installed.

4 The requirements given in **-2** and **-3** above may not apply to the following:

(1) Clearance distances between contacts generating arcs

(2) Appliances used in secondary windings of induction motors

(3) Oil-immersed appliances

(4) Caps and lamp-holders of indicator lamps

(5) Small switches in living quarters

(6) Filled portion of gas-filled appliances

Table H2.13 Minimum Clearances and Creepage Distances for Control Appliances

Rated insulating voltage (*V*) (*d.c* & *a.c.*)	Clearance (*mm*)						Creepage[3][4] (*mm*)					
	Less than 16 *A*[5]		16 *A* or over and 63 *A* or under[5]		Exceeding 63 *A*[5]		Less than 16 *A*[5]		16 *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
Exceeding 500 and 660 or under	6	8	6	8	8	10	8	12	8	12	10	14
Exceeding 660 and 800 or under	10	14	10	14	10	14	10	14	10	14	14	20
Exceeding 800 and 1,000 or under	14	20	14	20	14	20	14	20	14	20	20	28

Notes:

1. "*L-L*" applies to those clearances between bare live parts and between live parts and earthed metal parts.
2. "*L-A*" applies to those clearances between live parts and insulated metal parts which become a live part due to insulation deterioration.
3. Creepage distances are to be determined by insulation thermal class and shape.
   "*a*" applies to ceramic insulators (steatite and porcelain) and other comparable insulators, provided with ribbed construction or vertical partitions especially deigned to prevent any electricity leaks, which are recognized by experimentation to be equally as effective as ceramic insulators and which have tracking indices greater than 140*V*, *e.g.* phenol resins formed items.
   "*b*" applies to all other insulation materials.
4. In cases where "*L-A*" is greater than the corresponding creepages "*a*" or "*b*", creepage distances between live parts and insulated metals which operators may easily come in contact with and which become live parts by due to insulation deterioration are to be "*L-A*" or more.
5. Current values are to be expressed by rated current-carrying values.

2.7.2 Ambient Conditions

1 Electrical appliances incorporating semiconductors are to be suitable for proper operation at ambient temperatures of 55 °C.

2 Control appliances are not to cause any malfunctions such as undesired switching motions or change in an inclination in any

direction under the conditions given in Table H1.2.

2.8 Controlgears 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 for starting, stopping, reversing and controlling speed as well as be equipped with all essential safety devices.

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

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

4 Motors above 0.5 *kW* are to be provided with the controlgears complying with those requirements given in **-1**, **-2** and **-3** above and in the following **(1)** to **(3)**:

(1) Means are to be provided to prevent any undesired restarting after stoppages due to low voltage or complete loss of voltage. This requirement does not apply to those motors continuous availability of which are essential to the safety of the ship and to those motors operated automatically.

(2) Primary means of isolation are to be provided so that all power may be cut off from motors, except in cases where such means of isolation (provided at switchboards, section boards, distribution boards, etc.) are adjacent to motors.

(3) Means to automatically disconnect power supplies are to be provided in the event of excess current due to mechanical overloading of motors. This requirement does not apply to those motors for steering gears.

5 In cases where primary means of isolation are remote from motors, either of the following means or their equivalent is to be provided:

(1) Additional means of isolation fitted adjacent to motors are to be provided.

(2) Provisions are to be made for locking primary means of isolation in "off" positions.

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

7 In cases where controlgears for motors of essential services are built in grouped starter panels; busbars, appliances and others are to be arranged so that a single fault in any one of the appliances or circuits of controlgears for motors in grouped starter panels does not render other motors of essential services unusable. In addition, contorolgears of essential services are to be partitioned by fire-retardant walls, and they are also to be separated from other current carrying parts.

8 Transformers for power supplies 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 those motors of steering gears are to comply with those requirements given in 15.2.7, Part D.

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 satisfactorily release at 85 % of their rated voltage at maximum working temperatures, and *d.c.* compound-wound brakes under the same conditions as above are to satisfactorily release at 85 % of their starting currents.

3 *D.C.* series-wound brakes are to satisfactorily release at 40 % or more of their full-load currents and in every case at their starting current; furthermore, they are to satisfactorily dampen in cases where they are at 10 % or less of their full-load currents.

4 *A.C.* magnetic brakes are to comply with the following **(1)** and **(2)**:

(1) *A.C.* magnetic brakes are to satisfactorily release at 80 % of their rated voltages at working temperatures.

(2) *A.C.* magnetic brakes are not to be noisy due to any magnetic action under working conditions.

2.8.3 Temperature Rise

Temperature rises of controlgears for motors are not to exceed, under specified currents or rated voltages, the values given in Table H2.14, except as separately specified in this Part.

Table H2.14 Limits of Temperature Rise of Controlgears for Motors (Based on Ambient Temperatures of 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*	Copper or copper alloy	40
			Silver or silver alloy	70
		Switch on & off one attempt or more in about 8 *hours*	Copper or copper alloy	60
			Silver or silver alloy	70
	Multilayer form or knife form		Copper 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

Note:

The term "moulded-case type metal resistor" refers to those resistors which are to be buried in the insulation so that no surfaces of any metallic resistors are exposed.

2.8.4 Shop Tests

Controlgears for motors are to be tested in accordance with the requirements given in the following **(1)** to **(4)**. However, those tests required by **(1)** below 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.

(1) Controlgears for motors are to undergo the temperature tests under normal working condition, and any temperature rise of each is not to exceed those values given in **2.8.3**.

(2) Functions of instruments, switching gears, protective devices, etc. of controlgears for motors are to be verified.

(3) Controlgears for motors as well as all components, are to be able withstand high voltages by applying the following voltages at commercial frequencies for a period of 1 *minute* between all current-carrying parts of switchgears, including control devices and earths as well as between poles or phases. Instruments and auxiliary apparatus may be disconnected during these high voltage tests.

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*)

(4) Immediately after such high voltage tests have been performed, the insulation resistance between all current-carrying parts connected and earths as well as between current-carrying parts of opposite polarities or phases are not to be less than 1 *MΩ* in cases where tested with *d.c.* voltage of at least 500 *V*.

2.9 Cables

2.9.1 General

Cables are to comply with one of *IEC* standards listed in the following **(1)** to **(7)** or any equivalent thereto. However, cables such as flexible cables, fibre-optic cables, etc. used for special purposes may be accepted provided they comply with relevant standards

deemed appropriate by the Society or any equivalent thereto. Installation of cables is to comply with the requirements given in this 2.9.

(1) *IEC* 60092-350:2020
(2) *IEC* 60092-352:2005
(3) *IEC* 60092-353:2016
(4) *IEC* 60092-354:2020
(5) *IEC* 60092-360:2014
(6) *IEC* 60092-370:2019
(7) *IEC* 60092-376:2017

2.9.2 Choice of Cables

1 The rated voltage of any cable is not to 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 those power supply circuits requiring individual short-circuits and overcurrent protection.

3 Maximum rated conductor temperatures of materials used in cables are to be at least 10 °C higher than those maximum ambient temperatures likely to exist, or be normally produced, in those spaces where such cables are installed.

2.9.3 Choice of Protective Coverings*

Cables are to be protected by sheaths and/or metal armour in accordance with the following **(1)** to **(3)**:

(1) Cables fitted on weather decks, in bath rooms, cargo holds, machinery spaces, or any other locations 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 those cables with hygroscopic insulation.
(3) Cables fitted on weather decks, in cargo holds, in machinery spaces, etc., in locations where they can easily suffer from mechanical damage are to be protected by metal armour except in those cases 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 types.

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 main or emergency switchboard busbars to any points in installations except navigation lighting circuits, in cases where cables are carrying maximum current under normal conditions of service, are not to exceed 6 % of nominal voltages. However, the voltage drop on supply circuits from batteries with voltages not exceeding 24 *V* may be permitted up to 10 %.

2.9.7 Assessment of Lighting Loads

In assessing the current rating of lighting circuits, lampholders are to be assessed at those maximum loads which they are likely to be connected to, with a minimum of 60 *W*, unless such fittings are so constructed as to take only one lamp rated at less than 60 *W*.

2.9.8 Current Rating for Short-time or Intermittent Loads

Cables supplying motors used for cargo winches, windlass, capstan, etc. are to be suitably rated for their duties. In such cases, consideration is to be given to 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 service is not to exceed the values given in Table H2.15.
(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 H2.15 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 constant loads and 6 *minutes* without any loads at all) may be increased by multiplying the value given in Table H2.15 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) In cases where more than 6 cables belonging to the same circuit are bunched together, a correction factor of 0.85 is to be applied.

(5) In cases where ambient temperatures are different from those specified in **(1)** to **(3)**, the correction factor in **Table H2.16** may be applied.

Table H2.15 Current Ratings of Cables (for continuous service)(1) (Based on Ambient Temperatures of 45 °C)

Nominal sectional area of conductor (mm^2)	Current rating in amperes								
	PVC insulation(2) (heat resisting) (75 °C)			Cross-linked polyethylene Insulation(3) and *EP* rubber 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
1.5	17	14	12	23	20	16	26	22	18
2.5	24	20	17	30	26	21	32	27	22
4	32	27	22	40	34	28	43	37	30
6	41	35	29	52	44	36	55	47	39
10	57	48	40	72	61	50	76	65	53
16	76	65	53	96	82	67	102	87	71
25	100	85	70	127	108	89	135	115	95
35	125	106	88	157	133	110	166	141	116
50	150	128	105	196	167	137	208	177	146
70	190	162	133	242	206	169	256	218	179
95	230	196	161	293	249	205	310	264	217
120	270	230	189	339	288	237	359	305	251
150	310	264	217	389	331	272	412	350	288
185	350	298	245	444	377	311	470	400	329
240	415	353	291	522	444	365	553	470	387
300	475	404	333	601	511	421	636	541	445

Note:

(1) The values in this table are not applied to cables which do not satisfy the maximum rated conductor temperature of the concerned insulation.

(2) Polyvinylchlorid insulated wires for control equipment wiring, etc.

(3) Single core, flame retardant cross-linked polyethylene insulated flexible switchboard wire, etc.

Table H2.16 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 within ship structure is to be avoided as far as possible. In cases where such installations are unavoidable, loops of cable of lengths proportional to the expansion of such joints are to be provided. The internal radius of such loops is to be at least 12 *times* the external diameter of the cable.

3 In cases where duplicate supplies are required, those 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, in cases where such bunching is unavoidable, such 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 protective coverings which may damage the coverings of other cables are not to be bunched together with those other cables.

6 When installing cables, the minimum inside radius of bends are to be in accordance with the following:

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

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

(3) Mineral insulated cables: $6d$

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

7 Intrinsically safe circuit installations are to comply with the following:

(1) Cables for intrinsically safe circuits associated with intrinsically safe type electrical equipment are to be of exclusive use, being installed separately from other cables used 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. In cases where it is necessary to use multi-core cables in common, cables which have shields for each core or each pair of cores are to be used and such shields are to be effectively earthed. However, intrinsically safe circuits associated with category '*ia*' types of intrinsically safe type electrical equipment are not to be contained in cables associated with category '*ib*' types of intrinsically safe type electrical equipment.

2.9.11 Precaution against Fire*

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

2 All cables for power, lighting, internal communications, signals and navigational aids of essential and emergency services are to be, as far as practicable, routed clear of high fire risk areas and casings of all machinery spaces of category *A*. In addition, cables connecting fire pumps to emergency switchboards are to be fire resistant types complying with standards deemed appropriate by the Society in cases where they pass through high fire risk areas. All such cables are to be, as far as practicable, run in such a manner as to preclude their being rendered unserviceable by any heating of bulkheads that may be caused by fires in adjacent spaces.

3 Electrical services required to be operable under fire conditions are as follows:

(1) Control and power systems to power-operated fire doors and status indication for all fire doors

(2) Control and power systems to power-operated watertight doors and their status indication

(3) Emergency fire pump

(4) Emergency lighting

(5) Fire and general alarms

(6) Fire detection systems

(7) Fire-extinguishing systems and fire-extinguishing media release alarms

(8) Low location lighting

(9) Public address systems or other equivalent means of communication

(10) Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion specified in **2.2.13-1**

4 Where cables for services specified in **-3** above including their power supplies pass through high fire risk areas, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

(1) Cables being of a fire resistant type complying with *IEC* 60331-1:2018 for cables of greater than 20 *mm* overall diameter,

otherwise *IEC* 60331-21:1999+AMD1:2009 or *IEC* 60331-2:2018 for cables with an overall diameter not exceeding 20 *mm*, are installed and run continuous to keep the fire integrity within the high fire risk area (see **Fig. H2.2**).

(2) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

(3) Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

(4) Cables are to be laid within insulated steel pipes or steel ducts whose fire protection is equivalent to *A*-60 or more.

5 The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s). They are to be of a fire resistant type, in accordance with **-4(1)** above, where they pass through other high fire risk areas.

6 The definition for "high fire risk areas" in case of **-4** and **-5** above is the following:

(1) Machinery spaces as defined by **3.2.30, Part R**, except spaces having little or no fire risk as defined by paragraphs (10) of Regulation 9.2.2.3.2.2 of *SOLAS* Chapter II-2. (Including the interpretations for tables 9.3, 9.4, 9.5, 9.6, 9.7 and 9.8 given in *MSC*/*Circ*.1120 as amended by *MSC*.1/*Circ*.1436 and *MSC*.1/*Circ*.1510)

(2) Spaces containing fuel treatment equipment and other highly flammable substances

(3) Galley and Pantries containing cooking appliances

(4) Laundry containing drying equipment

(5) Spaces as defined by paragraphs (8), (12), and (14) of Regulation 9.2.2.3.2.2 of *SOLAS* Chapter II-2

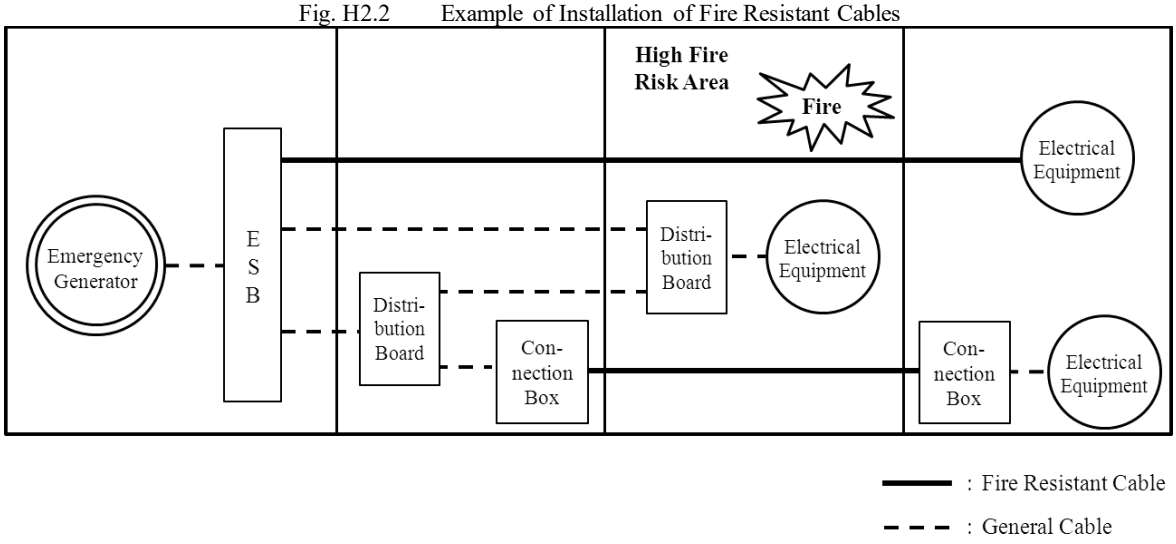
7 Means are to be provided so that fire resistant cables are easily distinguishable.

8 For special cables, requirements in the following standards may be used:

(1) *IEC* 60331-23:1999: Procedures and requirements - Electric data cables

(2) *IEC* 60331-25:1999: Procedures and requirements - Optical fibre cables

Fig. H2.2 Example of Installation of Fire Resistant Cables



2.9.12 Cables in Hazardous Areas*

In cases where cables installed in hazardous areas are at risk of fire or explosions due to electrical faults 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 both ends unless otherwise stated in this Part. However, in the case of final sub-circuits, earthing may be at supply ends only. This does not necessarily apply to any instrumentation cables in cases 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 entire length.

2.9.14 Supports and Fixing of Cables*

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

2 Distances between supporting and fixing points are to be suitably chosen according to cable type and vibration probabilities,

and are not to exceed 40 *cm*. With respect to horizontal cable runs, except for those along weather decks, in cases where such cables are laid on cable supports in the form of hanger ladders, etc., spacing between any fixing points may be up to 90 *cm* provided that there are supports which have a maximum spacing of 40 *cm*. Cable runs in cases where cables are installed in ducts or pipes are to be as deemed appropriate by the Society.

3 Clips, supports and accessories are to comply with the following **(1)** to **(4)**:

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

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

(3) Non-metallic clips are to be in accordance with the following **(a)** and **(b)**:

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

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

(4) Non-metallic supports are to be in accordance with the following **(a)** to **(g)**:

(a) They are to be of types that have passed any tests otherwise specified by the Society.

(b) They are to be sufficiently durable under any possible surrounding conditions.

(c) They are to be suitable for ambient temperatures.

(d) They are to be electrically conductive in cases where they are used in dangerous spaces.

(e) They are to be protected against UV light in cases where they are used on open decks.

(f) They are to be fixed with support spacing which is not to be greater than that used in those tests referred to in **(a)** above or 2 *m*, whichever is less.

(g) They are to be supplemented by metallic fixings to prevent any supports and cables from falling in the event of 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 carried out by means of cable glands or boxes so as to ensure that strength and tightness are not impaired.

2 In cases where cables pass through non-watertight bulkheads or steel structures, holes are to be bushed with suitable materials in order to avoid any damage to such cables. If the thickness of the steel is sufficient (≥ 6 *mm*) and there is no risk of damage to any 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 such fire integrity is not impaired.

2.9.16 Mechanical Protection of Cables

1 Cables without metal armour which are exposed to risks 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, in cases where there are exceptional risks 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 in those cases where such cables are protected by metal armour.

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 as well as be mechanically and electrically continuous across joints.

2 The internal radius of bend of pipes and conduits is not to be less than those values specified (*See* **2.9.10-6**). However, in cases where such pipes exceed 64 *mm* in diameter, the internal radius of bends is not to be less than twice the diameter of such pipes.

3 Drawing-in factors (those ratios of the sum of cross-sectional areas of the cables to internal cross-sectional areas of pipes) are not to exceed 0.4.

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

5 In cases where pipe arrangements are 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)** to **(5)**:

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

(2) Cables are to have sheaths made out of materials with good water resistant properties and be capable of withstanding the low temperatures of refrigerated spaces.

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

(4) In cases where cables have to pass through structural heat insulation, they are to be installed at right angles to such insulation and are to be protected by pipes, which are sealed at each end.

(5) Cables are to be installed with sufficient space behind the face of any chambers or air duct casings and are to be supported by plating, hangers or cleats. In cases where cables have corrosion-proof layers covering their armour, they may be placed directly on the faces of such chambers or air ducts.

2.9.19 Cables for Alternating Current

In cases 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 cases where cables are armoured, they are to be earthed at single points.

(2) In cases where they are installed in a pipes or conduits, all cables belonging to the same circuit are to be installed in the same pipes or conduits unless such metallic pipes or conduits are made out of non-magnetic material.

(3) Cable clips are to include cables of all phases of circuits unless such clips are made out of non-magnetic materials.

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

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

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

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

(8) Magnetic materials are not to be placed between single-core cables of a group. In cases where cables pass through steel plates, all cables of the same circuit are to pass through plates or glands constructed so that any distance between such cables and magnetic materials is not less than 75 *mm*, unless such cables are installed in trefoil formations.

2.9.20 Terminals, Joints and Branches of Cables*

1 Cables are to be jointed by terminals. However, in cases where deemed appropriate by the Society, these requirements do not apply. Soldering fluxes containing corrosive substances are not to be used.

2 Terminals are to have sufficient contacting surfaces and pressures.

3 The length of any 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 moisture-resistant insulation (*e.g.* mineral insulation) are to have their ends effectively sealed against any ingress of moisture.

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

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

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 given in this **2.10**.

2.10.2 Construction

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

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 are also to be provided with thermometers.

4 All transformers are to be capable of withstanding, without suffering any damage, thermal and mechanical effects of short-circuits at terminals of any winding for a period of 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 rises of transformers are not to exceed those values given in **Table H2.17** during any continuous operation at rated outputs.

Table H2.17 Limits of Temperature Rise of Transformers (Based on Ambient Temperatures of 45 °C)

Part		Limits of temperature rise (*K*)					
		Measuring method	Thermal class *A*	Thermal class *E*	Thermal class *B*	Thermal class *F*	Thermal class *H*
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 effects on adjacent insulations				

2.10.4 Modification of the Limits of Temperature Rise*

1 In cases where ambient temperatures exceed 45 °C, limits of temperature rise are to be decreased by the difference from those values given in **Table H2.17**.

2 In cases where temperatures of primary coolants do not exceed 45 °C, the limits of temperature rise may be increased in those cases deemed appropriate by the Society.

3 In cases where ambient temperatures do not exceed 45 °C, limits of temperature rise may be increased by the difference from those values given by **Table H2.17**. In such cases, ambient temperatures are not to be set below 40 °C.

2.10.5 Voltage Regulation

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

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 %

2.10.6 Shop Tests

Transformers are to be tested in accordance with the requirements in the following **(1)** to **(4)**. However, those tests required by **(1)** may be omitted for those transformers which are produced in a series of identical types from the second unit onward subject to Society approval.

(1) Temperature rises of transformers under rated full loads are not to exceed those values given in **2.10.3**.

(2) Transformers are to undergo voltage regulation tests and are to comply with the requirements given in **2.10.5**. However, it may be permissible to obtain such information from calculations.

(3) Immediately after such temperature tests have been performed, transformers are to be able to withstand high voltages by applying *a.c.* 1,000 *V* plus twice the maximum line voltages of commercial frequencies, between windings and between windings and earths for a period of 1 *minute*. Test voltages in these tests are to be at least 1,500 *V*.

(4) Transformers are to be able to withstand for the duration of the test given by the following formula those cases where twice the normal voltage is induced on the winding at any frequency between 100 and 500 *Hz*. However, the duration of such tests is to be for a period of at least 15 *seconds*, but not more than 60 *seconds*:

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

2.11 Accumulator Batteries

2.11.1 General*

1 The requirements given in this **2.11** apply to all permanently installed vented types of secondary batteries. However, the requirements specified in **2.11.5-4** are also applicable to valve-regulated sealed types of batteries.

2 Accumulator battery systems consisting of lithium-ion batteries with total capacities of 20 *kWh* or more and associated equipment are to be in accordance with **Annex 2.11.1-2.**

3 Any usage of types of secondary batteries other than vented types of secondary batteries and the secondary batteries specified in **-2** above is required to be as deemed appropriate by the Society.

4 Accumulator batteries are to be able to suitably perform with respect to their intended service.

2.11.2 Construction

Cells of all batteries are to be constructed and secured so as to prevent any spilling of electrolytes due to ship motion as well as to prevent any 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 only installed in those compartments assigned to them. They may be installed in boxes on deck if adequately ventilated and provided with means to prevent any ingress of water.

3 Engine starting batteries are to be located as close as practicable to those engines served. If such batteries cannot be accommodated in battery rooms, they are to be installed at places where adequate ventilation is ensured.

4 Batteries are not to be placed in living quarters.

2.11.4 Installation Procedures and Protection from Corrosion

1 Batteries are to be arranged to permit ready access for replacing, inspecting, 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 motion.

3 In cases where acid is used as the electrolyte, trays made out of acid resisting materials are to be provided below such cells unless those decks below are similarly protected.

4 The interior of battery compartments including any 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 such ducts and fans are made of corrosion-resisting material.

2.11.5 Ventilation*

1 Battery compartments are to be adequately ventilated by independent ventilation systems.

2 In cases where natural ventilation is employed, ventilation ducts are to be run directly from the top of battery compartments to the open air above, with no parts of the ducts at angles of more than 45° from vertical.

3 If natural ventilation is impracticable, mechanical exhaust-ventilation is to be provided. Electric motors for the ventilating fans are not to be placed inside any ducts. Ventilating fans are to be constructed and to be made of such materials so as to render any sparking impossible in the event of impellers touching fan casings.

4 The ventilation arrangements for installation of vented type batteries which have charging power higher than 2 *kW* are to be such that the quantity of air expelled is at least equal to:

$$Q = 110 \times I \times n \ (l/h)$$

I : Maximum current delivered by the charging equipment during gas formation, but not less than 25 % of the maximum obtainable charging current in amperes

n : Number of cells in series

Q : Quantity of air expelled in litres/hour

The ventilation rate for compartments containing valve-regulated sealed type batteries may be reduced to 25 % of that given above.

2.11.6 Electrical Equipment*

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

2 Lighting fittings provided within battery compartments are to comply with the requirements given in **2.16** and to be suitable for use in explosive atmospheres classified into gas and vapour group *IIC*, temperature class *T*1 and construction suitable for use in Zone 1 as specified in *IEC* 60079, or equivalent thereto.

3 Cables other than those for batteries and electrical installations specified in **-2** above are, as a rule, not to be installed in battery compartments except in cases 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.* generators and series resisters are to be provided with protection against any reversal of currents when charging voltages are at 20 % of line voltages or higher.

2 In the case of floating service or for any other conditions where loads are connected to batteries while they are charging, maximum battery voltages under any conditions of charging are not to exceed those safe values of any connected apparatus. Voltage regulators or other means of voltage control may be provided for this purpose.

2.12 Semiconductor Converters for Power

2.12.1 General*

1 The requirements given in this **2.12** are to apply to semiconductor converters 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 Converters are to be arranged so that they can be repaired or replaced.

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 a series or in parallel, they are to be arranged so that voltages 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 a manner that coolant circulation is not impeded and that 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 In cases where forced cooling devices are provided, converters are to be arranged so that they cannot remain loaded unless effective cooling is maintained.

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

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

4 Semiconductor elements and filter circuits are to be protected by fuses, etc. In addition, consideration is to be given to how the failure of converters may affect other equipment.

2.12.4 Shop Tests*

The converters and accessories specified in **1.2.1-1(7)** are to be tested in accordance with the following **(1)** to **(5)**. However, those tests required by **(1)** below may be omitted, subject to Society approval, for products which are produced in a series of identical types from the second unit onward.

(1) Temperature rise tests for converters and their accessories are to be carried out under normal working conditions. In addition, the temperature rise for the interiors of converters is not to exceed manufacturer specified values while 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 the values specified in the requirements given in **2.8.3**. Furthermore, temperature test methods for semiconductor element connections are to be as deemed appropriate by the Society.

(2) Instruments, switching devices and protective devices fitted in converters are to be checked for normal operation under operating conditions.

(3) High voltage tests specified in *IEC* 60146-1-1 or *IEC* 61800-5-1

(4) High voltage tests between live parts and earths for accessories charged with auxiliary circuit potential are to be in accordance with the requirements given in **2.8.4(3)**.

(5) Immediately after such high voltage tests have been carried out, insulation resistance between live parts of converters and their accessories and earths is not to be less than 1 *MΩ* when tested with *d.c.* voltages of at least 500 *V*.

2.13 Lighting Fittings

2.13.1 General

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

2.13.2 Construction

1 Ratings of lampholders are to be in accordance with *IEC Publication* 60092 or other standards that are deemed appropriate by the Society.

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

3 Large lampholders are to be provided with means for locking lamps into their holders.

4 Enclosures are to be composed of metal, glass or synthetic resins having sufficient mechanical, thermal and chemical resistant properties; furthermore, they are 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 maritime applications. Consideration is to be given so that the insulation of cables does not deteriorate at an early stage due to any temperature rises of terminals and other parts.

6 The internal wiring of lighting fittings is to 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 rooms or similar other spaces which are exposed to risks of mechanical damage are to be provided with suitable grilled metallic guards to protect their lamps and glass globes against such damage.

2.13.3 Arrangements

Lighting fittings are to be arranged so as to prevent any temperature rises which could damage cables and wiring, and to prevent any surrounding materials 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 Capacitors of 0.5 *μF* or more are to be provided with protective leaks or other protective means which reduces the voltage of capacitor to not more than 50 *V* within a period of 1 *minute* after disconnection from the supply sources.

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

2.14 Wiring Accessories

2.14.1 General

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

2 Insulating materials of live parts are to be made of flame-retardant and non-hygroscopic materials.

2.14.2 Temperature Rises

Temperature rises of live parts are not to exceed 30 *K*.

2.14.3 Switches

Switches are to be capable of breaking and making safe load currents 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 following **(1)** to **(5)**:

(1) Socket-outlets and plugs are to be such that they cannot be easily short-circuited regardless of whether plugs are in or out.

(2) Inserting only one pin of plugs into any socket-outlets is to be made impossible.

(3) Socket-outlets of rated currents exceeding 16 *A* are to be provided with switches so interlocked that plugs cannot be inserted or withdrawn in cases where switches are in the "on" position.

(4) In cases where distribution systems of different voltages are in use, socket-outlets and plugs are to be of such design that incorrect connections cannot be made.

(5) In cases where socket-outlets with earthing contacts are required, such socket-outlets and plugs are to be provided with additional contacts for earthing casings or frames of appliances. In addition, these earthing contacts are to make contact before 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 constructed so as to reduce fire risks to a minimum, and no such space heaters are to be fitted with any elements so exposed that clothing, curtains or other similar materials can be scorched or set on fire by heat from such elements.

2.15.2 Installation

Space heating appliances are to be mounted so that there will be no risk of the 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 any equivalent thereto; furthermore, they are also to comply with the requirements given in this 2.16.

2.16.2 Selection of Explosion-protected Construction

Constructions for explosion-protected electrical equipment used in hazardous areas (Zone 0, Zone 1 or Zone 2) on board ships are to be selected from the following explosion-protected types:

(1) Flameproof type

(2) Increased safety type

(3) Intrinsically safe type

(4) Pressurized protected type

(5) Encapsulation type

(6) Powder filling type

(7) Oil immersion type

(8) Type of protection '*n*'

(9) Special protection type

2.16.3 Materials*

1 Materials for explosion-protected constructions are to have adequate electrical, mechanical, thermal and chemical resistant properties against any environmental conditions as well as flammable gases or vapours (hereinafter referred to as "gases") at the installation locations of such electrical equipment.

2 Enclosures and outer fittings of portable appliances are to be made of materials which minimize the risk of sparks by friction, or are to have non-metallic strong covers with hanging straps.

3 Insulating compounds and sealing compounds used for integral parts of explosion-protected constructions are to be such that no harmful expansion, contraction, softening or cracking occurs such constructions are in service. In addition, any insulating compounds applied to bare live-parts are to be flame-retardant.

2.16.4 Construction*

1 Glazed ports of lighting fittings as well as any inspection windows of other electrical apparatus whose constructions are flameproof types, increased safety types and pressurized protected types are, as a rule, to be provided with robust metallic guards.

2 In cases where gaskets are used with views to give watertightness to explosion-protected electrical equipment installed on weather decks and in other similar spaces, such gaskets are to be fitted so that no explosion-proof characteristics are impaired due to any gasket deterioration or breakage.

3 Leading-in parts of cables are to be of constructions suitable for ship cables. Consideration is to be given so that cables can be surely fixed at their leading-in parts, except in cases where such cables are installed in steel conduits.

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

5 Types of explosion-protected electrical equipment, those kinds of gases for which such equipment is designed and any other items deemed necessary by the Society are to be clearly indicated on the surface of such equipment.

2.16.5 Special Requirement*

Explosion-protected electrical equipment is to be in accordance with any 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 given in this 2.17 are to be applied to those high voltage electrical installations with system voltages above *a.c.* 1,000 *V* up to *a.c.* 15,000 *V*.

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

2.17.2 Distribution

1 The following distribution systems **(1)** or **(2)** are considered as standard. Furthermore, the expressions "high-impedance" and "low-impedance" refer to the value of the earthing factor derived from the following formula. Earthing factors greater than or equal to 0.8 are considered to be "High-impedance". Those lower than 0.8 are considered to be "Low-impedance".

(1) Three-phase, three-wire, insulated systems

(2) Three-phase, three-wire, neutral earthed systems

  (a) High-impedance earthing

  (b) Low-impedance earthing

  (c) Direct earthing

$$earthing\ \ factor = \frac{phase\ to\ earth\ voltage\ of\ \ the\ health\ \ phase\ when\ an\ earth\ \ fault\ \ occurs}{phase\ to\ \ phase\ voltage}$$

2 In the case of three-wire insulated systems, high voltage equipment is to be able to withstand any transient over-voltages which may arise from earth-faults.

3 Neutral earthed systems are to comply with the following:

(1) In case of earth fault, the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault.

(2) It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode.

(3) Electrical equipment in directly earthed neutral or other neutral earthed systems is to withstand the current due to a single phase fault against earth for the time necessary to trip the protection device.

(4) Means of disconnection are 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.

(5) In the subdivided busbar arrangement, connection of the neutral to the hull is to be provided for each section of the electrical distribution system.

(6) In low impedance neutral earthed systems or direct neutral earthed systems, provisions are to be made to automatically disconnect any faulty circuits. High impedance neutral earthed systems, in cases where outgoing feeders are not isolated in the case of earth faults, are to be capable of withstanding transitional over voltages caused by earth faults.

4 All earthing resistors are to be connected to the hull. Earthing methods are to be considered in order to eliminate any 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 H1.1** 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 Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

4 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.

5 High voltage electrical equipment is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

6 In the case of rotating machines, transformers and reactors, effective means are to be provided to prevent the accumulation of moisture and condensation within such machines especially in cases where they are idle for appreciable periods.

7 To ensure safety of operation, a passageway that has a width of at least 1 *m* 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.

8 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.

9 High voltage generator stator windings are to have all phase ends brought out for the installation of the differential protection.

10 Rotating machines are to be provided with temperature detectors in their stator windings to actuate visual and audible alarms in normally attended positions whenever temperatures exceed their permissible limits.

11 In cases where rotating machines are provided with water-air heat exchangers, they are to be double tube types. Visual and audible alarms in normally attended positions are to be given to monitor cooling water leakage.

12 The degree of protection applying to enclosures of high voltage electrical equipment is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of *IEC* 60092-201:2019. Particularly rotating machines, transformers, high voltage switchboards, high voltage control boards and converters are to comply with the following:

(1) The degree of protection for the enclosures of rotating machines is to be at least IP43 and the degrees of protection for the terminals of them are to be at least IP44. However, in the case of rotating machines installed in key locked spaces, the degrees of protection for their enclosures may be IP23.

(2) The degree of protection for the enclosures of transformers is to be at least IP43. However, in the case of transformers installed in key locked spaces, the degrees of protection for their enclosures may be IP23. And, in case where transformers are installed in switch boards, protection of such enclosures may be dispensed with.

(3) The degree of protection for the enclosures of high voltage switchboards, high voltage control boards and static convertors is to be at least IP42. However, in case of high voltage switchboards, high voltage control boards and static convertors installed in key-locked spaces, a degree of protection of IP32 may be acceptable.

13 High voltage switchboards and high voltage control boards are to be constructed according to the *IEC* 62271-200:2011. In addition, high voltage switchboards are to be of metal - enclosed type in accordance with *IEC* 62271-200:2011 or of the insulation - enclosed type in accordance with the *IEC* 62271-201:2014. Furthermore, the high voltage sections are to be equipped with doors that

are either locked by key or some other equivalent means.

14 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.

15 High voltage switchboards are to comply with the requirements given in **2.5.3-1** and **2.5.3-2** of this chapter regardless of whether power is being fed to the propulsion system. If two separate high voltage switchboards are provided and interconnected by cables, circuit breakers are to be provided at each end of such cables.

16 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.

17 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.

18 Circuit-breakers are to be withdrawable types or their equivalent provided with means or arrangements for permitting safe maintenance while the busbars are live.

19 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.

20 Fixed contacts of withdrawable circuit breakers and switches are to be arranged so that live contacts are automatically covered at withdrawn positions by shutters. Shutters are to be clearly marked using colours or labels to indicate whether they are for incoming and outgoing circuits.

21 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 or short-circuit, and under-voltage, alarms which activate upon any discontinuity in release circuits and power supply failures are to be provided.

22 In general, phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are not to be less than the values given in **Table H2.18**. In **Table H2.18**, intermediate values may be accepted for nominal voltages provided that the next higher air clearance is observed. In the case of smaller distances, an impulse voltage test carried out in accordance with paragraph 4.2 of *IEC* 62271-1 and it is confirmed to have sufficient insulation performance.

23 Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with *IEC* 60092-503:2007 for the nominal voltage of the system, the nature of the insulation material and the transient overvoltage developed by switch and fault conditions.

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

25 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.

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

27 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.

28 High voltage switchboards and control boards are to be internal arc classified in accordance with *IEC* 62271-200:2011. In cases where they are accessible by authorized personnel only, *Accessibility Type A* is sufficient. *Accessibility Type B* is required if they are accessible by non-authorized personnel.

29 The installation and location of high voltage switchboards and control boards, are to correspond with its internal arc classification and classified sides (front, lateral and rear). In addition, the clearance between the switchboard and the ceiling/deckhead above is to meet the requirements of the internal arc classification according to *IEC* 62271-200:2011.

30 When external source of supply is necessary for auxiliary circuits, at least two external sources of supply are to be provided and so arranged that a failure or loss of one source will not cause the loss of more than one generator set and/or set of essential services. Where necessary one source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

Table H2.18 Minimum Air Clearances

Nominal voltage (*V*)	Minimum air clearances (*mm*)
3,000 (3,300)	55
6,000 (6,600)	90
10,000 (11,000)	120
15,000	160

2.17.4 Protective Devices, etc.

1 Fuses are not to be used for overload protection.

2 Protective devices, such as differential protection relays, are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator. In distribution systems with a neutral earthed, phase to earth faults are also to be treated as above.

3 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.

4 Circuit-breakers are generally to be used for short-circuit protection at primary sides of transformers.

5 In cases where transformers are arranged in parallel, any tripping of those protective devices at their primary sides is to be automatically followed by the tripping of those switches connected at their secondary sides.

6 Dry type transformers are to comply with *IEC* 60076-11:2018, while liquid cooled transformers are to comply with the applicable Parts of the *IEC* 60076 Series. 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

7 In cases where single consumers, such as bow thrusters or others, are supplied directly at higher voltages via step-up transformers, transformers may be protected at their lower-voltage sides.

8 Voltage transformers for control and instrumentation are to be provided with overload and short circuit protection on the secondary side.

9 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. The protection may be achieved by any of the following means:

(1) direct earthing of the low voltage circuits;

(2) appropriate neutral voltage limiter; or

(3) earthed screen between the primary and secondary windings of transformers.

10 Devices capable of indicating any earth faults in systems by means of visual and audible alarms are to be provided.

2.17.5 Cables

1 High voltage cables are to be constructed in accordance with the *IEC* 60092-353:2016 and *IEC* 60092-354:2020 or other equivalent standard.

2 In cases where practicable, high voltage cables are not to be run through accommodation spaces. In cases where it is necessary to run these though accommodation spaces, they are to be installed for their entire length in enclosed cable pipes.

3 The segregation of high voltage cables is to be as follows:

(1) High voltage cables are to be segregated from cables operating at different voltage ratings each other; in particular, they are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box.

(2) Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side as given in **Table H2.18**. However, high voltage cables are not to be installed on the same cable tray for the low voltage cables.

4 High voltage cables are to have metallic sheaths or metallic armour. In cases where high voltage cables having neither metallic sheaths 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)** throughout their entire length. These ducts or pipes are to be ensured of their electrical continuity with earthings.

5 Terminations of high voltage cables are to be as follows:

(1) Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material.

(2) In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.

(3) High voltage cables of the radial field type, i.e. having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.

(4) Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires etc.).

6 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 high voltage cables are to be tested in accordance with all applicable requirements of this Part. 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 and control boards, 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 A power-frequency voltage test is to be carried out on any high voltage switchboards and high voltage control boards. The test procedure and voltages are to be according to the *IEC* 62271-200:2011 section 7 / routine test.

4 In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with *IEC* 60034-15:2009 is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

5 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 high voltage control boards of the following values.
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 1,000 *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) Test voltages for high voltage cables of the following values.
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*

6 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 *times* the rated voltage U_0 for a period of 15 *minutes*. However, in the case of cables with a rated voltage U_0/U above 1.8/3 *kV* (U_m=3.6 *kV*), alternative testing procedures specified in **(1)** or **(2)**, in lieu of that specified above, may be accepted. Insulation resistance is to be measured before and after testing so as to confirm there are no abnormalities.

In such cases, U_0, U and U_m means as follows:

U_0 : The rated power-frequency voltage between the phase conductor and the ground or metallic screen for which the cable is designed

U : The rated power-frequency voltage between phase conductors for which the cable is designed

U_m: The maximum value of the "highest system voltage" for which the equipment may be used

(1) Testing the supply voltage in alternating current (*a.c.*) between the conductors and the shields for 5 *minutes*.

(2) Testing the supply voltage in alternating current (*a.c.*) for 24 *hours*.

2.18 Tests after Installation On Board

2.18.1 Insulation Resistance Test

1 In the case of circuits of electric propulsion, auxiliary power and lighting, insulation resistance between conductors and earths as well as between conductors is to be measured and its value is not to be less than those values specified in **Table H2.19**.

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

(1) In the case of circuits of 100 *V* and above, insulation resistance between conductors and earths as well as between conductors is to be measured, using methods deemed appropriate by the Society, and its value is not to be less than 1 *MΩ*.

(2) In the case of circuits below 100 *V*, insulation resistance is to be at least 1/ 3 *MΩ*.

3 The insulation resistance of generators and motors under working temperatures is to be those values specified in **Table H2.8**.

Table H2.19 Minimum Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance (*MΩ*)
$Un \leq 250$	$2 \times Un$	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 tests, any or all electric heaters, small appliances and the like which are connected may be disconnected from any circuits.

2.18.2 Performance Tests*

1 Generators are to be tested in accordance with the requirements **(1)** to **(3)** given below. In addition, during these tests, governor characteristics, voltage regulations and load balances are to satisfy those requirements given in **2.4.2**, **2.4.13** and **2.4.14**:

(1) The operation of overspeed trips 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 loads for durations sufficient enough to demonstrate that temperature rises, communication, absence of vibrations and others are satisfactory.

2 All switches, circuit-breakers and associated equipment on switchboards are to be operated on loads 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 conditions to demonstrate that wiring, capacity, speed and operation are satisfactory.

(2) 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 loads.

4 Lighting systems are to be tested in accordance with the following requirements **(1)** and **(2)**:

(1) All circuits are to be tested to demonstrate that lighting fittings, branch boxes, switches, socket-outlets and other accessories

are effectively connected and function satisfactorily.

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

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

6 Internal communication systems are to be thoroughly tested to demonstrate they are suitable and specified functioning. Particular attention is to be paid to those tests of operation of the essential electrical communication systems of ships which include engine order telegraphs, helm indicators, fire alarms, emergency signals, Morse signal lamps, navigation light indicator panels and telephones.

2.18.3 Voltage Drop

During then above tests, it is to be ascertained that any voltage drop of feeder circuits do not exceed those values specified in 2.9.6.

Chapter 3 DESIGN OF INSTALLATIONS

3.1 General

3.1.1 General

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

3.1.2 Design and Construction

Electrical installations are to comply with the following:

(1) All electrical auxiliary services necessary for maintaining ships in normal operational and habitable conditions are to be ensured without recourse to any emergency sources of electrical power;

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

(3) The safety of passengers, crews and ships from electrical hazards is to be ensured.

3.2 Main Sources of Electrical Power and Lighting Systems

3.2.1 Main Sources of Electrical Power*

1 Main sources of electrical power of sufficient capacity to supply all those services specified in **3.1.2(1)** are to be provided. Such main sources of electrical power are to consist of at least two generating sets.

2 The capacities of these generating sets specified in **-1** above are 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. A minimum of comfortable conditions of habitability is also to be ensured which includes at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

3 In cases where main sources of electrical power are necessary for the propulsion and steering of ships, systems are to be arranged so that electrical supplies to equipment necessary for propulsion and steering and to ensure ship safety will be maintained or immediately restored in cases where there is the loss of any one of the generators in service.

4 Those arrangements of ships main sources of electrical power are to be such that those services referred to in the requirement given in **3.1.2(1)** can be maintained regardless of the speed and direction of propulsion machinery or shafting.

5 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 main propulsion plants from a dead ship condition. Emergency sources 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 sources of electrical power is sufficient to provide at the same time those services required to be supplied by the requirements given in **3.3.2-2(1)** to **(4)**.

3.2.2 Number and Ratings of Transformers*

In cases where transformers constitute an essential part of those electrical supply systems required by **3.2.1**, such systems are to be arranged so as to ensure the same continuity of supply as is stated in **3.2.1**.

3.2.3 Lighting Systems*

1 Main electric lighting systems supplied from main sources of electrical power are to be provided in those spaces or compartments which crew and personnel normally use and where they work while on duty.

2 Main electric lighting systems is to be arranged so as not to be impaired in the event of fire or any other causality in those spaces containing emergency sources of electrical power, associated transforming equipment, emergency switchboards and emergency lighting switchboards.

3 Emergency lighting is to provide sufficient illumination necessary for safety in the following locations:

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

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

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

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

(5) It all stowage positions for firemen's outfit;

(6) At the steering gears;

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

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

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

3.2.4 Location of Main Switchboards*

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

3.2.5 Generators and Generator Systems, Having the Propulsion Machinery as their Prime Mover, not Forming Part of the Main Source of Electrical Power

Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power (hereinafter referred to as "shaft driven generator systems, etc."), may be used whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions provided that:

(Note)

"Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power" are those whose operation does not meet the requirements of *IEC* 60092-201:2019, paragraph 8.1.1.

(1) There are sufficient and adequately rated additional generators fitted, which constitute the main source of electrical power specified in **3.2.1-1**, meeting the requirements of *IEC* 60092-201:2019 paragraph 8.1.1.

(2) Arrangements are fitted to automatically start one or more of the generators within a period of 45 seconds, constituting the main source of electrical power specified in **3.2.1-1**, in compliance with **3.2.1-2** and also upon the frequency variations exceeding ± 10% of the limits specified in **(3)** and the event of any shaft driven generator systems, etc. being stopped.

(3) Within the declared operating range of shaft driven generator systems, etc. the specified limits for the voltage variations in *IEC* 60092-301:1980/AMD2:1995 and the frequency variations in **Table H2.1** can be met.

(4) The short circuit current of the shaft driven generator systems, etc. is sufficient to trip the circuit-breaker taking into account the selectivity of the protective devices for the distribution system.

(5) Where considered appropriate, load shedding arrangements are fitted to protect the generators against sustained overload.

(6) In those ships having remote control of the ship's propulsion machinery from the navigating bridge means are provided, the following requirements are to be complied with:

(a) Means are provided, or procedures be in place, so as to ensure that supplies to essential services are maintained during manoeuvring conditions in order to avoid a blackout situation.

(Note)

A "blackout situation" means that the main and auxiliary machinery installations, including the main power supply, are out of operation but the services for bringing them into operation (e.g. compressed air, starting current from batteries etc.) are available.

(b) The declared operating range is to be shown on navigation bridges, and devices to indicate the condition of shaft driven generator systems, etc. are to be established.

3.3 Emergency Sources of Electrical Power

3.3.1 General*

1 Self-contained emergency sources of electrical power are to be provided.

2 Emergency sources of electrical power, associated transforming equipment, transitional sources of emergency electrical power, emergency switchboards and emergency lighting switchboards are to be located above uppermost continuous decks and are to be readily accessible from open decks. They are not to be located forward of collision bulkheads, except, under exceptional circumstances, in cases where permitted by the Society.

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

4 Provided that suitable measures are taken for safeguarding independent emergency operations under all circumstances, emergency generators may be used in non-emergency cases for short periods of time to supply to non-emergency circuits.

3.3.2 Capacities of Emergency Sources of Power*

1 Any available electrical power is to be sufficient to supply all those services that are essential for safety in emergencies, with due regard being paid to such services which may have to be operated simultaneously.

2 Emergency sources of electrical power are to be capable, having regard for starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for those periods specified hereinafter, if they depend upon electrical sources for 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 the *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*, those navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force as well as those lights required by the National Regulations of those countries to which ships are registered.

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

(a) All internal communication equipment as required during emergencies;

(b) Installations listed in the following **i)** to **iv)** as required by Chapter IV, the Annex to the *SOLAS* Convention and installed on ships. However, in cases where these radio installations are installed in duplicate, it is not necessary to consider duplicated installations are operated simultaneously in determining the capacities of emergency sources of electrical power.

i) *VHF* radio installations

ii) *MF* radio installations

iii) Recognized mobile satellite service ship earth stations

iv) *MF/HF* radio installations

(c) Those navigational aids, which require electrical sources, as required by Regulation 19 and 20, Chapter V, the Annex the to *SOLAS* Convention;

In cases where such provision is unreasonable or impracticable, this requirement may be waived for those ships of less than 5,000 gross tonnage;

(d) Fire detection and fire alarm systems; and

(e) Intermittent operation of daylight signaling lamps, the ship whistles, manual fire alarms as well as all internal signals required during emergencies

Unless such services have independent supplies for a period of 18 *hours* from accumulator batteries suitably located for use during emergencies.

(f) All navigation equipment required by 9.3.2.2, Part I-A of *MSC*.385(94) *International Code for Ships Operating in Polar Waters (Polar Code)*, as amended.

(5) For a period of 18 *hours*, fire pumps designed so as to depend upon emergency generators by those requirements given in **10.2.2-3, Part R**.

(6) For the period of time required by **15.2.6, Part D**, steering gears in cases where it is required to be so supplied.

(7) For a period of 30 *minutes*, indications showing whether closing means are opened or closed and audible alarms showing that such closing means are operating as required by **2.2.3.1, Part 1, Part C**, and indicators showing whether these closing means are opened or closed as required by **2.2.3.2** and **2.3.4.2, Part 1, Part C** if they are operated by electrical power.

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

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

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

3 In cases where electrical sources are necessary to restore propulsion, capacities of emergency sources of power shall be sufficient to restore propulsion to ships from dead ship conditions within a period of 30 *minutes* after a blackout.

3.3.3 Kind and Performance of Emergency Sources of Electrical Power*

Emergency sources of electrical power are to be either generators or accumulator batteries or uninterruptible power systems, which are to comply with the following:

(1) In cases where emergency sources of electrical power are generators, they are to comply with the following:

(a) Emergency generators are to be driven by suitable primemovers with independent supplies of fuel, having a flashpoint (closed cup test) of not less than 43 °C;

(b) Emergency generators are to be automatically started upon the failure of any main sources of electrical power supplies unless transitional sources of emergency electrical power in accordance with the following **(c)** are provided; in cases where emergency generators are automatically started, they are to be automatically connected to emergency switchboards; those services referred to in the requirements given in **3.3.4** are then to be automatically connected to emergency generators; and

(c) Transitional sources of emergency electrical power as specified in **3.3.4** are to be provided unless emergency generators are provided capable both of supplying those services mentioned in **3.3.4** and of being automatically started and supplying any required loads as quickly as is safe and practicable for a maximum period of 45 *seconds*.

(2) In cases where emergency sources of electrical power are accumulator batteries, they are to be capable of:

(a) Carrying emergency electrical loads without recharging while maintaining battery voltages throughout discharge periods within 12 % above or below nominal voltages;

(b) Automatically connecting to emergency switchboards in the event of the failure of any main sources of electrical power; and

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

(3) In cases where emergency generators are uninterruptible power systems, the requirements are to be in accordance with **Annex 3.3.3(3)**.

3.3.4 Transitional Sources of Emergency Electrical Power*

Transitional sources of emergency electrical power, in cases where required by **3.3.3(1)(c)**, are to consist of accumulator batteries suitably located for use in emergencies which are to conform to the following **(1)** and **(2)**:

(1) Operate without recharging while maintaining battery voltages throughout discharge periods within 12 % above or below nominal voltages; and

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

(a) Lighting required by **3.3.2-2(1)** to **(3)**. For this transitional phase, the required emergency electric lighting, in respect of machinery spaces 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 independent supplies for those periods specified from accumulator batteries suitably located for use during emergencies.

3.3.5 Location, etc. of Emergency Sources of Electrical Power

1 Emergency switchboards are to be installed as near as is practicable to emergency sources of electrical power.

2 In cases where emergency sources of electrical power are generators, emergency switchboards are to be located in the same spaces unless the operation of such emergency switchboards would thereby be impaired.

3 No accumulator batteries fitted in accordance with this 3.3 are to be installed in the same spaces as emergency switchboards.

4 Indicators are to be mounted in suitable places on main switchboards or in machinery control rooms to indicate when batteries constituting either those emergency sources of electrical power or those transitional sources of electrical power referred to in the requirements given in 3.3.3(2) or 3.3.4 are being discharged.

5 Interconnector feeders connecting emergency switchboards and main switchboards are to conform to the following **(1)** to **(3)**:

(1) They are to be adequately protected at main switchboards against any overloads and short circuits;

(2) They are to disconnect automatically at emergency switchboards upon the failure of main sources of electrical power; and

(3) They are to be protected at emergency switchboards at least against short circuits in cases where systems are arranged for feedback operations. In addition, emergency switchboards are to be supplied during normal operation from main switchboards.

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

3.3.6 Provisions for Testing

Emergency electrical systems are to be provided with measures for periodic testing. Such periodic testing is to include the testing of automatic starting arrangements.

3.4 Starting Arrangements for Emergency Generating Sets

3.4.1 General*

1 Emergency generating sets are to be capable of being easily started from a 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 easy starting of such generating sets.

2 Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society which have a stored energy capability of at least three consecutive starts. Sources of such stored energy are to be protected to prevent any critical depletion by automatic starting systems, unless secondary independent means of starting are provided. In addition, secondary sources of energy are to be provided for an additional three starts within a period of 30 *minutes* unless manual starting can be demonstrated to be effective.

3 Stored energy is to be maintained at all times as follows:

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

(2) Compressed air starting systems may be maintained by main or auxiliary compressed air reservoirs through suitable non-return valves or by emergency air compressors which, if electrically driven, are supplied from emergency switchboards; and

(3) All of these starting, charging and energy storing devices are to be located in emergency generator spaces; furthermore, these devices are not to be used for any purpose other than the operation of emergency generating sets. However, this does not preclude the supply of air to those air reservoirs of emergency generating sets from main or auxiliary compressed air systems through those non-return valves fitted in emergency generator spaces.

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

5 In cases where manual starting is not practicable, starting arrangements are to comply with requirements -2 and -3 above. However, starting may be manually initiated.

3.5 Steering Gear, Waterjet Propulsion Systems, Azimuth Thrusters, etc.

3.5.1 Steering Gear

See **Chapter 15, Part D**.

3.5.2 Waterjet Propulsion Systems

See **Chapter 19, Part D**.

3.5.3 Azimuth Thrusters

See **Chapter 20, Part D**.

3.5.4 Selective Catalytic Reduction Systems and Associated Equipment

See **Chapter 21, Part D**.

3.5.5 Exhaust Gas Cleaning Systems and Associated Equipment

See **Chapter 22, Part D**.

3.5.6 Exhaust Gas Recirculation Systems and Associated Equipment

See **Chapter 23, Part D**.

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

3.6.1 Navigation Lights

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

2 Each navigation light is to be controlled and protected in each insulated pole by switches with fuses or circuit breakers fitted on navigation light indicator panels.

3 Navigation light indicator panels are to be supplied power by separate circuits from main switchboards or those secondary busbars of transformers connected to them and from emergency switchboards or those secondary busbars of transformers connected to them respectively. Such circuits are to be separated as far apart as practicable throughout their length.

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

5 Navigation light indicator panels are to be placed in accessible positions on navigation bridges.

6 In cases where the event of failure of navigation lights due to bulb blown and short-circuit, etc., visual and audible alarms are to activate on navigation light indicator panels. That alarm devices are to be fed from the main sources or emergency sources (or reserve sources) of power and that their feeder circuits are to be independent of the feeder circuits from navigation light indicator panels to navigation lights.

3.6.2 Not under Command Lights and Anchor Lights

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

3.6.3 Signal Lights

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

3.6.4 General Emergency Alarm Systems

Those general emergency alarm systems specified in Regulation 50 as well as public address systems or those other suitable means of communication specified in Paragraph 4.2, Regulation 6, Chapter III, the Annex to the *SOLAS* Convention are to be supplied power from both main sources of electrical power and emergency sources of electrical power.

3.6.5 On-board Communication Systems

Those on-board communication systems specified in Paragraph 4.1, Regulation 6, Chapter III, the Annex to the *SOLAS* Convention are to be supplied power from electrical source(s) suitably located for use during emergencies.

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 sections not less than 75 mm^2 which are riveted with copper rivets or fastened with copper clamps to suitable copper spikes not less than 12 *mm* in diameter, projecting at least 150 *mm* above the top of masts. At lower ends, this copper tape or rope is to be securely clamped to the nearest metal forming part of ships.

2 Lightning conductors are to be run as straight as possible and any sharp bends in these conductors are to be avoided. All clamps used are to be made of brass or copper, preferably of the serrated contact type, and effectively locked. No connections are to be dependent on soldered joints.

3 The resistance of lightning conductors between mast tops and those points on earth plates or hulls is not to exceed 0.02 Ω.

3.8 Spare Parts, Tools and Instruments

3.8.1 Spare Parts*

1 In the case of rotating machines and controlgears intended for electric propulsion plants, the types and quantities of spare parts specified in **Table H3.1**, **Table H3.3** and **Table H3.5** are to be provided.

2 In the case of ship service generators, motors of important use and their controlgears and switchboards, the types and quantities of spare parts specified in **Table H3.1** to **Table H3.5**, so far as applicable, are recommended, as a standard, to be provided.

3 The quantities required by **-1** and **-2** above are the number of spare parts for all totally identical installations per ship.

4 In the case of steering gear motors and motor-generators, if no stand-by machines are installed; those spare parts specified in **Table H3.2** are to be provided in addition to any spare parts for motors enumerated in **Table H3.1**.

5 In cases where voltages of emergency lighting circuits are different from those of general service, 1 spare for each 2 lamps are to be provided

3.8.2 Testing Instruments

In the case of ships having electrical installations of 50 *kW* and above, 500 *V* insulation resistance meters are to be provided in order that such insulations 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.

(2) One portable ammeter, *a.c.* or *d.c.*, or both as required. These are to have shunts or current transformers as required.

Table H3.1 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
Brushholder 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 H3.5**
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.* wound-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

In cases where special tools are required to adjust or disassemble equipment, one set such tools are 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. Such boxes are to be clearly marked on their surface regarding their contents and are to be placed in suitable places. In cases where lockers are provided to store these spare parts, individual boxes may be omitted.

Table H3.2 Additional Spare Parts for Steering Gear Motors without Stand-by Motors or Motor-generators

Spare parts	Number required
Armatures of *d.c.* motors and motor-generators	1 for each size (complete with shafts and couplings)
Stators of *a.c.* cage-rotor motors	1 for each size
Rotors of *a.c.* wound-rotors motors	1 for each size (complete with shafts and couplings)

Table H3.3 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 H3.5**
Lamp lenses and bulbs	*See* **Table H3.5**

Table H3.4 Spare Parts for Brakes

Spare parts	Number required
Shoe linings and rivets	1 set for each 4 or less
Springs	1 for each 4 or less
Coils	1 for each 10 or less

Table H3.5 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 elements or less
Complete moulded case thermal type circuit-breakers, where non-interchangeable 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 those 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 those requirements in any 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 enclosed cargo holds

(3) Coal carriers

(4) Ships carrying dangerous goods

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 this chapter as well as the requirements in **Chapter 4, Part R**, **Chapters 10** and **12, Part N** and **Chapters 10** and **12, Part S**.

4.2.2 Distribution Systems

1 Notwithstanding those requirements given in **2.2.1-1**, distribution systems are to be one of the following:

(1) Two-wire insulated *d.c.* systems

(2) Single-phase two-wire insulated *a.c.* systems

(3) Three-phase three-wire insulated *a.c.* systems

2 Notwithstanding those requirements given in **-1** above, hull return distribution systems may be used for those systems listed in **2.2.1-2(1)** to **(3)**.

3 Notwithstanding those requirements given in **-1** above, earthed distribution systems may be used for the following systems:

(1) Intrinsically safe circuits

(2) Power supplies, control circuits and instrumentation circuits in cases where, for technical or safety reasons, earthed systems are necessary. However, this is only provided that currents in hulls are 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. However, this is only provided that any arising earthing currents do not flow directly through any hazardous areas

4 Those neutral or earth conductors required for protection against electric shock are not to be bound together with single conductors in hazardous areas.

4.2.3 Hazardous Areas*

1 Hazardous areas for tankers are to be categorized in accordance with those requirements given 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 those requirements given 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 those requirements given in **4.7.1**.

4 Areas and spaces not mentioned in **-1** to **-3** above, but considered to present risks because of the presence of explosive gas atmospheres, are to be categorized as hazardous areas in accordance with those requirements otherwise specified by the Society.

5 Access doors or other openings are not to be provided in the following boundaries except in cases where required for operational

purposes and safety reasons. In cases where access doors or other openings are provided, any areas connected to the boundaries of hazardous areas are to be categorized as hazardous areas as well in accordance with those requirements otherwise specified by the Society.

(1) Boundaries between Zone 1 and Zone 2 hazardous areas

(2) Boundaries 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 such installations are essential for operational purposes or safety reasons. However, in cases where such installation is necessary, this restriction does not apply to the following electrical installations:

(1) Zone 0

(a) Category '*ia*' intrinsically safe type electrical equipment including simple electrical apparatus (thermocouples, switching devices, etc.) and their associated cables

(b) Submerged cargo pump motors and their supply cables (In such cases, motors are to be automatically stopped by alarms from at least two independent detecting methods for pump delivery low pressures, lower currents of motors or low liquid levels.)

(2) Zone 1

(a) Those electrical installations specified in **(1)** above

(b) Category '*ib*' intrinsically safe type electrical equipment including simple electrical apparatus (thermocouples, switching devices, etc.) and their associated cables

(c) Flameproof type or pressurized type electrical equipment and their associated cables

(d) Increased safety type, encapsulated type, powder filling type or oil immersion type electrical equipment and their associated cables

(e) Hull fittings (terminals or shell-plating penetrations for anodes or electrodes of impressed current cathodic protection systems, or transducers such as those for depth-sounding or log systems) and their associated cables

(f) Through runs of cables

(3) Zone 2

(a) Those electrical installations specified in **(2)** above

(b) Other electrical equipment deemed appropriate by the Society and their associated cables

2 In cases where electrical equipment is installed in hazardous areas in accordance with the requirement given in **-1** above, it is to be confirmed that such equipment is safe to use in explosive gas atmospheres.

3 Aerials and associated riggings are to be located well clear of any gas or vapour outlets.

4 As a rule, no portable electrical equipment is to be located in any hazardous areas. In cases where it is unavoidable to locate such equipment in hazardous areas, Society approval is needed.

5 All cables are to be one of the following types. In cases where some corrosion is to be expected, *PVC* or chloroprene sheaths are to be applied over any armour or metallic sheaths of cables for corrosion protection.

(1) Mineral insulated and copper sheathed

(2) Non-metallic sheathed and metal armoured

6 Installation of cables is to comply with the following:

(1) Cables are to be installed as close to hull centre lines as practicable.

(2) Cables are to be installed sufficiently apart from decks, bulkheads, tanks and each kind of pipe.

(3) Cables are, as a rule, to be protected against mechanical damage. Especially those cables installed on open decks are to be protected by metallic casings or non-metallic casings complying with those requirements specified in **2.9.14-3(4)**. Furthermore, cables and their supports are to be fitted in such a manner as to withstand expansion, contraction and any other effects of hull structures.

(4) Penetration parts of cables or cable pipes through decks and bulkheads of hazardous areas are to be constructed so as to maintain gas-tightness and liquid-tightness as necessary.

(5) In cases where 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 glands or equivalent devices.

(7) In cases where cable joints are used, Society approval is necessary. In such cases, cable joints are permitted to be used in Zones 1 and 2. However, with respect to intrinsically-safe circuits, they are permitted to be used in Zone 0.

(8) In cases where cables are immersed in cargoes, the construction of these cables is to be such as to allow them to withstand any substances to which they are exposed, or these cables are to be enclosed in casings, e.g. metallic pipes, which are capable of withstanding any such substances.

(9) In cases where cables run through cargo pump room or cargo compressor room, 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 at least earthed at both ends. In cases 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 points. In such cases, no non-earthing points are to be located in hazardous areas.

(1) Cables passing through hazardous areas

(2) Cables connected to equipment installed in hazardous areas

8 Electrical circuits passing into Zone 0 are to be provided with the following measures:

(1) Circuits other than intrinsically-safe circuits are to be automatically disconnected or are to be prevented from being energized in the event of abnormally low levels of insulation resistance or high levels of leakage current.

(2) Protective systems are to be arranged so that manual intervention is necessary in order to reconnect any circuits after being disconnected as a result of short circuits, overloads or earth-fault conditions.

9 In case where flame-proof type electrical motors for cargo handling equipment are installed in cargo pump rooms or cargo compressor rooms located within hazardous areas, motors are to be arranged so that they can be easily approached as well as to allow the carrying out of proper maintenance and inspections.

4.2.5 Lighting in Hazardous Areas

1 In cases where hazardous areas are lit by lighting fittings located in adjacent non-hazardous areas through glazed ports fitted into bulkheads or decks, such glazed ports are to be constructed so as not to impair any of the water-tight, gastight, fireproof and strength integrity properties of such bulkheads and decks. Due consideration is to be given to the ventilation of these lighting fittings so that any excessive temperature rises are not caused on these glazed ports.

2 Lighting fittings installed in cargo pump rooms for tankers and ships carrying dangerous chemicals in bulk are to be divided between at least two branch circuits. Ships carrying liquefied gases in bulk are to comply with the requirements given in **10.2.7, Part N**.

3 All switches and protective devices related to those circuits specified in **-2** above are to interrupt all poles or phases and to be located in non-hazardous areas.

4.2.6 Ventilation*

1 Ventilators installed in cargo pump rooms or cargo compressor rooms are to be arranged in order that no discontinuities of ventilation are expected to occur for long periods of time and so that no accumulation of gas or vapours occurs. In cases where of ventilation failures, alarms are to be activated in continually manned spaces, *e.g.* navigation bridges or machinery control rooms, in addition to those relevant cargo pump rooms and cargo compressor rooms.

2 Electric motors for the ventilators specified in **-1** above for ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk are to be placed outside ventilation ducts.

3 The ventilators specified in **-1** above for tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk are to be ones that do not to produce any source of ignition in compliance with the requirements given in **4.5.4-1(1), Part R**, **12.1.7, Part N** and **12.2.8, Part S**.

4 The ventilation air change ratios in cargo pump rooms for tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk are to comply with the requirements given in **4.5.4-1(1), Part R**, **12.1.3, Part N** and **12.2.3, Part S**.

5 Ventilation ducts, air intakes and exhaust outlets serving artificial ventilation systems are to be positioned in accordance with standards deemed appropriate by the Society.

4.2.7 Maintenance for Explosion-protected Electrical Equipment*

Maintenance deemed appropriate by the Society for explosion-protected electrical equipment in hazardous areas is to be periodically carried out by experienced personnel who are sufficiently trained for such tasks. Documentation for such maintenance is 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 following areas or spaces in tankers and ships carrying dangerous chemicals in bulk having flashpoints not exceeding 60 °C are to be classified as Zone 0, Zone 1, and Zone 2 as shown below:

(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 cofferdams; hereinafter, referred to in the same way.)
  (d) Cargo pump rooms
  (e) Enclosed or semi-enclosed spaces (means those spaces separated by decks and bulkheads in cases where conditions of ventilation are significantly different from that of the 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 cargo tanks (for example, trunks, passage-ways, holds, etc.; hereinafter, referred to in the same way.)
  (g) Areas on open decks or semi-enclosed spaces on open decks, within a sphere with a 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.; hereinafter, referred to in the same way), cargo manifold valves, cargo valves, cargo pipe flanges and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations
  (h) Areas on open decks or semi-enclosed spaces on open decks, within a vertical cylinder of unlimited height and with a 6 *m* radius from the outlet centre, and within a hemisphere with a 6 *m* radius below those outlet which permit the flow of large volumes of gas or vapour during loading, discharging or ballasting
  (i) Areas on open decks or semi-enclosed spaces on open decks, within 1.5 *m* from cargo pump room entrances, within a sphere with a 1.5 *m* radius from cargo pump room ventilation inlets and those openings specified in **(2)** above
  (j) Areas on open decks within spillage coamings surrounding cargo manifold valves and for 3 *m* beyond these, up to a height of 2.4 *m* above such decks
  (k) Areas on open decks over all cargo tanks (including all ballast tanks within cargo tank blocks; hereinafter, referred to in the same way) in cases where structures are restricting natural ventilation and to the full breadth of ships plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks
  (l) Compartments for cargo hoses
  (m) Enclosed or semi-enclosed spaces in which pipes containing cargo are located

(3) Zone 2
  (a) Areas on open decks or semi-enclosed spaces on open decks, within 1.5 *m* surrounding the areas specified in **(2)** above. However, the "any ventilation outlets, cargo tank openings for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations" referred to in **(2)(g)** above are to be in accordance with requirements otherwise specified by the Society. (except those hazardous areas otherwise specified in the Rules; hereinafter, referred to in the same way).
  (b) Spaces within 4 *m* surrounding those areas specified in **(2)(h)** above
  (c) Spaces forming air-locks between those areas specified in **(2)** above and non-hazardous areas
  (d) Areas on open decks within spillage coamings intended to keep spillages clear of accommodation and service spaces and for 3 *m* beyond these spaces, up to a height of 2.4 *m* above such decks
  (e) Areas on open decks over cargo tanks in cases where unrestricted natural ventilation is guaranteed and to the full breadth

of ships plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks

(f) Spaces forward of open decks specified in **(e)** and **(2)(k)** above, below levels of open decks, and having openings at levels less than 0.5 *m* above open decks (However, in cases where such 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 spaces are mechanically ventilated; hereinafter, referred to as the same.)

(g) Ballast pump rooms adjacent to cargo tanks

4.4 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoint Exceeding 60 °C and Cargoes which are Heated to Temperatures more than 15 °C lower than their Flashpoint

4.4.1 Classification of Hazardous Areas

Those areas or spaces in tankers and ships carrying dangerous chemicals in bulk having a flashpoint exceeding 60 °C and cargoes which are heated to temperatures more than 15 °C lower than their flashpoint are to be classified in accordance with those requirements specified in 4.3.1.

4.5 Tankers and Ships Carrying Dangerous Chemicals in Bulk having a Flashpoints Exceeding 60 °C and Cargoes which are not Heated or Heated to Temperatures less than 15 °C lower than their Flashpoint

4.5.1 Classification of Hazardous Areas

The following areas or spaces in tankers and ships carrying dangerous chemicals in bulk having a flashpoint exceeding 60 °C and cargoes which are not heated or heated to temperatures less than 15 °C lower than their flashpoint are to be classified as Zone 2:

(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 following areas or spaces in ships carrying dangerous chemicals in bulk reacting with other products to evolve flammable gases are to be classified as Zone 1 and 2 as shown below:

(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 decks or semi-enclosed spaces on open decks, within a distance of 1.5 *m* surrounding openings of those areas specified in **(1)** above

(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 tops of cargo tanks

(g) Enclosed or semi-enclosed spaces in which pipes containing cargos are located

(h) Areas on open decks or semi-enclosed spaces on open decks, within a sphere with a 1.5 *m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets, cargo manifold valves, cargo valves, cargo pipe flanges and cargo

pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations

(i) Areas on open decks within spillage coamings surrounding cargo manifold valves and 1.5 *m* beyond these, up to a height of 1.5 *m* above such decks

(j) Areas on open decks or semi-enclosed spaces on open decks, within a vertical cylinder of unlimited height and 3 *m* radius from the centre of outlets, and within a hemisphere with a 3 *m* radius below those outlets which permit 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 following areas or spaces in ships carrying liquefied gases in bulk are to be classified as Zone 0, Zone 1 and Zone 2 as shown below:

(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 secondary barriers

(2) Zone 1

(a) Void spaces adjacent to integral cargo tanks

(b) Hold spaces containing independent cargo tanks not requiring secondary barriers

(c) Cofferdams and segregated ballast tanks adjacent to cargo tanks

(d) Spaces separated from those hold spaces specified in **(1)(d)** above by single gastight boundaries

(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 tops of cargo tanks

(h) Areas on open decks or semi-enclosed spaces on open decks, within a sphere with a 3 *m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets, cargo manifold valves, cargo valves, cargo pipe flanges and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations

(i) Areas on open decks or semi-enclosed spaces on open decks, within a vertical cylinder of unlimited height and 6 *m* radius from the centre of outlets, and within a hemisphere with a 6 *m* radius below those outlets which permits the flow of large volumes of gas or vapour during loading, discharging or ballasting

(j) Areas on open decks or semi-enclosed spaces on open decks, within a distance of 1.5 *m* from cargo pump room entrances, within a sphere with a 1.5 *m* radius from cargo pump room ventilation inlets and those openings specified in **(2)** above

(k) Areas on open decks within spillage coamings surrounding cargo manifold valves and 3 *m* beyond these, up to a height of 2.4 *m* above such decks

(l) Areas on open decks over all cargo tanks in cases where structures are restricting natural ventilation and to the full breadth of ships plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks

(m) Compartments for cargo hoses

(n) Enclosed or semi-enclosed spaces in which pipes containing cargo are located (except spaces which contains gas detection equipment complying with **13.6.11, Part N** of the Rules and which utilize boil-off gas as fuel in accordance with the requirements given in **Chapter 16, Part N** of the Rules.)

(3) Zone 2

(a) Areas on open decks or semi-enclosed spaces on open decks, within a distance of 1.5 *m* surrounding those areas specified in **(2)** above. However, the “any ventilation outlets, cargo tank openings for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations” referred to in **(2)(h)** above are to be in accordance with

requirements otherwise specified by the Society.

(b) Spaces within a distance of 4 *m* surrounding those areas specified in **(2)(i)** above

(c) Spaces forming air-locks between those areas specified in **(2)** above and non-hazardous areas

(d) Areas on open decks within spillage coamings intended to keep any spillage clear of accommodation and service spaces and 3 *m* beyond these, up to a height of 2.4 *m* above such decks

(e) Areas on open decks over all cargo tanks in cases where unrestricted natural ventilation is guaranteed and to the full breadth of ships plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks

(f) Spaces forward of those open decks specified in **(e)** and **(2)(l)** above, below the level of such open decks, and having openings at levels less than 0.5 *m* above such open decks

(g) Spaces within a distance of 2.4 *m* of the outer surfaces of cargo tanks in cases where such surfaces are 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 the carriage of motor vehicles with fuel in their tanks for their own propulsion, etc. are to comply with those requirements given in **20.3, Part R**.

4.8.2 Electrical Installations in Cargo Holds for Carriage of Motor Vehicles with Compressed Natural Gas in their Tanks for their own Propulsion

Cargo holds of vehicle carriers defined in **3.2.54, Part R** for carriage of motor vehicles with compressed natural gas in their tanks for their own propulsion are to comply with those requirements given in **20A.3, Part R**.

4.8.3 Electrical Installations in Cargo Holds for Carriage of Motor Vehicles with Compressed Hydrogen in their Tanks for their own Propulsion

Cargo holds of vehicle carriers defined in **3.2.54, Part R** for carriage of motor vehicles with compressed hydrogen in their tanks for their own propulsion are to comply with those requirements given in **20A.4, Part R**.

4.9 Coal Carriers

4.9.1 Electrical Installations in Cargo Holds*

1 Electrical installations are not to be installed in any of the spaces or areas listed in the following **(1)** to **(3)** unless such installation is essential for operational purposes.

(1) Cargo holds

(2) Enclosed spaces adjacent to cargo holds having non gastight or watertight doors, hatches, and the like into such cargo holds

(3) Areas within 3 *m* of any cargo hold mechanical exhaust ventilation outlet

2 In cases where the installation of electrical installations in such spaces is unavoidable, such installations are to comply with requirements given in the following **(1)** to **(4)**:

(1) Electrical installations are to be explosion-protected types as deemed appropriate by the Society and they are to have enclosures for safe operation in coal dust. And, such electrical installations are to be installed so as to be protected from suffering any mechanical damage. However, other electrical installations suitable for the location and the purpose of service and considered by the Society to be the equivalent of explosion-protected type electrical installations with regard to safety may be used.

(2) Switches and socket-outlets are not to be installed except in case where they are connected to intrinsically safe circuits.

(3) Any cables passing through cargo holds are to be led in gastight heavy gauge steel pipes, and both ends of such pipes are to be sealed using cable glands or the like at the boundaries of cargo holds. Any cables leading to electrical equipment installed in cargo holds are to be protected by either metallic casings or non-metallic casings which are in compliance with those requirements specified in **2.9.14-3(4)**. In addition, such casings are to be sealed using cable glands or the like at the boundaries of cargo holds.

(4) Mechanical exhaust ventilation fans fitted in the ducts of cargo holds are to be non-sparking types.

3 Notwithstanding those requirements give in **-1** and **-2** above, electrical installations installed in those spaces and areas listed in **-1(1)** to **(3)** of bulk carriers, which sometimes carry coal, and that are not used during coal carrying are to comply with requirements given in the following **(1)** and **(2)**:

(1) Electrical equipment is to have enclosures less likely to permit any ingress of coal dust.

(2) Electrical installations are to be installed so as to be protected from suffering any mechanical damage. In addition, feeder circuits for such equipment are to be provided with multipole linked switches situated in accessible locations outside those spaces or areas specified in **-1(1)** to **(3)** above, and so devised as to have the equipment usually locked with such switches in their 'off' positions.

4.10 Special Requirements for Ships Carrying Dangerous Goods

4.10.1 General

Electrical installations for ships carrying dangerous goods are to comply with those requirements given in **Chapter 19, Part R** as well as any of 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, in addition to those given in this Chapter.

2 Semiconductor convertors for propulsion motors are to comply with those requirements given in **-1** above and any other requirements deemed necessary by the Society.

3 Machinery for electric propulsion ships is to meet the relevant requirements in **Part D** in addition to those given in this Chapter.

5.1.2 Additional Requirements for the Prime Movers Driving Propulsion Generators

1 In cases where ships are manoeuvring from propeller speeds ahead to astern while making ahead, prime movers driving propulsion generators are generally to be provided with control systems capable of absorbing or limiting any regenerated power without tripping any of the overspeed protection devices specified in **2.4.1-2**, **3.3.1-1** or **4.3.1-1, Part D**. Furthermore, such prime movers and generators are to be constructed to withstand any revolutions up to the setting revolutions of such overspeed protection devices.

2 All characteristics of governors on prime movers are to be as deemed appropriate by the Society, except in cases where propulsion generators are also used as main generators.

3 In cases where engine speeds are regulated to control propeller speeds, governors are to be capable of being controlled remotely as well as locally. However, in cases where deemed appropriate by the Society, these requirements do not apply.

4 In cases where *d.c.* generators which are to be separately driven are connected electronically in a series, means are to be provided to prevent any reverse running of these generators in the event of the loss of driving power of any single unit in the series.

5.2 Propulsion Electrical Equipment and Cables

5.2.1 General*

1 Excessive electromagnetic interference of propulsion electrical equipment (*e.g.*, sources of electrical power devices for propulsion, propulsion transformers, propulsion semiconductor convertors, propulsion motors) is not to occur under normal manoeuvring conditions.

2 Propulsion electrical equipment connected to circuits with propulsion semiconductor convertors is to be designed considering the harmonic content effects occurring on such circuits.

3 Propulsion electrical equipment and cables connected to circuits with propulsion semiconductor convertors are to be designed in consideration of the additional heating contribution caused by the harmonics generated by such circuits.

5.2.2 General Requirements for Propulsion Motors*

1 Propulsion motors are to perform as specified in the following **(1)** to **(5)**:

(1) The amount of available torque is to be sufficient enough for stopping or reversing such ships in a reasonable amount of time when such ships are running at maximum service speeds.

(2) Adequate torque margins are to be provided in *a.c.* propulsion systems to guard against any motors being pulled out of sync during rough weather and at times of turning operations in multiple-screw ships.

(3) Motors are not to produce any harmful torsional vibrations within normal ranges of rotational speeds.

(4) Propulsion motors are to be capable of withstanding a sudden short circuit at their terminals under all conditions without suffering damage.

(5) Permanent exited motors and their current carrying components are to be capable of withstanding any steady state short circuit currents.

2 In the case of *d.c.* motors liable to go over those speeds specified in **2.4.7** because of propeller missing or propeller racing, overspeed protection devices are to be provided. In such cases, rotors are to be suitably constructed to prevent any damage due to

excessive overspeeding.

3 In cases where arrangements permit propulsion motors to be connected to generating plants having a continuous rating greater than the motor ratings, means are to be provided to prevent any continuous operation at the overload or overtorque conditions not permitted for such motors and shaftings.

4 Propulsion motor shafts are to conform to those requirements given in **2.4.11**. In such cases, diameters of rotor shafts in the lengths from those sections where rotors are fixed to the shaft ends of propeller sides are to conform to those requirements given in **2.4.11-4(1)**. The value of F_1 is to comply with those values specified either in **(1)** or **(2)** below:

(1) In cases where motors have bearings at both ends: 110

(2) In cases where motor have no bearings at their propeller sides: 120

5 In cases where the coolers of propulsion motors fail, but restricted service is to be possible.

6 Breaking or blocking systems or decupling systems which can fix the shafts of propulsion motors are to be provided in preparation for those cases where such propulsion motors failure. In this case, the power output of the remaining shafts may be limited as long as manoeuvrability is maintained under all weather conditions.

7 In cases where the temperature rise for the windings of propulsion motors mentioned above in **5.2.3-3.** exceed design allowance values, means of decreasing nominal propulsion power are to be provided.

5.2.3 Construction and Arrangement of Propulsion Rotating Machines*

1 Means are to be provided to prevent any accumulation of bilgewater under propulsion motors, generators, exciters or electromagnetic slip-couplings (hereinafter referred to as "propulsion rotating machines" in this Chapter).

2 Slip rings and commutators of propulsion rotating machines are to be suitably arranged so that they can be easily maintained. For the purpose of inspection and repair, easy access is to be provided to each kind of coil and bearing. In cases where the Society considers it necessary, propulsion rotating machines are to be constructed in a way that permits the removal and replacement of their field windings.

3 Temperature sensors for monitoring and alarming are to be provided for the stator windings of *a.c.* machines or the interpoles, mainpoles and compensation windings of *d.c.* machines which exceed ratings of 500 *kW* (or *kVA*).

4 Propulsion rotating machines provided with forced ventilation systems, air ducts, air filters, water-cooled heat exchangers, etc., are to have thermometers for measuring cooling air temperatures and visible and audible alarm systems responsible for detecting excessive bearing temperatures. Especially, in cases where water-cooled heat exchangers are adopted, additional leakage monitoring systems are to be provided.

5 Effective means are to be provided in rotating machines to prevent any accumulation of moisture and condensation.

6 The lubrication of bearings is to be effective at all operational speeds including creep speeds. In cases where forced lubrication systems for bearings are used, such systems are to be provided with alarm devices which give visible and audible alarms in the event of 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 alarms have sounded are to be provided as well.

7 Bearings 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 breakers, differential current protection devices are to be provided for propulsion generators with ratings exceed 1,500 *kW* (or *kVA*).

9 Regenerated power which may occur when reversing operation of ship from full ahead to full astern or from full astern to full ahead is carried out is to be limited by the control system in order to protect generators from overspeed or reverse power. However, the requirement does not apply in cases where external means such as a braking resistor is provided to absorb excess amounts of regenerated energy and to reduce the speed of the propulsion motor.

5.2.4 Temperature Rise of Rotating Machines

In cases where variable speed propulsion rotating machines are fitted with integral fans and have to be operated at speeds below rated speeds at full-load torque, full-load current, full-load excitation or the like, temperature limits according to **Table H2.3** of **2.4.3** are not to be 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 D**).

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 cases 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 Failures of semiconductor elements and harmonic filter installed in propulsion semiconductor convertors are to be monitored at all times. Harmonic filter protection circuits are to be fail-safe.

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 primary and secondary sides. However, it is acceptable to only protect the primary side provided that overcurrent protection is arranged on the secondary side.

7 High voltage propulsion transformers are to be provided with differential protection relays to protect the primary side (high voltage busbar side), except in cases where other means deemed equivalent to such relays are provided instead.

5.2.7 Measuring Instruments

Measuring instruments specified below are to be installed on the control panels of propulsion motors or local control positions:

(1) Voltmeters for propulsion motors (only in the case of variable speed control)

(2) Ammeters for propulsion motors (Ammeters for field currents 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 installations or equipment mentioned in the following **(1)** to **(5)** are to be capable of starting propulsion motors and obtaining navigable speeds for ships even though one of those mentioned below 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 systems)

(5) Other installations and equipment which the Society deems necessary

2 In cases where sources of electrical power for propulsion correspond to **(1)** and **(2)** below, they may be used as those main sources of electrical power specified in **3.2.1**.

(1) In cases where one set of the sources of electrical power for propulsion is out of operation, those capacities specified in **3.2.1-2** are to be secured by the remaining sources of electrical power for propulsion, which at the same time has a capacity sufficient enough to obtain navigable speeds for ships.

(2) At times of load fluctuations and braking of the propeller, variations of voltage and frequency are to comply with the requirements given in **2.1.2-3**.

5.3.2 Electrical Power Supply Circuits

1 Electrical equipment or installations, in duplicate, in accordance with the requirements given in **5.3.1-1** are to be supplied with electrical power by mutually independent circuits. In such cases, wiring cables are to be separated as far apart as practicable through out their length.

2 Propulsion systems having two or more generators or motors respectively on single propeller shafts, are to be arranged so that any one unit of them can be taken out of service and isolated electronically.

3 The safety measures specified in the following **(1)** to **(5)** are to be implemented for electrical power supply circuits.

(1) Overcurrent protective devices, if any, in main circuits are to be sufficiently high so that there is no possibility of their operating due to overcurrent caused by manoeuvring in rough weather conditions, turning operations or astern operations (under the conditions specified in **1.3.2, Part D**).

(2) Means for earth leakage detection are to be installed on electrical power supply circuits to propulsion motors.

(3) Excluding brushless exciting circuits and exciting circuits of rotating machines of less than 500 *kW*, earth leakage detection is to be installed at insulated exciting circuits.

(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 that causes the opening 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 the electrical installations of those ships or vessels listed below in place of any 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 voyages 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 voyages

(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 those ships specified in **6.1.1(1)**, the requirements of this **6.2** may be applied.

6.2.2 Ambient Conditions

In **Table H1.1** of **1.1.7**, an air temperature of 40 °C and a sea water temperature of 27 °C may be applied in place of an air temperature of 45 °C and a sea water temperature of 32 °C except for those ships which are navigating tropical areas.

6.2.3 Distribution Systems

The requirements given in **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 given in **2.2.2**, insulation monitoring systems 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 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 those spaces where main propulsion machinery or boilers are provided. Furthermore, one of these circuits may be a reserve lighting circuit.

6.2.6 Construction and Materials of Main Switchboard

1 The requirements given in **2.5.3-1** may not apply.

2 The requirements given in **2.5.3-2** may not apply except for those ships intended to be registered as ships provided with operation systems for unattended machinery spaces according to the Rules for Automatic and Remote Control Systems (hereinafter referred to as **M0** classified ships in this Chapter)

6.2.7 Measuring Instruments for *d.c.* Generators

In the requirements given in **2.5.6**, in cases where there are two or more *d.c.* generators which are not operated in parallel, one ammeter and one voltmeter may be permitted in cases where one portable voltmeter and one portable ammeter specified in **3.8.2** are

located on board.

6.2.8 Measuring Instruments for *a.c.* Generators

In the requirements given in 2.5.7, in cases where there are two or more *a.c.* generators which are not operated in parallel, one ammeter and one voltmeter may be permitted in cases where one portable voltmeter and one portable ammeter specified in 3.8.2 are located on board.

6.2.9 Controlgears for Motors

The requirements given in 2.8.1-7 and -8 may not apply. However, notwithstanding the requirements given in 2.8.1-7 and -8, in the case of ships with a gross tonnage of 500 *tons* or more, grouped starter panels are 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 Cable Fires

The requirements given in 2.9.11 may not apply.

6.2.11 Main Source of Electrical Power

1 Notwithstanding the requirements given in 3.2.1-1 to -3, except for **M0** classified ships, the number of main sources of electrical power may be just one. However, in cases where no other generators are provided, accumulator batteries with capacities sufficient enough to supply electrical power to those lighting systems, signalling systems, communication equipment, etc. which are necessary for ensuring ship safety are to be provided as reserve sources of electrical power.

2 In the cases of **M0** classified ships, the requirements for minimum comfortable conditions of habitability specified in 3.2.1-2 may not apply.

3 The requirements given in 3.2.1-3 may not apply except for **M0** classified ships.

6.2.12 Number of Transformers

In those ships other than **M0** classified ships, if emergency sources of electrical power or reserve sources of electrical power (accumulator batteries) are provided with capacities sufficient enough to feed lighting systems, signalling systems, communication systems, etc., the requirements given in 3.2.2 may not apply.

6.2.13 Lighting Systems

The requirements given in 3.2.3-2 and -4 may not apply. Furthermore, when applying those requirements given in 3.2.3-3, ships are to be provided with reserve lighting systems at the following places:

(1) Launching stations of life rafts as well as the outboard sides in the vicinity

(2) All corridors, stairs and exits

(3) Machinery spaces and places where reserve sources of electrical power are installed

(4) Control stations of main engines

6.2.14 Locations of Main Switchboards

The requirements given in 3.2.4 may not apply.

6.2.15 Emergency Sources of Electrical Power

The requirements given in 3.3 may not apply.

6.2.16 Starting Arrangements for Emergency Generating Sets

The requirements given in 3.4 may not apply.

6.2.17 Power Supply to Navigation Lights

Notwithstanding the requirements given in 3.6.1-3 and -6, power is to be supplied to navigation light indicator panels (including alarm circuits) by separate circuits from main switchboards and reserve sources of electrical power or lighting distribution panels provided on navigation bridges (limited to those cases where two or more generating sets are provided). However, in the case of ships with a gross tonnage of less than 500 *tonnes*, a single circuit from charging and discharging panels supplied by main sources of electrical power (through main switchboards) and reserve sources of electrical power is deemed acceptable.

6.2.18 Power Supply to Not under Command Lights, Anchor Lights and Signalling Lights

Notwithstanding the requirements given in 3.6.2 and 3.6.3, power supplies to not under command lights, anchor lights and signalling lights may be from main sources of electrical power and independent reserve sources of electrical power.

6.2.19 Power Supply to General Alarm Systems

Notwithstanding the requirements given in 3.6.4, emergency sources of electrical power may be of independent reserve sources of electrical power.

6.2.20 Spare Parts

The requirements given in **3.8.1-4** may not apply to those ships which have effective manually operated auxiliary steering gear.

6.3 Electrical Installations of Ships Specified in 6.1.1(2)

6.3.1 General

For those ships specified in **6.1.1(2)**, the requirements given in **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** as well as the following requirements may be complied with.

6.3.2 Control Gears for Motors

The requirements given in **2.8.1-7** and **-8** may not apply.

6.3.3 Main Sources 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 given in **3.2.1-3**, the reliability of ships main sources of electrical power may be modified for any ships other than **M0** classified ships.

6.3.4 Emergency Sources of Electrical Power

The requirements given in **3.3** may not apply. However, reserve sources of electrical power providing power simultaneously to the following loads for a period of at least 3 *hours* (a period of 30 continuous *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) Lighting systems at those locations indicated in **6.2.13**

6.3.5 Power Supply to Navigation Lights

Notwithstanding the requirements given in **3.6.1-3** and **-6**, power is to be supplied to navigation light indicator panels (including alarm circuits) by one circuit each from main switchboards supplied from main sources of electrical power and reserve sources of electrical power.

6.4 Electrical Installations of Ships Specified in 6.1.1(3)

6.4.1 General

For those ships specified in **6.1.1(3)**, the requirements given in **6.2.2**, **6.2.3**, **6.2.7** to **6.2.9** and **6.2.20** as well as the following requirements may be complied with.

6.4.2 Capacity of Emergency Sources of Power

The requirements given in **3.3.2-2(10)** may be complied with.

6.5 Electrical Installations of Ships Specified in 6.1.1(4)

6.5.1 General

For those ships specified in **6.1.1(4)**, the requirements given in **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 those vessels specified in **6.1.1(5)**, the requirements given in **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 those vessels specified in **6.1.1(6)**, the requirements given in **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 as well as the following requirements may be complied with.

6.7.2 Main Source of Electrical Power

The requirements given in 3.2.1-3 and -4 may not apply to generating sets driven by main propulsion machinery as one of two generating sets consisting of main sources of electrical power of any ships other than **M0** classified ships.

6.7.3 Lighting Systems

The requirements given in 3.2.3-2 and -4 may not apply. Furthermore, when applying the requirements given in 3.2.3-3, vessels are to be provided with reserve lighting systems at the following places:

(1) Launching stations of life rafts as well as outboard sides in the vicinity

(2) All corridors, stairs and exits

(3) Machinery spaces and places where reserve sources of electrical power are installed

(4) Control stations of main engines

(5) Spaces where the catch is processed

6.7.4 Emergency Sources of Electrical Power

The requirements given in 3.3 may not apply. However, reserve sources of electrical power providing power simultaneously to the following loads for a period of at least for 3 *hours* (a period of 30 continuous *minutes* for signalling equipment and alarming devices of intermittent services) are to be provided.

(1) All internal communications required in an emergency

(2) Navigation lights, not under command lights, anchor lights and signalling lights

(3) Lighting systems at those locations indicated in 6.7.3

6.8 Electrical Installations of Vessels Specified in 6.1.1(7)

6.8.1 General

For those vessels specified in 6.1.1(7), the requirements given in 6.2.5, 6.2.7 to 6.2.9 and 6.7.2 as well as the following requirements may be complied with.

6.8.2 Emergency Sources of Electrical Power

In applying the requirements given in 3.3.2-2, the following requirements may be applied in place of those requirements given in 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*, any navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea which are in force and any lights required by the National Regulations of the country to which the ship is registered.

(3) For a period of 30 *minutes* (continuous operation), signalling lights and ship whistles.

Annex 2.11.1-2 Accumulator Battery Systems

1.1 General

1.1.1 Scope

1 This annex applies to accumulator battery systems consisting of lithium-ion batteries with total capacities of 20 *kWh* or more, and associated equipment.

2 Accumulator battery systems consisting of lithium-ion batteries with total capacities of 20 *kWh* or more are used as emergency power sources are to comply with other relevant requirements in addition to this annex.

3 Accumulator battery systems and related equipment shall be based on relevant international standards.

1.1.2 Terminology

1 The terms used in this chapter mean as follows.

(1) "Cell" means a battery that produces electrical energy by means of an electrochemical reaction occurring between a pair of positive and negative electrodes. A cell is the smallest unit that constitutes a cell block (a group of cells connected in parallel), module or string.

(2) "Module" means a group of cells connected in parallel, or in a series.

(3) "String" means a group of modules connected in a series.

(4) "Battery management system" (hereinafter referred to as "*BMS*") means a system with functions for monitoring and protecting accumulator battery systems, battery packs, or modules.

(5) "Energy management system" (hereinafter referred to as "*EMS*") is a system that is independent from *BMS*, and has functions such as monitoring the capacity of the accumulator battery system, controlling charge and discharge, and managing the operation mode.

(6) "Battery pack" means a combination of one or more cells or modules and a *BMS*, which itself can be charged and discharged by combining it with electrical power converter.

(7) "Accumulator battery system" means a system, as shown in **Fig. 1**, that includes modules, electrical connections, *BMS* and other related devices (protection devices, cooling units, etc.).

(8) "Electrical power converter" means a device, as shown in **Fig. 2**, that converts the power stored in the accumulator battery system into the appropriate power for each case, such as when feeding (discharging) power to the distribution board or propulsion motor, or when charging the accumulator battery system from the distribution board or power generating equipment.

(9) "Accumulator battery system compartment" means a compartment where an accumulator battery system is installed.

(10) "State of Charge" (hereinafter referred to as "*SOC*") means the ratio of the available capacity at given time to the fully charged capacity at given time.

(11) "State of Health" means the ratio of the fully charged capacity of the accumulator battery system at a given time to the fully charged capacity of the latest accumulator battery system which has just been manufactured.

Fig. 1 Example of Accumulator Battery System and Associated Equipment

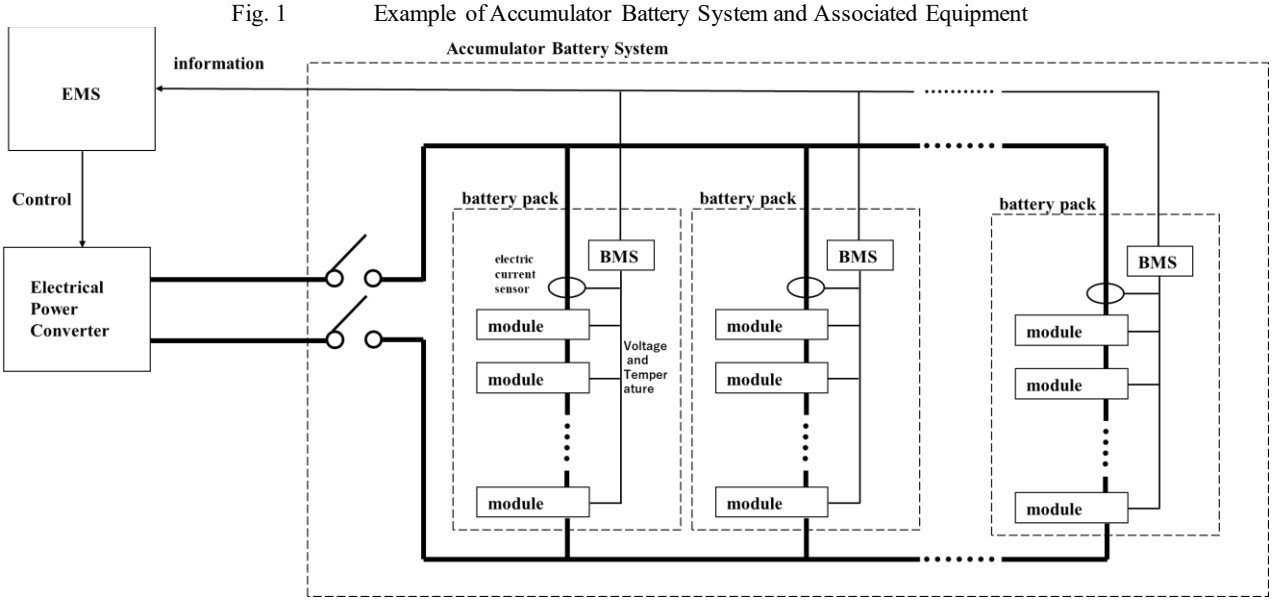
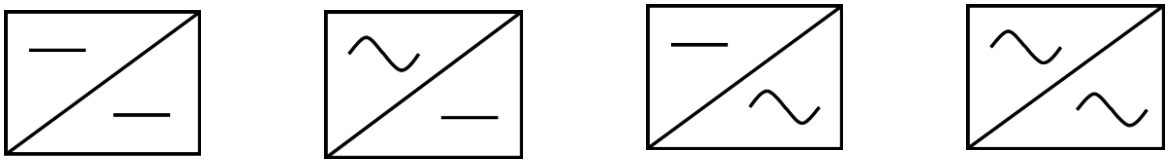
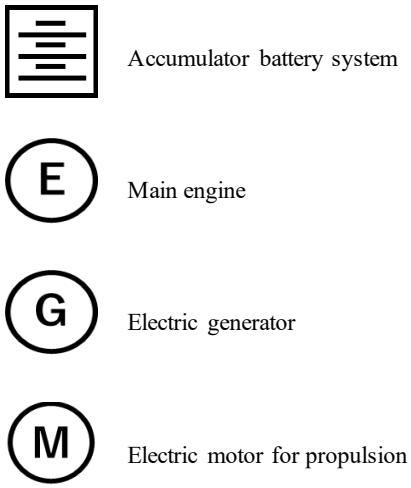


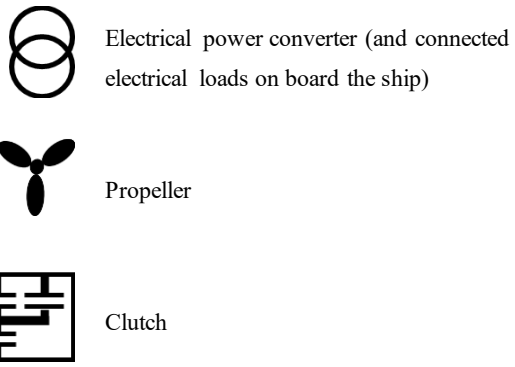
Fig. 2 Electrical Power Converter

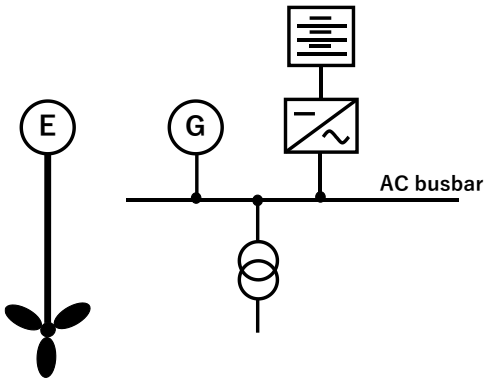


(a) DC－DC converter (b) AC－DC converter (c) DC－AC converter (d) AC－AC converter

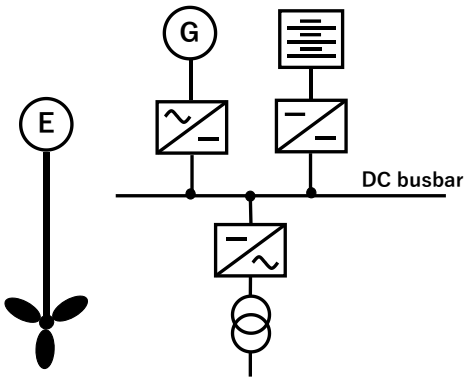
Fig. 3 Examples of Distribution Systems Which Use Accumulator Battery Systems





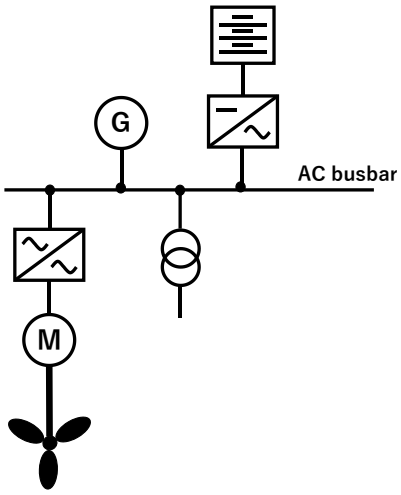


(i) AC distribution system

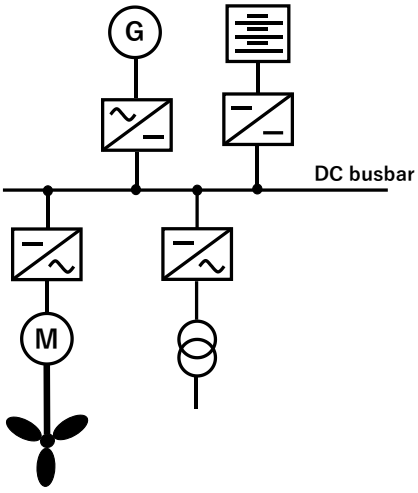


(ii) DC distribution system

(a) Cases where power sources other than electrical power is used for propulsion and where accumulator battery systems and electric generators can be used as main sources of electrical power

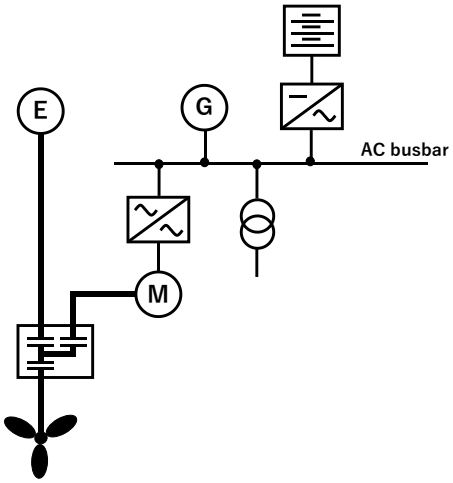


(i) AC distribution system

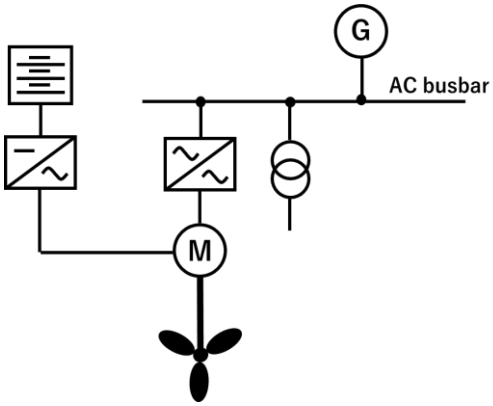


(ii) DC distribution system

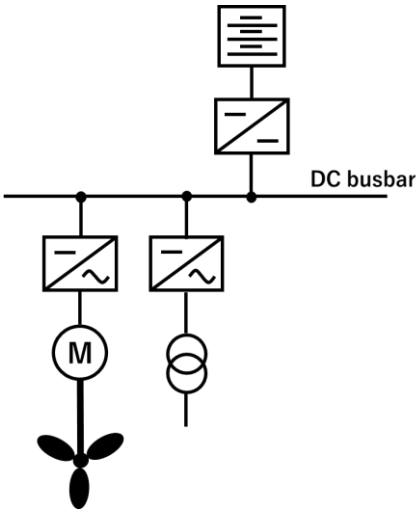
(b) Cases where accumulation battery systems and electric generators for electric propulsion ships can be used as power sources for electric motors used for propulsion or as main sources of electrical power



(c) Cases where use power sources other than electrical power are used for propulsion or main sources of electrical power, and where accumulator battery systems and electric generators can be used as main sources of electrical power



(d) Cases where accumulator battery systems for electric propulsion ships can feed only electric motors used for propulsion



(e) Cases where accumulator battery systems can be used as main sources of electrical power for electric propulsion ships

1.1.3 Submission of Drawings and Documents

1 The drawings for approval and documents for reference to be submitted to the Society for the design of systems using accumulator battery systems are as follows. However, other drawings and documents may be required if deemed necessary by the Society. As for the operation manuals specified in **(2)(a)**, it is acceptable to submit all such manuals after all the designs of the accumulator battery system have been completed.

(1) Drawings for approval (the following, if already approved under other relevant provisions, are required to be submitted as reference)
  (a) Arrangements for accumulator battery systems and other associated equipment (ventilation equipment, gas detection equipment, etc.) in accumulator battery system compartments.
  (b) Arrangements for accumulator battery system compartments (with adjacent compartments identified)
  (c) Fire protection construction plans for accumulator battery system compartments (as specified in **1.2.3-1** and **-2**)
  (d) Fire control plans (as specified in **15.2.2, Part R**).
  (e) Documents related to fire extinguishing systems (documents stating arrangements, types, extinguishing media, number of extinguishing media, etc. as specified in **1.2.3-4** and **-5**)
  (f) Arrangements of fixed fire detection and alarm systems (as specified in **1.2.3-3**)
  (g) System diagrams for the fixed fire detection and alarm systems (as specified in **1.2.3-3**)
  (h) Plans showing ventilation systems related to **1.2.2** (including detailed arrangements of pipes and ducts as well as arrangements of ventilation inlets, ventilation outlets, etc.)
  (i) System diagrams of the gas detection systems (as specified in **1.2.2-10**)
  (j) Wiring system diagrams (including ratings of circuit breakers, contactors and fuses as well as types of cables, cable sizes, etc.)
  (k) Documents related to risk assessment (as specified in **1.2.4**)
  (l) Onboard testing plans (as specified in **1.2.7** and **1.3.8**)
  (m) Layouts inside accumulator battery system panels
  (n) Arrangements outside accumulator battery system panels
(2) Documents for reference
  (a) Operation manuals
  (b) Maintenance manuals

2 The drawings for approval and documents for reference to be submitted to the Society for the designs of accumulator battery systems and their components (e.g. cells and modules) are as follows. However, other drawings and documents may be required when deemed necessary by the Society.

(1) Drawings for approval
  (a) Specifications for accumulator battery systems
  (b) System diagrams for accumulator battery systems (including descriptions of cable sizes, types, materials, etc.)
  (c) Instruction manuals for the control functions of accumulator battery systems
  (d) List of items monitored and protected by *BMS*
  (e) Testing plans for conducting the tests specified in **1.4.3**
(2) Documents for reference
  (a) Test reports for cells or modules (not required for cells or modules of types used in accumulator battery systems which have already received approval of use)
  (b) Test reports for accumulator battery systems (not required for accumulator battery systems of a type which has received approval of use)
  (c) Environmental conditions for *BMS* (temperature, vibration, humidity, *EMC*, and protection type)

1.2 Safety Requirements

1.2.1 Installation Compartments

1 Accumulator battery system compartments are to be located aft of collision bulkheads. Accumulator battery system

compartments are to not be located in accommodation areas. In cases where accumulator battery system compartments are adjacent to accommodation areas, the entrances and exits of accumulator battery system compartments are to be fitted at locations which faces areas other than accommodation areas.

2 Only equipment related to accumulator battery systems (excluding electrical power converters and *EMS*) are to be installed in accumulator battery system compartments.

3 Ambient conditions of accumulator battery systems are to be in accordance with **1.1.7, Part H**. In addition, such conditions are to be suitable for the environmental conditions (temperature, humidity, etc.) recommend for accumulator battery systems by manufacturers.

4 Ambient temperatures in accumulator battery system compartments are to be indicated in engine control rooms or at accumulator battery system control stations. In cases where ambient temperatures reach limit values recommended by accumulator battery manufacturers, alarms are to be issued in engine control rooms or at accumulator battery system control stations.

5 Electrical equipment installed at locations 450 *mm* or closer to the ceilings of accumulator battery system compartments are to be explosion-protected electrical equipment suitable for use in explosive mixtures classified as apparatus group *IIC* and temperature class *T*2 as specified in *IEC* 60079, be equivalent thereto, or be of a higher standard (explosion-protected type is not limited). However, this does not apply in cases where it is judged that explosion-protected electrical equipment is not needed per the results of the risk assessments specified in **1.2.4-1(13)**. In addition, mechanical ventilators do not need to be explosion-protected electrical equipment in cases where the ventilator is of the external motor driven type.

6 Cables installed at locations 450 *mm* or closer to the ceilings of accumulator battery system compartments are to be suitably protected in accordance with the following **(1)** and **(2)** items in cases where there are risks of fire or explosion in the event of electrical accidents at such locations.

(1) Cables are, in principle, to be protected by metal sheaths.

(2) Means for preventing mechanical damage to cables are to be provided as necessary.

1.2.2 Ventilation

1 Mechanical ventilation systems capable of ventilating at least 6 *times per hour* are to be installed in accumulator battery system compartments in order to exhaust gases generated from accumulator batteries in the event of an emergency.

2 In principle, ventilation outlets for accumulator battery system compartments are to be located near the ceiling and ventilation inlets are to be located near the floor.

3 Exhaust gases from accumulator battery system compartments are to be led to areas on open decks where there are no dangers of fire, explosion, or which may have adverse effects on human health.

4 Areas within spheres with a 1.5 *m* radius from ventilation outlets on open decks for ducts used for ventilation are classified as hazardous areas of Zone 2.

5 Operating indicators for mechanical ventilation systems, as specified in **-1** above, are to be provided at engine control rooms or accumulator battery system control stations. Visible and audible alarms are to be issued in engine control rooms or at accumulator battery system control stations in the event of mechanical ventilator malfunction or power supply loss.

6 Mechanical ventilators are to be fed by electrical power sources independent of accumulator battery systems in the accumulator battery system compartments in which such ventilators are installed. Mechanical ventilator fans are to be of a non-sparking construction as specified in **4.5.4-1(1), Part R**.

7 Pipes and ducts used for ventilation of accumulator battery system compartments are to be leakproof and are to be separated from the pipes and ducts used for ventilation of other compartments.

8 Pipes and ducts used for ventilation of accumulator battery system compartments are to be provided with closing appliances. However, in cases where all the conditions specified in **(1)** to **(3)** of **R5.2.1-1, Part R** are satisfied, closing appliances may be omitted.

9 In cases where the closing appliances specified in **-8** above are installed, notices stating “This closing device is to be kept open and only closed in the event of fire or other emergency - Explosive Gas”, are to be provided near such closing appliances to mitigate the possibility of inadvertent closing.

10 Gas detection systems are to be installed in accumulator battery system compartments to detect flammable gases that may be emitted in the event of accumulator battery malfunctions. Such gas detection systems are to be fed by electrical power sources independent of the accumulator battery systems in the accumulator battery system compartments where the gas detection systems are installed. In addition, such gas detection systems are to comply with *IEC* 60079-29-1.

11 In cases where gas concentrations of 30 *% LEL* are detected by the gas detection systems specified in **-10** above, visible audible alarms are be issued at navigation bridges as well as in engine control rooms or at accumulator battery control stations

12 In cases where gas concentrations of 30 *% LEL* are detected by the gas detection systems specified in **-10** above, all electrical equipment installed in accumulator battery system compartments, except for the following **(1)** to **(4)** items, is to be automatically shut off in an emergency. In addition, mechanical ventilation systems are to automatically operate in cases where gas concentrations of 30 *% LEL* are detected.

(1) Explosion-protected electrical equipment

(2) Gas detection systems

(3) Fire detection and alarm systems

(4) Mechanical ventilation systems

1.2.3 Fire Considerations

1 Accumulator battery system compartments are to be classified as either **(1)** or **(2)** below and **Chapter 9, Part R** is to be applied.

(1) In cases where accumulator battery systems fall under **1.3.1-1(1)** or **(2)**: Machinery Spaces of category *A*

(2) Other than **(1)** above: Other machinery spaces

2 In cases where accumulator battery system compartments are adjacent to either **(1)** or **(2)** below, fire integrity of in-between bulkheads is to be *A*-60.

(1) Machinery Spaces of category *A*

(2) Cargo spaces in which dangerous goods are intended to be carried

3 Accumulator battery system compartments are to be equipped with fixed fire detection and alarm systems complying with **Chapter 29, Part R**.

4 Compartments in which cells of accumulator battery systems are located are to be provided with either of the fixed fire-extinguishing systems specified in **10.5.1-1(1)** to **(3), Part R** in accordance with the manufacturer recommendations or the characteristics of cells of accumulator battery systems.

5 In addition to the fixed fire-extinguishing systems specified in **-4** above, at least one portable fire extinguisher is to be provided in accumulator battery system compartments near entrances. Such fire extinguishers are to comply with **Chapter 24, Part R**, and the fire extinguishing media are to be in accordance with manufacturer recommendations or the characteristics of the cells of accumulator battery systems.

1.2.4 Risk Assessments

1 Risk assessments are to be carried out to verify the risks to the safety of personnel and the ship arising from the use of accumulator battery systems. The following **(1)** through **(13)** items are to be included in such risk assessments.

(1) Risk of gas leakages that may occur during normal operations or abnormal conditions and countermeasures

(2) Risk of fire and countermeasures

(3) Risk of explosions (composition, volume and release rate of gas emitted from cells during thermal runaway, etc.) and countermeasures

(4) Appropriate detection, monitoring, and alarm methods for gas emitted from cells (e.g. numbers and locations of gas detectors and fire detectors)

(5) Appropriate ventilation methods in accumulator battery system compartments

(6) Appropriate fire extinguishing methods (kind of fire extinguishing medium, numbers and locations of fire extinguishing systems, etc.)

(7) Risk of thermal runaway of cells and countermeasures

(8) Risk of internal and external short circuits and earth faults, and countermeasures

(9) Electrical protection (appropriate protection against overcurrent, overcharge, overdischarge, etc.)

(10) Appropriate protection against electrical faults due to external leakage or pollution

(11) Risk of flooding of modules due to cooling liquid leakage and countermeasures

(12) Risk of external factors (flooding, heat, etc.) and countermeasures

(13) Necessity of making electrical equipment in accumulator battery system compartments explosion-protected types.

2 Measures are to be taken based on the results of the risk assessments described in **-1** above.

1.2.5 System Design

1 Accumulator battery systems are to be arranged so that they are easily accessible for replacement, inspection, testing and cleaning. Accumulator battery system compartments are to be equipped with locks to prevent access by unauthorized personnel.

2 Accumulator battery systems are to be fixed to ships by methods specified by manufacturers so that they cannot be rendered inoperable by the vibration, upsetting, etc. of ships.

3 Emergency disconnection to battery systems is to be available from the following **(1)** to **(3)** locations. Such disconnections are to be carried out by circuits independent of the circuits for control, monitoring and alarms (e.g. the *BMS* functions specified in **1.4.2**). Note that it is not necessary to provide such disconnections in cases where accumulator battery systems fall under **1.3.1-1(3)**. In cases where accumulator battery systems fall under **1.3.1-1(2)**, there is no need to provide such disconnections at **(3)**.

(1) Outside accumulator battery system compartments (e.g. in adjacent compartments, corridors, near doors)

(2) Engine control rooms or accumulator battery system control stations

(3) Navigation bridges

4 Earth insulation levels for accumulator battery system output terminals are to be continuously monitored insulation and audible or visual indications of abnormally low insulation values are to be provided at engine control rooms or accumulator battery system control stations. "Abnormally low insulation values" means insulation resistance values corresponding, as a standard, to 1/10 of those under normal conditions of electric circuits which are to be monitored.

1.2.6 Electrical Power Converters

1 Electrical power converters are to comply with requirements for semiconductor power converters in **2.12, Part H**.

2 Electrical power converters are to be tested at manufacturing plants or other locations as is required for the semiconductor power converters in **2.12.4, Part H**.

3 Electrical power converters for charging and discharging accumulator battery systems are to comply with the specifications specified by accumulator battery system manufacturers.

4 Electrical power converters for charging and discharging accumulator battery systems are to be capable of maintaining proper charging voltages according to the characteristics of accumulator battery systems.

1.2.7 Tests After Installation On Board

1 After installation on board, accumulator battery systems and associated equipment are to be subjected to the following **(1)** through **(3)** verification tests.

(1) Accumulator battery system operation tests

The entire system (including the accumulator battery systems, electrical power converters, *EMS*, etc.) is to be checked for normal operation.

(2) Operation tests of the protective functions provided for accumulator battery systems

(3) Operation tests of devices installed in accumulator battery system compartments (ventilation systems, gas detection systems, fire extinguishing systems, fire detection and alarm systems, etc.)

1.2.8 Maintenance, Management, etc.

1 Maintenance and management methods for accumulator battery systems, replacement times, etc. designated by accumulator battery system manufacturers are to be followed.

1.3 Additional Requirements for Electrical Propulsion, Main Electrical Power Source or Emergency Electrical Power Source Purposes

1.3.1 General

1 This **1.3** applies to accumulator battery systems that fall under any of the following **(1)** through **(3)** types.

(1) Accumulator battery systems for electrical power propulsion purposes, partial or total.

(2) Accumulator battery systems for main electrical power source purposes, partial or total.

(3) Accumulator battery systems for emergency electrical power source purposes

2 At least one or more other independent accumulator battery system is to be provided in cases where either the following **(1)** or **(2)** applies. Such accumulator battery systems are to be located in separate compartments and are to feed by independent circuits.

(1) In cases where ships are equipped with accumulator battery systems corresponding to **-1(1)** above are provided and ships are

unable to maintain navigable speeds by other power supply units when the accumulator battery systems fail or stop. In such cases, "navigable speed" means those speeds at which ships are capable of being steered and kept navigable for extended periods of time. Speeds regarded as "navigable speeds" are normally 7 *knots* or speeds corresponding to 1/2 of the speed specified in **2.1.8, Part A** at full loaded draught.

(2) In cases where ships are equipped with accumulator battery systems that fall under **-1(2)** above and other main electrical power sources cannot satisfy **3.2.1-2** and **-3, Part H** when accumulator battery systems fail or stop.

3 Ships of less than 500 *gross tonnage* not engaged in international voyages need not satisfy **-2** above, subject to the approval by the Administration.

4 **Chapter 18, Part D** applies to the equipment specified in **1.3.7-1(1)** and **(2)**.

1.3.2 Accumulator Battery System Capacity

1 In cases where either **1.3.1-2(1)** or **(2)** above applies, accumulator battery systems are to have sufficient capacities, taking into account system aging, expected sailing time, etc.

1.3.3 Monitoring

1 The following **(1)** through **(4)** items are to be indicated at navigation bridges.

(1) Available accumulator battery system electrical energy (*kWh*)

(2) Available accumulator battery system electrical power (*kW*)

(3) State of Charge (*SOC*)

(4) State of Health

1.3.4 Capacity Monitoring Functions

1 *EMS* or other means are to have functions for monitoring accumulator battery system capacities as well as controlling recharge and discharge.

2 The parameters in **1.3.3-1(1)** and **(2)** are to be calculated by either *EMS* or other means.

1.3.5 Electrical Power Converters

1 Electrical power converters for feeding power from accumulator battery systems to main switchboards are to comply with the following **(1)** to **(5)** items. For DC distribution systems (e.g. **Fig. 3(a)(ii)**, **Fig. 3(b)(ii)**, **Fig. 3(e)**), only **(3)** through **(5)** apply; however, in cases where electric propulsion ships (such as shown in **Fig. 3(e)**) depend entirely on accumulator battery system power for their power requirements, **(3)** and **(4)** need not be satisfied as long as there are no problems supplying power to each load.

(1) In cases where electric power converters are driven at rated frequencies, giving rated voltages and rated symmetrical loads, the total harmonic distortion (*THD*) of distribution systems connected to such electrical power converters are not to exceed values of 5 %; this, however, does not apply if the safe operation of other electric devices connected to such distribution systems is maintained by the adoption of suitable methods for decreasing harmonic content effects such as harmonic filters, and total harmonic distortion (*THD*) values do not exceed 8 %.

(2) The following frequency characteristics are to be provided.

(a) Accumulator battery systems that fall under **1.3.1-1(2)**

i) Momentary frequency variations are, in principle, to be 10 % or less of maximum rated frequency when rated loads of electrical power converters are suddenly thrown off. However, in cases where momentary frequency variations are 10 % or less of the rated frequency when the maximum load on board is suddenly thrown off and the frequency is returned to within 1 % of the final steady frequency in not more than 5 *seconds*, momentary frequency variations in excess of 10 % of rated frequencies may be acceptable in cases where rated loads of such electric power converters are suddenly thrown off.

ii) Momentary frequency variations are, in principle, to be 10 % or less of maximum rated frequency when 50 % of the rated loads of electrical power converters are suddenly thrown on followed by the remaining 50 % of such loads suddenly being thrown on after an interval to restore the steady state. On the other hand, momentary frequency variations are to be 10 % or less of maximum rated frequency when 100 % of the rated loads of electrical power converters are suddenly thrown on, and frequencies are to return to within 1 % of final steady frequencies in not more than 5 *seconds*. In cases where such throwing-on methods are difficult according to the above requirements, and where a three-stage or more throwing-on method is adopted, throw-on power calculation sheets which take into consideration the following **1)** to **4)** are to be submitted to the Society for approval.

1) Power restoration after blackout
2) Sequential starting
3) Starting with large start-up loads
4) Instantaneous load transfers in cases where one set of generators fails (during parallel running)

(b) Accumulator battery systems that fall under **1.3.1-1(3)**

i) Momentary frequency variations are not to exceed the values specified in **(a)i)** in cases where total emergency consumer loads are suddenly thrown off.

ii) Momentary frequency variations are, in principle, not to exceed the values specified in **(a)ii)** and frequencies to return to within 1 % of final steady frequencies in not more than 5 *seconds* in cases where total emergency consumer loads are suddenly thrown on. However, if it is difficult to meet the above requirements and in cases where the following **1)** through **3)** are adopted, throwing-on in steps methods may be used.

1) Total emergency consumer loads are to be thrown on within 45 *seconds* after blackout.
2) Electric power converters are to be designed so that the maximum step loads in emergency consumer loads are to be thrown on at one time.
3) Documents such as thrown on power calculations specifying the adoption of throwing on in steps are to be submitted.

iii) At all loads in ranges between no loads and total emergency consumer loads, all permanent frequency variations are not to exceed the values specified in **(a)iii)** above.

(3) Overall voltage regulation of electrical power converters is to be such that rated voltages at all loads from zero to full loads at rated power factors are maintained under steady conditions within ± 2.5 %. However, for accumulator battery systems that fall under **1.3.1-1(3)**, such voltage limits may be within ± 3.5 %.

(4) In cases where electrical power converters operating at rated voltages and rated frequencies are subjected to sudden changes in symmetrical loads within the limits of specified currents and power factors, voltages are not to fall below 85 % nor exceed 120 % of rated voltage. Voltages of such electrical power converters are then to be restored to within ± 3 % of their rated voltage in a period of not more than 1.5 *seconds*. However, for accumulator battery systems that fall under **1.3.1-1(3)**, such voltage values may be increased to ± 4 % in a period of not more than 5 *seconds*.

(5) Electrical power converters are to be capable of maintaining currents of at least three times their rated full-load currents for durations of at least 2 *seconds* or for those durations of any time delays which may be fitted in tripping devices for selective tripping. In addition, depending on the distribution systems on ships, test conditions may be relaxed in cases where there are no effects on selective trip operations of protective devices. In such case, the documents listed in **(a)** through **(d)** are to be submitted to the Society for approval beforehand.

(a) Short circuit current calculations in cases where accumulator batteries operate independently
(b) List of circuit breakers used (including breaking capacities, operation setting values, etc.)
(c) Proposal for short circuit withstand tests
(d) Declaration stating that the present selective coordination of trips is effective under short-circuit conditions

2 Electrical power converters for supplying power from accumulator battery systems to main switchboards are to be tested at manufacturing plants or other locations in accordance with the following **(1)** and **(2)**.

(1) Tests of AC power distribution systems are to be carried out to verify that the voltage total harmonic distortion (*THD*) specified in **-1(1)** above does not exceed 5 % under no load conditions.

(2) In cases where accumulator battery systems may be operated alone, steady short-circuit tests are to be conducted to verify that **-1(5)** above is satisfied. Power sources used in such tests do not have to be accumulator battery systems. Manufacturer simulation models for electrical power converters may be used in cases where such simulations have been validated through tests of identical types of the same model.

3 Electrical power converters used to feed electric motors for propulsion are to comply with **5.2.5, Part H**.

1.3.6 Load Sharing

1 In cases where two or more accumulator battery systems are operated in parallel or in cases where accumulator battery systems and AC generators are operated in parallel, each system and generator operating in parallel is to be capable of stable operation between of 20 % and 100 % of the total combined loads of all such systems and generators. Furthermore, the *kW* loads for each system or

generator operating in parallel is not to differ from its proportionate share of the total combined loads of all such systems and generators by more than 15 % of the rated output of the largest system or generator, or 25 % of the rating of the individual system or generator.

2 In cases where two or more accumulator battery systems are operated in parallel or in cases where accumulator battery systems and AC generators are operated in parallel, each system and generator operating in parallel is to be capable of stable operation and the reactive loads for each system or generator are not to differ from its proportionate share of the total combined reactive loads of all such systems and generators by more than 10 % of the rated reactive output of the largest system or generator, or 25 % of the smallest system or generator (whichever value is smaller).

1.3.7 Shop Tests

1 The electrical equipment specified below is to be tested in accordance with **18.7.1, Part D** at manufacturing plants or other locations. However, with respect to equipment which has been already received approval of use from the Society, some or all of the environmental tests specified in **18.7.1(1), Part D** may be omitted.

(1) Equipment related to the charging and discharging control of accumulator battery systems (e.g. the *EMS* referred to in **1.1.2-1(5)**)

(2) Electrical power converters used in accumulator battery systems

1.3.8 Tests After Installation On Board

1 In addition to **1.2.7**, tests to verify that **1.3.5-1(2)** to **(4)** and **1.3.6** are satisfied are to be carried out.

battery system manufacturers are to be followed.

1.4 Accumulator Battery Systems

1.4.1 General

1 This **1.4** applies accumulator battery systems and their components (e.g. cells and modules).

2 Accumulator battery systems are to be equipped with *BMS*.

3 Accumulator battery systems are to be capable of disconnecting both output poles by means of contactors or circuit breakers.

4 Accumulator battery systems are to be equipped with fuses to protect the accumulator batteries.

5 Suitable measures are to be taken as far as possible to prevent salt damage and moisture condensation on accumulator battery system enclosures as well as associated modules, *BMS* and cables, etc.

6 Accumulator battery systems are to comply with **Chapter 18, Part D**.

1.4.2 *BMS*

1 *BMS* are to measure the following **(1)** to **(3)**

(1) Cell voltage

(2) Cell or module temperature

(3) Current flowing in strings (or battery packs)

2 *BMS* are to be capable of electrically disconnecting at points where any of the following **(1)** through **(4)** abnormal conditions are detected.

(1) Overcurrent

(2) Voltages exceeding upper limit voltages

(3) Voltages below lower limit voltages

(4) Overheating

3 *BMS* are to be capable of automatically correcting charge imbalances (cell balance).

4 The parameters listed in **(1)** to **(4)** below are to be indicated in engine control rooms or at accumulator battery control stations.

(1) System output voltage

(2) Maximum and minimum cell voltages for all cells

(3) Maximum and minimum cell temperatures (or module temperatures) for all cells (or modules)

(4) Current flowing in strings (or battery packs)

5 Visible and audible alarms are to be issued at navigation bridges as well as in engine control rooms or at accumulator battery system control stations in cases where anomalies concerning the following **(1)** to **(7)** items are detected.

(1) Cell or module temperature

(2) Voltages exceeding upper voltage limits

(3) Voltages below lower limit voltages

(4) Electrical disconnection of accumulator battery systems

(5) Tripping of contactors or circuit breakers of accumulator battery systems

(6) Data communication

(7) Refrigerant leakage

6 If any of the items in **1.3.1-1(1)** through **(3)** applies, the following **(1)** and **(2)** items are to be calculated by the *BMS* or other means.

(1) State of Charge ("*SOC*")

(2) State of Health

7 *BMS* are to comply with requirements for electrical equipment specified in **2.1.3, Part H**. In addition, insulating materials, wiring materials, etc. for *BMS* are to be flame retardant.

1.4.3 Shop Tests

1 Cells and modules of accumulator battery systems are to be tested as specified in **Table 1** at manufacturing plants or other locations. However, all the tests may be omitted for cells and modules of types used in accumulator battery systems that have already received approval of use from the Society in accordance with **Chapter 9, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2 Control and protection functions of *BMS* for accumulator battery systems are to be tested as specified in **Table 2** at manufacturing plants or other locations. However, all the tests may be omitted for accumulator battery systems that have already received approval of use from the Society in accordance with **Chapter 9, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

3 Accumulator battery systems are to be tested as specified in **Table 3** at manufacturing plants or other locations.

4 Accumulator battery systems are to be tested as specified in **18.7.1, Part D** at manufacturing plants. It is acceptable for environmental tests to use only those elements (e.g. battery packs) of accumulator battery systems installed on board ships that have the minimum functions required for verification of tests. However, some of all of the environmental tests specified in **18.7.1(1), Part D** may be omitted for accumulator battery systems which have already received approval of use from the Society.

Table 1 Testing of Cells and Modules at Manufacturing Plants and Other Locations

Test type	Corresponding standard number
External short-circuit test	*JIS C* 8715-2 7.2.1 or *IEC* 62619 7.2.1
Impact test	*JIS C* 8715-2 7.2.2 or *IEC* 62619 7.2.2
Drop test	*JIS C* 8715-2 7.2.3 or *IEC* 62619 7.2.3
Thermal abuse test	*JIS C* 8715-2 7.2.4 or *IEC* 62619 7.2.4
Overcharge test	*JIS C* 8715-2 7.2.5 or *IEC* 62619 7.2.5
Forced discharge test	*JIS C* 8715-2 7.2.6 or *IEC* 62619 7.2.6
Internal short-circuit test (1)	*JIS C* 8715-2 7.3.2 or *IEC* 62619 7.3.2

Note:

(1) Internal short-circuit tests need not be carried out in cases where the propagation tests in **1.4.3-2** are carried out.

Table 2 Testing of BMS Control and Protection Functions at Manufacturing Plants and Other Locations

Test type	Corresponding standard number
Propagation test (1)	*JIS C* 8715-2 7.3.3 or *IEC* 62619 7.3.3
Overcharge control of voltage	*JIS C* 8715-2 8.2.2 or *IEC* 62619 8.2.2
Overcharge control of current	*JIS C* 8715-2 8.2.3 or *IEC* 62619 8.2.3
Overheating control	*JIS C* 8715-2 8.2.4 or *IEC* 62619 8.2.4
Discharge performance	*JIS C* 8715-1 6.3.1 or *IEC* 62620 6.3.1
Sensor failures(2)	according to specification
Cell balancing(2)	according to specification
SOC validation(2)	according to specification

Notes:

(1) Internal short-circuit test need not be carried out in cases where the internal short-circuit tests for cells in **1.4.3-1** are carried out.

(2) Detailed test contents are to be included in manufacturer testing plans.

Table 3 Testing of Accumulator Battery Systems at Manufacturing Plants and Other locations

Test type	Corresponding standard number
External examination	–
High voltage test	Refer to **2.8.4-4, Part H** (1)
Insulation resistance test	Refer to **2.8.4-5, Part H**

Note:

(1) Components (cells, sensors, etc.) that may be damaged by high voltage tests are to be removed, and tests are to be carried out on the conductive parts of accumulator battery systems.

Annex 3.3.3(3) UNINTERRUPTIBLE POWER SYSTEM UNITS

1.1 General

1.1.1 Application

This annex to uninterruptible power system (hereinafter referred to as "UPS") units, as defined in *IEC* 62040-3:2011, apply when providing an alternative power supply or transitional power supply to the emergency sources of power specified in **3.3, Part H**. Any batteries and semiconductor converters combined with UPS units are to be in accordance with those requirements specified in **2.11** and **2.12, Part H** as practicable.

1.1.2 Definitions

Definitions of the terms used in this annex are as follows:

(1) UPS means sources of electrical power with semiconductor converters, switches and batteries, used for maintaining continuity of loads in cases of input power failure.(*IEC* 62040-3:2011)

(2) Off-line UPS units mean those electrical power devices in which output loads are powered from bypass lines under normal operation and which are only transferred to inverters if such bypass supply falls or goes outside preset limits.

(3) Line interactive UPS units means those systems specified in **(2)** above which are attached to equipment which controls voltage vibrations.

(4) On-line UPS units mean those systems which supply electrical power to loads via inverters without any power interruption.

1.2 Design

1.2.1 Construction

1 UPS units are to be constructed in accordance with *IEC* 62040:2017, *IEC* 62040-2:2016, *IEC* 62040-3:2011, *IEC* 62040-4:2013 and/or *IEC* 62040-5-3:2016, as applicable, or acceptable and relevant national or international standards.

2 The operation of UPS units is not to depend on any external services.

3 The type of UPS unit (off-line, line-interactive, on-line) is to be appropriate for the power supply requirements of the relevant connected loads (see **2.1.2-3, Part H**).

4 UPS units are to have external bypass circuits.

5 UPS units are to have self-monitoring functions, and audible and visual alarms are to be activated in those spaces where crew members are normally stationed (e.g. navigation bridges and machinery control spaces) in the following cases:

(1) Power supply failures (abnormal voltage or frequency)

(2) Earth faults

(3) Operation of battery protective devices

(4) Discharge of batteries

(5) Operation of bypass circuits for on-line UPS units

1.2.2 Arrangements

1 UPS units are to be suitably located for use in emergency situations.

2 In case where UPS units utilising valve regulated sealed batteries are provided with the ventilation arrangements in accordance with the requirements of *IEC* 62040-1:2017, *IEC* 62040-2:2016, *IEC* 62040-3:2011, *IEC* 62040-4:2013 and/or *IEC* 62040-5-3:2016, the Society may approve the location of such UPS units in the compartment where normal electrical equipment are located.

1.2.3 Performance

1 Output power is to be maintained for the duration time required for relevant connected equipment as specified in **3.3.2, Part H**.

2 No additional circuits are to be connected to any UPS units unless their battery capacity is more than the total capacity of the output power specified in **-1** above.

3 On the restoration of input power, the ratings of any charging units are to be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

4 In cases where supplying to loads via inverters from the batteries in UPS, maximum permitted voltage fluctuations on the output side of the circuit may be taken as those specified in **Tables H2.1(a)** or **H2.1(b)**, **2.1.2-3, Part H** respectively, notwithstanding any voltage drops of such batteries.

1.3 Testing

1.3.1 Shop Tests

1 UPS units of 50 *kVA* and over are to be tested at places of manufacturer or at other works. In addition, tests for semiconductor converters are to be carried out in accordance with those requirements specified in **1.2.1-1, Part H**.

2 Appropriate tests are to be carried out in accordance with the following items to demonstrate that UPS units are suitable for its intended environment.

(1) Functionality, including operation of alarms

(2) Temperature rise

(3) Ventilation rates

(4) Battery capacities

3 UPS units which are connected to equipment requiring a continuous supply of power even in at times of UPS input power failure are to be checked to verify that this operational condition can be maintained.

Contents

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part HELECTRICAL INSTALLATIONS

H1 GENERAL

H1.1 General

H1.1.1 Scope

1 Electrical equipment for ships operating by remote control and automatic control are to comply with the requirements given in **Part H of the Rules** as well as with the requirements given in **Part D of the Rules**.

2 The requirements given in **Part H of the Rules** do not apply to the following electrical equipment except in those cases where explosion-protected construction is necessary:

(1) Radiotelegraph or radiotelephone equipment provided in accordance with international law or the laws of the flag state

(2) Navigational aids provided in accordance with international law or the laws of the flag state (those prescribed in Regulations 19 and 20, Chapter V, the Annex to *SOLAS* Convention)

3 Home electrical appliances to be brought on board ships such as television sets, radio sets, table lamps, electric heaters, etc., are not included in any of the electrical installations specified in **Part H of the Rules**.

4 Cables, circuit breakers and fuses connected to the electrical equipment stipulated in requirements given in **-2** and **-3** above are to comply with the relevant requirements given in **Part H of the Rules**.

H1.1.6 Drawings and Data

1 "Diagrams of wiring systems" specified in **1.1.6(1)(f), Part H of the Rules** are to be include the following information concerning electrical systems of the windlass, as applicable:

(1) Cable specification and size

(2) Motor controller

(3) Protective device rating or setting

2 "Sectional assembly drawings" specified in **1.1.6(1)(h), Part H of the Rules** are to be include the information of associated gears.

3 The wording "lists of any electrical equipment installed in such hazardous areas" specified in **1.1.6(2)(d)** and **(e)**, **Part H of the Rules** means such lists are to include the following information:

(1) The installation arrangement, kind of construction, type (including the certificate number and the name of any testing institution), manufacturer name, quantity and usage of any explosion-protected electrical equipment

(2) Relevant documents related to how conditions impact such things as ventilation ratios, pressurizations or air-locks of each type of hazardous areas in order to confirm the effectiveness of such equipment (in cases where applicable)

4 "Total Harmonic Distortion (THD) calculation report" specified in **1.1.6(2)(f)i), Part H of the Rules** is to be include the following information:

(1) Results of the calculation of the Total Harmonic Distortion (THD) value experienced when a failure of a harmonic filter occurs.

(2) With respect to **2.1.2-4, Part H of the Rules**, the acceptable limit of the Total Harmonic Distortion (THD) value.

5 The "harmonic filter operation guide" specified in **1.1.6(2)(f)ii), Part H of the Rules** is to include the following information:

(1) The permitted operating mode of the electrical distribution system while maintaining the Total Harmonic Distortion (THD) values within acceptable limits during normal operation.

(2) The permitted operating mode of the electrical distribution system in the case of failure of any combination of harmonic filters.

6 Data specified in **-4** and **-5** are to be submitted by the system integrator of the distribution system.

7 In applying **1.1.6(1)** and **(2), Part H of the Rules** the drawings and documents referred to in **1.1.3, Annex 2.11.1-2, Part H of the Rules** are to be submitted for ships equipped with accumulator battery systems to which **Annex 2.11.1-2, Part H of the Rules** is applied.

H1.2 Testing

H1.2.1 Shop Tests

1 The wording "survey methods which it considers to be appropriate" in **1.2.1-1, Part H of the Rules,** and the wording "tests for any equipment with small capacities as specified in **(4)** and **(5)** are to be conducted as deemed appropriate by the Society" specified in **1.2.1-1**, **Part H of the Rules** means to be in accordance with the following **(1)** and **(2)** respectively:

(1) The wording "survey methods which it considers to be appropriate" means survey methods which the Society considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where the Surveyor is in attendance, notwithstanding any of the requirements in this Part.

(2) The wording "tests for any equipment with small capacities as specified in **(4)** and **(5)** are to be conducted as deemed appropriate by the Society" means those shop tests for electrical motors whose capacities at continuous ratings are less than 100 *kW* and controlgears of those motors may be substituted for by manufacturer tests. In such cases, submission or presentation of test records may be required by the Society.

2 Those "motors for essential services" specified in **1.2.1-1(4)**, **Part H of the Rules** means those driving auxiliary machinery corresponding to auxiliary machinery essential for main propulsion, auxiliary machinery for manouevring and safety, and auxiliary machinery for cargo handling specified in **Table D1.1.6-1**, **Part D**.

3 In applying **1.2.1-1(7), Part H of the Rules** the tests for cells (or modules), accumulator battery systems and electrical power converters referred to in **Annex 2.11.1-2, Part H of the Rules** are to be carried out for ships equipped with accumulator battery systems to which **Annex 2.11.1-2, Part H of the Rules** is applied.

4 The wording "subject to Society approval" in **1.2.1-3**, **Part H of the Rules** means compliance with the requirements given in the **Rules for Approval of Manufacturers and Service Suppliers**. Equipment and cables approved are made public in the **List of Approved Materials and Equipment**.

5 The wording "to be subjected to type tests" in **1.2.1-4**, **Part H of the Rules** means **Part 8 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**. Equipment and cables approved are made public in the **List of Approved Materials and Equipment**.

6 Cables requiring type approval are as follows:

(1) Cables used for power feeding systems and power distribution circuits for power, lighting and internal communications and used for control circuits

(2) Flexible cords used for feeding power systems and power distribution circuits and control circuits

(3) Multicore vinyl insulated cables for 150 *V* electronic equipment

7 Type tests may be carried out for flexible cords, vinyl sheathed cords, insulated cables for switchboards and control equipment, coaxial cables, etc., other than those specified in **-6** above in cases where a request is made by the manufacturer.

H2 ELECTRICAL INSTALLATIONS AND SYSTEM DESIGN

H2.1 General

H2.1.2 Voltage and Frequency

1 In **2.1.2-3, Part H of the Rules**, voltage fluctuations in main busbars and emergency switchboard busbars are to be designed after taking into account any voltage drop in power cables so that any electrical equipment supplied by such switchboards are capable of operating satisfactorily without any problems.

2 In **2.1.2-3, Part H of the Rules**, the steady state voltages and frequencies of *a.c.* motors are to be considered to change simultaneously, and any fluctuations in such events in terms of the sum of the absolute value of respective ratios of these fluctuations are to be within 10 %. Furthermore, any limits placed on the fluctuations of voltages and frequencies are to be set as the maximum amplitude of each.

3 The wording "specially approved by Society" given in **2.1.2-4, Part H of the Rules** means to satisfy any of the following:

(1) In distribution systems connected with semiconductor converters where the safe operation of other electric devices connected to such distribution systems is maintained by the adoption of suitable methods for decreasing harmonic content effects such as harmonic filters, and Total Harmonic Distortion (THD) values do not exceed 8 %.

(2) In electric propulsion ships, where the distribution systems connected with propulsion semiconductor converters are closed circuits independent from other internal distribution systems, and Total Harmonic Distortion (THD) values do not exceed 10 %.

Fig. H2.1.2-1 Application Example of H2.1.2-3(1)

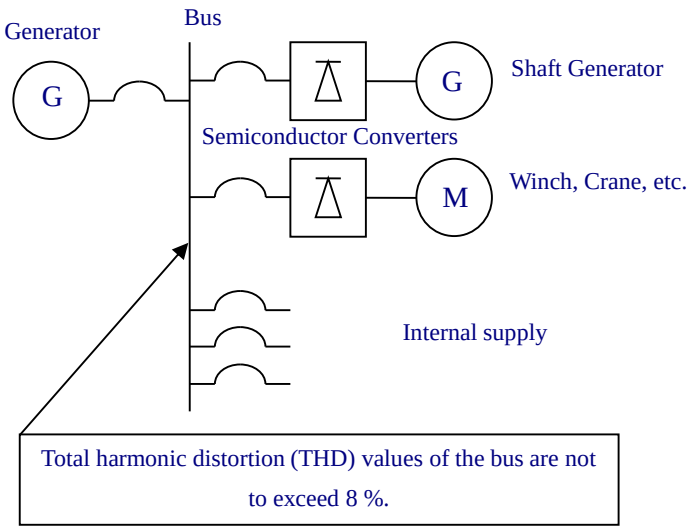
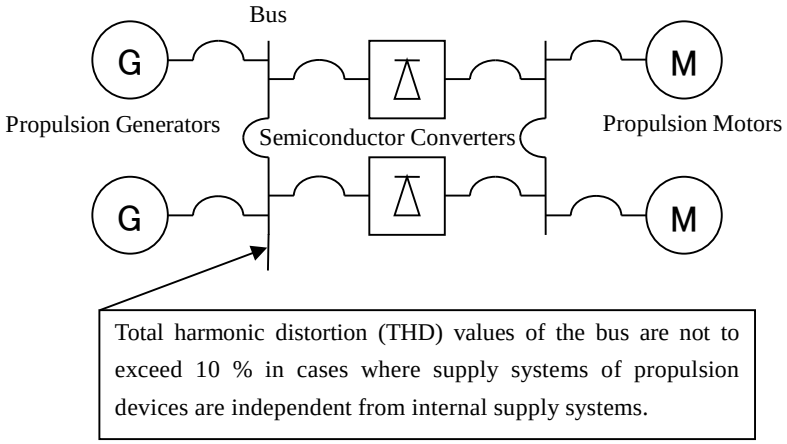


Fig. H2.1.2-2 Application Example of H2.1.2-3(2)



H2.1.3 Construction, Materials, Installations, etc.

1 Electrical equipment is to be constructed so as to allow accessibility to all parts requiring inspection, overhauling and repairs.

2 Rotating, reciprocating, high temperature parts and live parts of electrical equipment are to be arranged with suitable protections, so that operators or other personnel working in the vicinity of such parts are kept free from injury.

3 Power source switches of electrical equipment are to be arranged so that such equipment is not charged through control circuits and/or pilot lamps when such switches are in their "off" positions.

4 The protective enclosures of electrical equipment are to comply with the following requirements:

(1) Degree and marking of the protection of such enclosures

The degree of protection of such enclosures is to be as given in **Table H2.1.3-1**. Protection types are to be expressed by the combination of the following letters and numerals.

(a) Code letters "IP"

(b) The first characteristic numeral shows the degree of protection against any access to hazardous parts and any ingress of solid foreign objects.

(c) The second characteristic numeral shows the degree of protection against any ingress of water with harmful effects.

(d) An additional letter (optional) shows the degree of protection against any access to hazardous parts.

(e) A supplementary letter (optional) shows any supplementary information.

(2) Construction and test methods of degree of protection

Construction and testing methods of degrees of protection are to be as given in **Table H2.1.3-2**, **Table H2.1.3-3**, **Table H2.1.3-4** and **Table H2.1.3-5**. Manufacturers are to carry out tests for the first product and confirm the availability of degree of protection shown on equipment. Surveyors may require tests for such products when deemed necessary.

(3) Application of electrical equipment

The requirements given in **Table H2.1.3-6** are to be taken into consideration for the applications of electrical equipment with regard to their degree of protection.

5 Electrical installations recognized as suitable for installation in acetylene stores are to be certified as being of the safe type explosion-protected electrical equipment specified in **2.16.2(1)** to **(4), Part H of the Rules** as well as being of Gas and Vapour Group *II*C, Temperature Class *T*2 or higher. In addition, cables associated with such equipment are considered to be part of the equipment.

Table H2.1.3-1 Degrees of Protection and Markings

Code letters	First characteristic numeral	Second characteristic numeral	Additional letter (optional)	Supplementary letter (optional)
	Against any access to hazardous parts and any ingress of solid foreign objects	Against any ingress of water with harmful effects	Against any access to hazardous parts	Supplementary information
IP	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7 8	A B C D	H M S W

Note:

In cases where it is not necessary to indicate either the first characteristic numeral or the second characteristic numeral, the degree of protection may be represented by the letter *X*.

Examples:

IP*X*8 Degree of protection only against the ingress of water with harmful effects

IP5*X* Degree of protection only against the access to hazardous parts and ingress of solid foreign objects

Table H2.1.3-2 Degree of Protections against Access to Hazardous Parts and Ingress of Solid Foreign Objects Shown by the First Characteristic Numeral

First characteristic numeral	Construction of protection	Testing methods and criteria
0	Non protected	-
1	Protected against access to hazardous parts with the back of a hand and protected against solid foreign objects of 50 *mm* ϕ and greater	The sphere of 50 (+0.05, -0) *mm* is not to fully penetrate with 50 *N* ± 10 % of test force and adequate clearance form hazardous parts is to be kept.
2	Protected against access to hazardous parts with a finger and protected against solid foreign objects of 12.5 *mm* ϕ and greater	The jointed test finger of 12 *mm* , 80 *mm* length, may penetrate up to its 80 *mm* length with test force of 10 *N* ± 10 %, but adequate clearance from hazardous parts is to be kept. In addition, the sphere of 12.5 (+0.05, -0) *mm* ϕ is not to fully penetrate with 30 *N* ± 10 % of test force.
3	Protected against access to hazardous parts with a tool and protected against solid foreign objects of 2.5 *mm* ϕ and greater	The test rod of 2.5 (+0.05, -0) *mm* is not to penetrate with 3 *N* ± 10 % of test force and adequate clearance form hazardous parts is to be kept.
4	Protected against access to hazardous parts with a wire and protected against solid foreign objects of 1.0 *mm* ϕ and greater	The test rod of 1.0 (+0.05, -0) *mm* is not to penetrate with 1 *N* ± 10 % of test force and adequate clearance form hazardous parts is to be kept.
5	Protected against access to hazardous parts with a wire and dust-protected	(1) Testing methods and criteria against the first characteristic numeral 4 are to be complied with. (2) The enclosure where the normal working cycle of the equipment causes reductions in air pressure within the enclosure below that of the surrounding air, *e.g.*, due to thermal cycling effects (hereinafter referred to as *Category* 1 enclosure) is to comply with the following **(a)** and **(b)**. At the end of the test, talcum powder is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety. (a) The test is to be made using a dust chamber. The powder circulation pump circulates and floats the talcum powder continuously in the test chamber. The talcum powder used is to be capable of passing through a square-meshed sieve the nominal wire diameter of which is 50 μm and the nominal width between wires 75 μm. The amount of talcum powder is to be 2 kg/m^2 of the test chamber. It is not to be used for more than 20 tests. The enclosure under test is to be supported inside the chamber by fixing or hanging. The pressure inside the enclosure is to be maintained below the surrounding atmospheric by a vacuum pump. The depression of the pressure is not to exceed 2 *kPa*. (b) If an extraction rate of 40 to 60 *vol./hour* is obtained the duration of the test is to be 2 *hours*. If, with a maximum depression of 2 *kPa*, the extraction rate is less than 40 *vol./hour*, the test is to be continued until 80 *vol.* have been drawn through, or a period of 8 *hours* has elapsed. (3) Enclosures where no pressure difference relative to the surrounding air is present (hereinafter referred to as *Category* 2 enclosures) is to comply with the above **(2)** tests in condition that the enclosure under the test is supported in its normal operating position, but is not connected to a vacuum pump. The test is to be continued for a period of 8 *hours*. At the end of the test, talcum powder is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
6	Protected against access to hazardous parts with a wire and dust-tight	(1) Testing methods and criteria against the first characteristic numeral 4 are to be complied with. (2) The above **(2)** tests against the first characteristic numeral 5 is to be carried out and deposit of dust is not to be observed inside the enclosure at the end of the test.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table H2.1.3-3 Degree of Protection against Ingress of Water with Harmful Effects

Second characteristic numeral	Construction of protection	Testing methods and criteria
0	Non-protected	-
1	Protected against vertically falling water drops	The enclosure under test is to be placed in its normal operating position and 200 *mm* below the drip box. A flow of water drops of which flow rate is 1 (+0.5, -0) *mm*/*min*. are to be produced for 10 *min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
2	Protected against vertically falling water drops when enclosure tilted up to 15°	The enclosure under test is to be placed in its normal operating position and 200 *mm* below the drip box. A flow of water drops of which flow rate is 3 (+0.5, -0) *mm*/*min*. are to be produced for 2.5 *min*. in each of four fixed positions. These positions are to be 15° on either side of the vertical. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
3	Protected against spraying water	The enclosure under test is to be placed in its normal operating position. A uniform flow of water drops are to be produced over the whole area between vertical and 60° on either side of the vertical at the distance of 300 *mm* to 500 *mm* from the enclosure. The delivery rate of water flow is to be 10 (+0.5, -0.5) *l*/*min*. The pressure to achieve this delivery rate is to be the range of 50 *kPa* to 150 *kPa*. The test duration is to be 1 *min*./m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum of 5 *min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
4	Protected against splashing water	The enclosure under test is to be placed in its normal operating position. A uniform flow of water drops are to be produced over the whole area between vertical and 180° on either side of the vertical at the distance of 300 *mm* to 500 *mm* from the enclosure. The delivery rate of water flow is 10 (+0.5, -0.5) *l*/*min*. The pressure to achieve this delivery rate is to be the range of 50 *kPa* to 150 *kPa*. The test duration is to be 1 *min*./m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum of 5 *min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
5	Protected against water jet	The enclosure under test is to be placed in its normal operating position. A stream of water from a standard nozzle of which internal diameter is 6.3 *mm* is to be sprayed to the enclosure from all directions. The distance between the nozzle and the enclosure is to be 2.5 *m*. The delivery rate is (12.5 *l* ± 0.5 %) /*min*. Core of the substantial stream is to be a circle of approximately 40 *mm* diameter at 2.5 *m* distance from nozzle. Test duration per square metre of enclosure surface area likely to be sprayed is to be 1 *min*. Minimum test duration is to be 3 *min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
6	Protected against powerful jet	The enclosure under test is to be placed in its normal operating position. A stream of water from a standard nozzle of which internal diameter is 12.5 *mm* is to be sprayed to the enclosure from all directions. The distance between the nozzle and the enclosure is to be 2.5 *m* to 3 *m*. The delivery rate is to be (100 *l* ± 0.5 %) /*min*. Core of the substantial stream is to be a circle of approximately 120 *mm* diameter at 2.5 *m* distance from nozzle. Test duration per square metre of enclosure surface area likely to be sprayed is to be 1 *min*. Minimum test duration is to be 3 *min*. At the end of the test, no water is to be entered into the enclosure.
7	Protected against the effects of temporary immersion in water	The highest point of enclosures is to be located deeper than 150 *mm* below the surface of water, and also the lowest point of the enclosure is to be located deeper than 1,000 *mm* below the surface of water. The duration of the test is to be 30 *min*. The water temperature is not to differ from that of the equipment by more than 5 °C. However, it may be waived where the equipment is energized and/or its parts in motion. At the end of the test, no water is to be entered into the enclosure.
8	Protected against the effects of continuous immersion in water	The test conditions are to be subject to agreement between manufacturer and user, but they are to be more severe than the conditions for the second characteristic numeral 7 and they are to take account of the condition that the enclosure will be continuously immersed in actual use. At the end of the test, no water is to be entered into the enclosure.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table H2.1.3-4 Degree of Protection against Access to Hazardous Parts Shown by the Additional Letters

Additional letter	Construction of enclosure	Test methods and criteria
A	Protected against access with the back of the hand	The access probe, sphere of 50 *mm* , is to have adequate clearance form hazardous parts with 50 *N* ± 10 % of test force.
B	Protected against access with a finger	The jointed test finger of 12 *mm* , 80 *mm* length, is to have adequate clearance form hazardous parts with 10 *N* ± 10 % of test force.
C	Protected against access with a tool	The access probe of 2.5 *mm* , 100 *mm* length, is to have adequate clearance form hazardous parts with 3 *N* ± 10 % of test force.
D	Protected against access with a wire	The access probe of 1.0 *mm* , 100 *mm* length, is to have adequate clearance form hazardous parts with 1 *N* ± 10 % of test force.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table H2.1.3-5 Supplementary Information Shown by the Supplementary Letters

Supplementary letter	Significance
H	High-voltage apparatus
M	Tested for harmful effects due to the ingress of water when the movable parts of the equipment, *e.g.* the rotor of the rotating machine, are in motion
S	Tested for harmful effects due to the ingress of water when the movable parts of the equipment, *e.g.* the rotor of the rotating machine, are stationary
W	Suitable for use under specified weather conditions and provided with additional protective features or processes

Table H2.1.3-6 Application of Degree of Protection

Degree of protection	Conditions in area of installation	Examples of areas of installation
Explosion-protected electrical equipment	Danger of explosion	Dangerous areas for oil tankers, ammonia plant rooms, battery rooms, lamp rooms, paint lockers, store rooms of welding gas bottles, holds regarded as dangerous areas as well as pipe tunnels for oils with flash point of 60 °C or below (Note **1**)
IP20	Danger of touching live parts	Accommodation spaces, control rooms and monitoring rooms in dry conditions
IP22	Danger of dripping liquid and/or moderate mechanical damage	Navigation bridges, above the floors of machinery spaces and boiler rooms, steering gear rooms, refrigerating machine rooms (excluding ammonia plants), emergency machinery rooms, provision stores as well as general stores/lockers (Note **2**)
IP34	Danger of spraying liquid and/or increased mechanical damage	Bath rooms and shower rooms, below the floors of machinery spaces and boiler rooms, enclosed F.O. purifier rooms as well as enclosed L.O. purifier rooms (Note **3**)
IP44		Ballast pump rooms, refrigerating rooms, galleys, laundries as well as the entire range of coverage of sprinkler water of areas protected by the fixed local application fire-fighting systems specified in **10.5.5-3, Part R of the Rules** (Note **4**)
IP55	Danger of spurting liquid and/or serious mechanical damage Presence of cargo dust and/or aggressive fumes	Shaft tunnels or pipe tunnels in double bottoms, general cargo holds, and open decks (Note **5**)
IP56	Danger of liquids in massive quantities	Open decks hit by rough seas (Note **6**)
IPX8	In water	Bilge wells

Notes:

1 Receptacles are not to be installed in those areas listed in this column.

2 (a) In the case of wiring accessories (switches, receptacles, junction boxes, etc., hereinafter referred to the same) installed in those areas listed in this column excluding navigation bridges, provision stores and general stores/lockers, the degree of protection is to be IP44.

(b) In the case of electrical equipment installed on navigation bridges, which are located in a way to preclude any dripping liquids emanating from ventilation ducts or in the vicinity of the windows, or not located in the vicinity of any wing doors being exposed to sea water or rain, the degree of protection may be IP20.

3 (a) In the case of wiring accessories installed in those areas listed in this column, the degree of protection is to be IP55.

(b) In the case of switchboards, control devices, motors, controlgears for motors, heating appliances installed in those areas listed in this column, the degree of protection is to be IP44.

(c) Receptacles are not to be installed below the floors of machinery spaces and boiler rooms, enclosed F.O. purifier rooms and enclosed L.O. purifier rooms unless a lid is attached to such receptacles which is located in a way to preclude splashing water, fuel oil, or lubricating oil from the equipment.

4 (a) In the case of lighting fittings installed in ballast pump rooms, refrigeration rooms, galleys, laundries, the degree of protection may be IP34.

(b) The wording “areas exposed to sprinkler water” means areas where electrical equipment is affected by water sprays or water mists produced by fixed local application fire-fighting systems. Especially in the case of water spray type systems, such areas are defined as those between the positions of nozzles and the nearest deck or similar constructions located directly beneath such nozzles as well as the insides of those cones of which vertexes are nozzles, completely including those protected areas.

(c) Electrical equipment which is located in those areas which are affected by water mist produced by fixed local application fire-fighting systems may be in accordance with the requirements given in **R10.5.5-9(3)**.

5 In the case of wiring accessories installed in the shaft tunnels of double bottoms or pipe tunnels, the degree of protection is to be IP56.

6 In the case of lighting fittings installed on open decks exposed to rough seas, the degree of protection may be IP55.

H2.1.4 Earthing

1 The following exposed metal parts may not be earthed:

(1) Non-current-carrying metal parts of electrical equipment which are unlikely to be touched by people during times when such equipment is being used.

(2) Lamp caps

(3) Shades, reflectors and guards, supported on lampholders or luminaires constructed of, or shrouded in, non-conducting materials.

(4) Metal parts or screws separated by insulators from current-carrying parts or from earthed non-current-carrying parts which are not charged or earthed under normal service conditions.

(5) Bearing housing insulated to prevent any circulation of currents in bearings.

(6) Clips of fluorescent lighting tubes

(7) Equipment power supplied at safety voltages

(8) Cable clips

2 Earthing may be made under the requirements specified below:

(1) All earthing connections are to be made through copper or other corrosion resistant materials and are to be securely installed to hull structures. All earthing conductors are to be protected in cases where necessary against any mechanical damage and galvanic corrosion.

(2) In cases where metal frames or enclosures of electrical equipment are directly fitted to hull structures, and those surfaces in contact are clean and free from any rust, scale and paint as well as bolted firmly, no earthing conductors may be provided.

(3) Nominal cross-sectional areas of all copper earthing conductors are to be as given in **Table H2.1.4-1**. In cases where earthing conductors other than copper are used, their conductance is to be of more than that of those copper conductors given in this

table.

(4) Connections between earthing conductors and hull structures are to be made in accessible positions, and to be secured by screws made of brass or some other corrosion-resistant-materials that have a diameter not less than 4 *mm* and which are to be used for this purpose only. In any case, contact faces are to have glossy metal surfaces when these screws are tightened.

3 In power distribution systems, in cases where one line of the system is earthed and normally a non-current carrying line, earthing connections are to be as specified in **-2** above. However, the upper limit value of 64 mm^2 of those cross-sectional areas of earthing conductors given in **Table H2.1.4-1** does not apply.

4 Non-current-carrying metal parts of portable electrical appliances are to be earthed through plugs and receptacles by mean of earthing conductors provided in flexible cables or cords.

Table H2.1.4-1 Sizes of Earthing Conductors

Types of earthing conductors	Cross-sectional areas of current-carrying conductors	Minimum cross-sectional areas of copper earthing conductors
Earthing conductors in flexible cables or flexible cords	Up to and including 16 mm^2	100% cross-sectional area of current-carrying conductors
	Exceeding 16 mm^2	50% cross-sectional area of current-carrying conductors (at least 16 mm^2)
Insulated earthing conductors incorporated in fixed cables	Up to and including 16 mm^2	100% cross-sectional area of current-carrying conductors (at least 1.5 mm^2)
	Exceeding 16 mm^2	50% cross-sectional area of current-carrying conductors (at least 16 mm^2)
Separate earthing conductors	Up to and including 3 mm^2	100% cross-sectional area of current-carrying conductors (at least 1.5 mm^2 for stranded earthing connections or 3 mm^2 for unstranded earthing connections)
	Exceeding 3 mm^2 Up to and including 125 mm^2	50% cross-sectional area of current-carrying conductors (at least 3 mm^2)
	Exceeding 125 mm^2	64 mm^2

H2.2 System Design - General

H2.2.1 Distribution Systems

The following items are relevant to that equipment specified in **2.2.1-2(2), Part H of the Rules**.

(1) Electrical equipment for the starting and ignition of internal combustion engines

(2) Radio equipment provided with noise suppressing condensers

(3) Equipment of intrinsic safety constructions requiring earthing

H2.2.2 Insulation Monitoring Systems

1 The term “distribution system” generally means the following circuits:

(1) Primary distribution circuits directly connected to generator circuits

(2) Secondary distribution circuits connected via insulated transformers with those primary distribution circuits specified in **(1)** above. However, unless otherwise specified, secondary circuits exclusively for specifically designated equipment (*e.g.* Suez Canal search lights, heaters and lighting circuits provided in cranes, etc.) may be excluded.

(3) Lighting circuits supplied from accumulator batteries or busbars of feeder panels to which such circuits are connected.

2 Alarm set values of insulation monitoring systems are to have insulation resistance values, as a standard, corresponding to 1/10 of that of the electric circuit in normal condition for which monitoring is to be made.

3 In cases where insulation monitoring systems are used in common with earthing lamp, they are to be interlocked against each other.

H2.2.7 Lighting Circuits

For lighting circuits which satisfy the following conditions, the wording “not exceed 80 % of the ratings of protective devices”

in **2.2.7-2, Part H of the Rules** can be interpreted to mean "not exceed the ratings of protective devices".

(1) Such circuits are not used in accommodation areas

(2) Electrical apparatus with unspecified load currents (such as receptacles, etc.) are not connected.

(3) The ratings or appropriate settings of protection devices are decided based upon maximum load currents of connected lighting points

H2.2.8 Circuits for Internal Communication Systems and Navigational Aids

1 Essential internal communication systems, signal systems and navigational aids are to include the following items:

(1) Navigation lights and signalling lights required under the provisions of International Conventions.

(2) Internal communication systems as specified below:

(a) Those means of communication between navigation bridges and control stations of those main engines specified in **1.3.7(1), Part D of the Rules**

(b) The engineers' alarms specified in **1.3.8, Part D of the Rules**

(c) Those means of communication between navigation bridges and those steering compartments specified in **15.2.9, Part D of the Rules**

(d) Those means of vocal communication specified in **4.3.2 of the Rules for Automatic and Remote Control Systems**

(e) Those public address systems or other adequate means of communication specified in **3.6.4, Part H of the Rules**

(f) Those emergency communication system specified in **3.6.5, Part H of the Rules**

(3) The following internal signal systems:

(a) Emergency alarm systems specified in **3.6.4, Part H of the Rules**

(b) Fire alarm systems required by **Part R of the Rules**

(c) Alarm systems annunciating the discharged of fire extinguishing agents from those fixed gas fire-extinguishing systems specified in **25.2.1-3(2), Part R of the Rules**

(4) Steering gear control systems and rudder angle indicators

(5) Navigational aids required by International Conventions

(6) Other internal communication, signalling systems and navigational aids as deemed necessary by the Society

2 Irrespective of the requirements of **2.2.8-1, Part H of the Rules**, in cases where public address systems are used as general emergency alarms and fire alarms, the following requirements are to be satisfied in addition to any relevant requirements given in Chapter III, the Annex to *SOLAS* Convention.

(1) Such systems are to be arranged so as to automatically override any other input systems. In addition, any volume controls provided to give required outputs whenever general emergency alarms are required.

(2) Such systems are to be arranged so as to prevent any feedback or other interference.

(3) In order to minimize the effects of a single failure, such systems are to have:

(a) Two sets of segregated amplifiers;

(b) Segregated cable routes to public rooms, alleyways, stairways and control stations; and

(c) Electrical protection for individual loudspeakers against short circuits.

H2.2.11 Circuits for Shore Connections

In cases where portable phase sequence indicators or polarity detectors are provided on board ship, those detectors in shore connection boxes may be omitted.

H2.2.12 Disconnecting Switches of Circuits

In cases where those switches specified in **2.2.12-2, Part H of the Rules** are provided on board ship in dispersed manner, their wiring connection diagrams are to be displayed in monitoring rooms or other adequate spaces.

H2.2.13 Remote Stopping of Ventilating Fans and Pumps

"Consideration against the fuse element failure" specified in **2.2.13-2, Part H** of the Rules is satisfied if no volt alarms, electrical source indicators, or the like are provided at normally attended positions. In the case of **M0** ships, visual indicators of those alarm at normally attended positions may be displayed as group alarms in cases where such alarms are included in centralized monitoring and control systems and are individually indicated at centralized control stations (normally unattended).

H2.3 System Design - Protection

H2.3.3 Protection against Short-circuits

1 In cases where the determination of the cascade breaking capacities of breakers necessary for employing for short-circuit protection is intended in accordance with **2.3.3-3, Part H of the Rules**, test methods and criteria are to be as specified below:

(1) Test methods

Back-up circuit breakers or fuses are to be connected in series with circuit breakers on load sides, and short-circuit tests under an operating duty of 1 time "*O* - 2 *minutes** - *CO*" for those circuit breaker on load sides are to be carried out.

Note: In cases where thermal trip reset times and fuse replacement times exceed 2 *minutes*, those times asterisked are the ones deemed appropriate by the Society.

(2) Criteria after tests

Circuit breakers on load sides are to satisfy the following requirements:

(a) No short-circuit is to be caused if back-up circuit breakers are reclosed with power supplies connected, and no voltages are to be applied on terminals of circuit breakers on load sides.

(b) Circuit breakers can be safely and easily replaced with spares.

(c) No damage is to be caused on cases proper and covers.

(d) Making and breaking of circuits are to be possible.

(e) High voltage tests are to be carried out at voltages twice rated voltages, and to prove that it resists such voltages.

(f) Insulation resistances are to be 0.5 *MΩ* or more.

2 In calculating short-circuit currents, the contribution of generators which are interlocked and are not to connected simultaneously to the bus may not be included in such short-circuit currents. (For example, in cases where 4 of 6 generators are connected simultaneously to a bus, the contribution of those 4 generators is to be included in short-circuit currents.) In the case of generators which are connected to a bus simultaneously only when switching such as harbour use generators, the contribution of such generators are to be included in short-circuit currents.

H2.3.5 Protection of Generators

1 Adjusting values of trip currents for the overcurrent tripping devices with time delays of generators are to be selected in such a manner that such generators can be protected safely from any overcurrents according to the thermal capacities of the generators and the tripping characteristics of the overcurrent tripping devices with time delays. Furthermore, in selecting the type and adjusting values for those overcurrent tripping devices with long time delays and short time delays of short-circuit protection, consideration is to be given as to their coordination.

2 In cases where preference tripping devices are provided in the generator circuits of two or more generators operating in parallel, adjusting values and time delay characteristics are to be as selected so that any overcurrent tripping devices of generators would not come into simultaneous action with any preference tripping devices when the latter activates. Furthermore, in cases where these devices are expected to operate by rush current motors for essential service, interlock devices may be arranged so that these devices do not operate under the starting conditions of motors.

3 Adjusting values of reverse power protection for the following are to be as specified as standard:

(1) Generators driven by turbines: 2 – 6 %

(2) Generators driven by reciprocating internal combustion engines: 6 – 15 %

H2.3.6 Load Shedding

1 The wording "unessential loads" specified in **2.3.6-1, Part H of the Rules** means those loads other than the electrical services specified in **H3.2.1-2**.

2 The wording "any conditions otherwise specified by the Society" in **2.3.6-2, Part H of the Rules** means the following conditions:

(1) Feeder circuits to those services for propulsion and steering are not to be included in preference tripping or any other equivalent arrangements.

(2) Feeder circuits to those services for maintaining ship safety except for the following may be included in preference tripping or other equivalent arrangements.

(a) Lighting systems

(b) Navigation lights, aids and signals

(c) Internal safety communication equipment

(d) Bilge pumps, ballast pumps, fire pumps and Ventilating fans for engines except in cases where those services can immediately be available when power supplies are restored to normal operating conditions after preferential tripping.

H2.3.7 Protection of Feeder Circuits

In applying **2.3.7-2, Part H of the Rules**, in cases where fuses are used as short-circuit and overload protection devices of circuits which are supplied power at voltages not exceeding 50 *V d.c.* or 50 *V a.c.* root mean square between conductors, switches on the power source sides of these fuses may be dispensed with.

H2.4 Rotating Machines

H2.4.3 Limits of Temperature Rise

1 Temperature rise of bearings

(1) Temperature rise of bearings are not exceed 35 *K* in cases where temperatures are measured on surfaces, 40 *K* in cases where temperatures are measured by temperature elements embedded in metal, or 50 *K* in cases where temperatures are measured on surfaces using heat resisting lubricants; for example, lithium soap based greases.

(2) In cases where heat resisting insulation of Thermal class F or higher is used in rotating machines and it is difficult to apply those requirements specified in **(1)** above, documents relating to the heat resistance of bearings and lubricants are to be submitted to the Society for approval.

2 In the case of rotating machines with forced cooling air coolers, temperatures of windings are to be measured by embedded temperature detectors or resistance methods.

H2.4.4 Modification of Limits of Temperature Rise

In dealing with the wording "in those cases where deemed appropriate by the Society" referred to in **2.4.4-2, Part H of the Rules**, limits of temperature rise may be modified as follows:

(1) In cases where forced cooling is provided and temperatures of cooling water at inlets of air coolers are not higher than 32 °C, limits of temperature rise may be set 13 *K* higher than those limits specified in **Table H2.3, Part H of the Rules**.

(2) In cases where forced cooling is provided and temperatures of cooling water at inlets of air coolers are higher than 32 °C, limits of temperature rise may be determined by the Society in each case.

H2.4.5 Overload and Overcurrent Capability

In excess torque tests for special types of motors, overload scaling may be determined as follows unless otherwise specified:

Single-phase motors: 133 % of rated torque for 15 *seconds*

Motors for deck machinery: 150 % of rated torque for 15 *seconds*

H2.4.6 Short-circuit Scaling

The wording "to be capable of withstanding the mechanical and thermal effects" referred to in **2.4.6-1, Part H of the Rules** means as follows:

(1) In the event of short-circuit at rated operating conditions, *a.c.* generators are to keep their mechanical strength, and their conductors and insulating materials are not to be burned for a period of at least 1 *second*.

(2) In the event of short-circuit at rated operating conditions, *d.c.* generators are to keep their mechanical strength and electrical functions after separation of fault circuits.

H2.4.11 Shafts of Rotating Machine

1 In cases where the method of weld flanges on shafts of generators is adopted in order to form shaft couplings for the first time, plans for welding procedure qualification tests including test items on fatigue strength and the data covering the working process standards are to be submitted in advance for Society approval.

2 In cases where welding ribs or other similar things on shafts of generators are provided, the following are to be submitted in advance for Society approval:

(1) Calculation sheets on standard design stresses and strength on ribs or other torque members intended to be welded onto shafts.

(2) Details of welding quality control systems and working process standards.

(3) Test records, including any results of macro-section, micro-section and hardness surveys on welded parts of any specimens welded in accordance with those working process standards referred to in **(2)** above.

3 In cases where spiders or other main torque members of welded structures are provided, those requirements specified in **-2** above are to be applied.

4 Welding on the shafts of motors are to comply with the following:

(1) In cases where motors are rated as 100 *kW* or more and are to drive auxiliary machinery intended for essential services, those requirements specified in **-1** and **-2** above are to be applied.

(2) In cases where motors are rated up to 100 *kW* then

(a) those requirements specified in **(1)** above are to be applied in cases where weld flanges on shafts are provided.

(b) working process standards for welding are to be submitted to the Society in cases where welding ribs or other similar things on the shafts are provided.

H2.4.15 Shop Tests

1 The wording "generator or motor which is produced in series having identical type with their unit" referred to in **2.4.15, Part H of the Rules** means those generators or motors which are of the same capacity, voltage, current, rotational speed, principal dimensions, cooling method, insulation thermal class and manufactured according to the same process at the same plant. The wording "small capacity" means up to 100 *kW* of continuous rating capacity.

2 Procedures, etc. for omitting temperature rise tests, overcurrent or excess torque tests, and steady short-circuit tests (hereinafter referred to as "temperature rise tests, etc."), are to comply with the following:

(1) Scope

Rotating machines to which **2.4.15, Part H of the Rules** applies and for which temperature rise tests, etc. for the same type of rotating machines are applied are to be recognized as being acceptable products when it manufactured at "plants approved by the Society in accordance with **1.2.1-3, Part H of the Rules**" or "plants being capable of manufacturing products requested approval under stable operation according to quality control standards in view of the results of survey previously carried out by the Society".

(2) Application

Application form (**APP-TR-OMM-H**) is to be submitted in duplicate for each manufacturing plant to the Society branch office in charge of the required testing. The branch office is to examine the application and, in those cases where deemed appropriate, stamp one of copies of the submitted application with its seal of acceptance (i.e. the branch office stamp) and then return the stamped copy to the applicant.

(3) Representative machine tests

Prior to accepting the omission of temperature rise tests, etc., for products for which the application referred to in **(2)** above is submitted, all specified tests are to be carried out for a representative machine in the presence of the Surveyors, and a corresponding representative machine tests report is to be prepared. In addition to the standard measurement items, representative machine test reports are to contain those items related to the temperature rise and the definition of the same type specified in **-1** above.

(4) Representative machine test reports

The Surveyors are to examine the test reports specified in **(3)** above and, in those cases where deemed appropriate, sign them and require the quality control manager of the manufacturing plant to keep them together with the copy of the application specified in **(2)** above. In cases where the margin between the actual measured temperature rise value of the representative machine and the specified standard measured value is small, it is to be confirmed that there is no possibility of any of the subsequently produced units exceeding the specified value due to machine differences. For cases where the same or a similar model was approved in the past, confirmation may be made by examining prior test reports; however, for cases where a model is being produced for the first time, confirmation is to be made by carrying out temperature rise tests, etc. on additional units.

(5) Individual machine tests

The consent of the party ordering the machines is to be obtained by manufacturer in cases where the omission of temperature rise tests, etc. is permitted for each subsequent unit produced of a machine for which representative machine tests are passed. In addition, the quality control manager is to make a checklist for each unit so that it is possible to easily confirm that the unit is of the same type as the representative machine. (However, checklist need not be provided when it is clear that the same type

is used; for example, in the case of main generators for the same ship in which all required tests are carried out for a single generator, and temperature rise tests, etc. are omitted for the other generators.)

(6) Individual machine test reports

The temperature rise test results for a representative machine are to be entered into the corresponding column of the individual machine test report, and the wording "*TYPE TESTED*" is to also be entered or stamped next to results.

(7) Checklists

Appropriate checklists (**CL-RM-H**) are to be prepared by the manufacturer to allow easy confirmation of an individual machine being of the same type as a representative machine during the individual testing of a product after discussion among relevant parties according to the type of the product to be tested. In addition, values for entries with checklist in the "Identical" column only are required to be the same as that of the representative machine, whereas the values for entries with checklist in both the "Identical" and "Almost identical" column may be equal to or less than those of the representative machine.

3 The wording "separately specified procedures" referred to in **2.4.15(5), Part H of the Rules** means as follows:

(1) Synchronous machines

(a) Zero power-factor tests

Zero power-factor tests, tests with almost zero power-factor currents on rotating machines operated as generators or motors without loads at rated voltages and frequencies, can be applied to synchronous phase advancers without modification. In cases where such tests are applied to synchronous generators or motors and the *kVA* is not adequate for rated outputs due to low intensities of field currents, such field currents are to be high enough and test results are to be modified in accordance with the following:

i) The temperature rise of armature winding t_O and armature core t_{CO} are measured through another temperature test at rated voltage without loads (on armature open circuit).

ii) Other symbols used in **iii)** are as follows:

t' : temperature rises of windings during zero power-factor tests at voltage V' and current I'

t'_C : temperature rises of cores during zero power-factor tests at voltage V' and current I'

t'_f : temperature rises of field windings during zero power-factor tests at field current I'_f

iii) Temperature rises at rated states are calculated using the following equations in cases where V, I and I_f represent rated voltage, current and field current respectively.

Armature windings:

$$T = t_O + (t' - t_O) \times \left(\frac{I}{I'}\right)^2$$

Armature cores:

$$T_C = t_{CO} + (t'_C - t_{CO}) \times \left(\frac{I}{I'}\right)^2$$

Field windings:

$$T_f = t'_f \times \left(\frac{I_f}{I'_f}\right)^2$$

(Testing voltage V' is to be as close to the rated voltage as practicable but be at least higher than 90% of it)

(b) Presumption method of temperature rises

i) In the case of temperature rises of the armature cores of rotating machines operated at rated outputs, temperature rises of the armature cores of rotating machines operated without loads at voltages which are 110 % of their rated voltages are substituted. In the case of temperature rises of the armature windings of rotating machines operated at rated outputs, temperature rises of the armature windings of rotating machines operated at voltages which are 125 % of their rated current with all terminals shorted are substituted.

ii) In the case of temperature rises of the armature cores/windings of rotating machines operated at rated outputs, the sum of the temperature rises of armature cores/windings of rotating machines operated at rated voltages without loads and operated at rated currents with all terminals shorted are substituted.

iii) In the case of temperature rises of armature cores/windings of rotating machines operated at rated outputs, temperature rises of armature cores/windings of rotating machines which are operated at rated rotational speeds and carrying *d.c.*

or single phase circulating currents, equivalent to their rated currents, on circularly connected armature windings with openings to make terminal voltages, by excitation, be equivalent to their rated voltages are substituted. Field currents are modified by zero power-factor tests.

(2) Induction machines

(a) Primary side superposed load method

Induction machines connected as shown in **Fig. H2.4.15-1** are operated without loads and voltages and frequencies of low voltages superposed on those voltages impressed by main sources of electric power are adjusted. Generally, primary currents are equalized to total load currents (current based method) but for induction machines of special squirrel-cage, two poles and high outputs, inputs are equalized to the loss at rated loads calculated by the circle diagram method (loss based method).

(b) Secondary side superposed load method

Induction machines connected as shown in **Fig. H2.4.15-2** are operated without loads and voltages and frequencies of those low voltages superposed on secondary sides are adjusted to make primary sides carry almost total load currents.

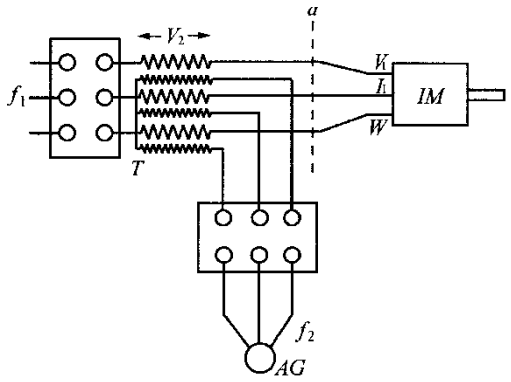
4 Temperature tests on duty type rating three-phase induction motors may be in accordance with "Methods for determining temperature rises of three-phase induction motors at periodic duty rating" (Standard of The Japan Electrical Manufacturers' Association; *JEM* 1385).

5 In those commutation tests specified in **2.4.15(11), Part H of the Rules**, any sparks arising between commutator segments and brushes in *D.C.* machines are categorized into eight types as shown in **Fig. H2.4.15-3**, and categories 5 through 8 are deemed to be harmful.

6 Notwithstanding **-5** above, sparks which cause any scorching or damage to the commutator surfaces or which wear out or break up brushes during temperature tests and overload tests are deemed to be harmful.

7 Through operation at rated or lower outputs, sparks are recommended to be of categories 1 or 2.

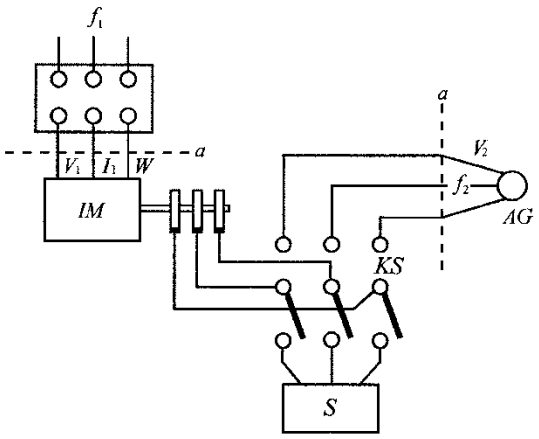
Fig. H2.4.15-1Test Circuits of Primary Side Superposed Load Methods



IM : rotating machine to be tested
T : D.C. transformer inserted in series
a : connecting points of a voltmeter, ammeter and wattmeter
AG : generator for an auxiliary source of electrical power
V_1 : terminal voltage (rated voltage)
f_1 : frequency of the source of electrical power (rated frequency)
I_1 : primary current to the induction machine
V_2 : superposed voltage
f_2 : superposed frequency
W : input

(note) 1. Auxiliary and main source of the electrical powers are to have the same phase sequence direction.
2. Superposed voltage V_2 is to be low enough comparing to V_1; to be as low as the impedance voltage of the rotating machine to be tested.

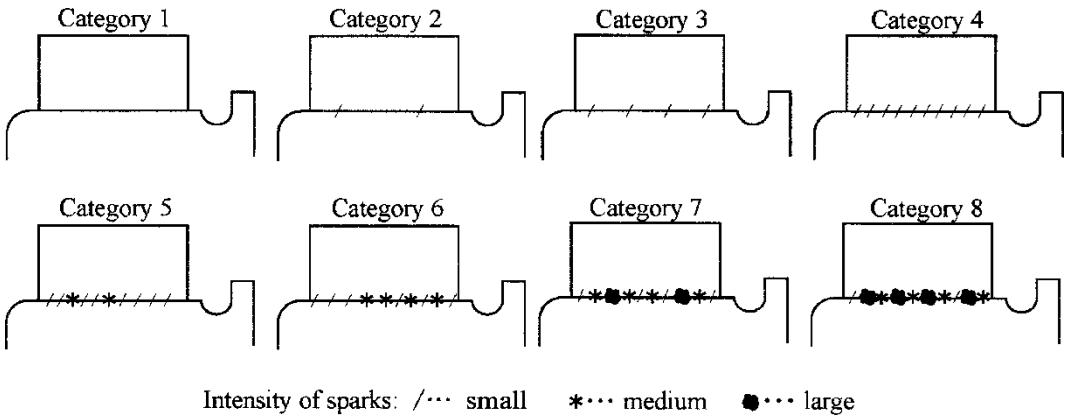
Fig. H2.4.15-2Test Circuits of Secondary Side Superposed Load Methods



IM : rotating machine to be tested
a : connecting points of a voltmeter, ammeter and wattmeter
AG : generator for an auxiliary source of electrical power
V_1 : terminal voltage (rated voltage)
f_1 : frequency of the source of electrical power (rated frequency)
I_1 : primary current to the induction machine
V_2 : superposed voltage
f_2 : superposed frequency
W : input
S : starting resister
KS : switch

(note) 1. Phase rotation of auxiliary source of electrical power shall be chosen so that the rotative direction of a rotor is to be the same in case of operation by auxiliary and main source of electrical power.
2. Superposing frequency f_2 is to be lower than a half of f_1 and is recommended to be as low as practicable.

Fig. H2.4.15-3Category of Sparks



H2.5 Switchboards, Section Boards and Distribution Boards

H2.5.1 Location

In cases where the laying of steam pipes, water pipes, oil pipes, etc. in the proximity of switchboards is unavoidable, the flanges of such pipes are to be of welded joints or means are to be provided so that no detrimental effects are exerted on switchboards if any leakage occurs.

H2.5.2 Precautions for Operator Safety

The width of the space provided in front of switchboards as specified in **2.5.2-5, Part H of the Rules** is to be a standard of 0.9 *m* or more. Furthermore, in cases where switchboards are constructed so that necessary operation and maintenance can be performed at their front, passageways at the rear of such switchboards may be omitted.

H2.5.3 Construction and Materials

1 The following may be regarded as the "other approved means" specified in **2.5.3-2(2), Part H of the Rules**:

(1) Circuit breakers without tripping elements

(2) Disconnecting switches (including sliding type disconnecting devices)

2 In applying **2.5.3-6, Part H of the Rules**, flame-retardant tests for insulating materials are to be carried out in accordance with the following:

(1) Such tests are to be carried out at normal ambient temperatures. The standard size of test specimens is to be 120 *mm* long, 10 *mm* wide and 3 *mm* thick.

(2) Test specimens are to be fastened to thin metal wires so that their longitudinal axes are inclined to an angle of approximately 45 *degrees* to the horizontal and their transverse axes are horizontal.

(3) Conventional Bunsen burners fed with town gas are to be used, the flames of which, when adjusted in still air and in vertical positions, are approximately 125 *mm* long with the blue part of these flames being about 35 *mm* long.

(4) Burner axes are to be set vertically in such positions that the tips of the blue parts of these flames just touches the lower ends of any specimens.

(5) Flames are to be applied five times for 15 *second* intervals for 15 *seconds* between each application, and materials are deemed to be flame-retardant if any burnt or damaged parts of specimens are not more than 60 *mm* long. During such tests, specimens are not to be allowed to burn themselves.

H2.5.4 Busbars

1 Busbars, contact faces of busbars and linking conductors are to be protected against any corrosion or oxidization by means of silver plating, tin plating or dippling in solder baths, etc.

2 Current ratings of busbars may generally be determined by **Table H2.5.4-1**.

3 The wording "in cases where deemed appropriate by the Society" in **2.5.4-4, Part H of the Rules** refers to cases where documents which show that there are no adverse effects on any of the following **(1)** to **(5)** are submitted to and approved by the Society in cases where the temperature rises of any busbars, connecting conductors and their connections that are carrying full-load currents exceed 45 *K* at an ambient temperature of 45 °C.

(1) Mechanical strength of the conducting material

(2) Possible effect on adjacent equipment

(3) Permissible temperature limits of the insulating materials in contact with the conductor

(4) Effect of the temperature of the conductor on the apparatus connected to busbars

(5) For plug-in contacts, the nature and surface treatment of the contact material

Table H2.5.4-1 Current Rating of Busbars

<table>
<tr><th colspan="3">Type</th><th>Current rating</th></tr>
<tr><td>For generators</td><td colspan="2">In cases where only one generator is feeding power to the busbars.</td><td>100 % or more of the rated current of the generator.</td></tr>
<tr><td rowspan="2">For generators</td><td rowspan="2">In cases where two or more generators are feeding power at their full capacities to the busbars.</td><td>Subdivided busbar arrangement (distribution systems consisting of multiple busbars)</td><td>For each busbar (including spare circuits),
((100 % of the large capacity rated currents (e.g. bow thrusters, etc.)) + (75 % of the sum of the rated currents of the rest of the feeding circuits)) or more</td></tr>
<tr><td>Single busbar arrangement (distribution system consisting of a single busbar)</td><td>((100 % of the rated current of one generator of the largest capacity) + (80 % of the sum of the rated currents of generators)) or more</td></tr>
<tr><td rowspan="2">For power feeding</td><td colspan="2">In the case of general power feeding circuits.</td><td>75 % or more of the sum of the rated currents of the feeding circuits (including spare circuits). However, there is no need of exceeding the capacity of the generator busbars.</td></tr>
<tr><td colspan="2">In cases where feeding circuits have only one load circuit, or where power is fed to groups of motors under continuous service.</td><td>The total load current or more.</td></tr>
</table>

H2.5.8 Instrument Scales

"Instrument scales" means the effective measuring range. When an extended scale is required for the starting current as in the case of ammeters for motors, it is not necessary to apply the requirements given in **2.5.8, Part H of the Rules** to the extended part.

H2.5.10 Shop Tests

1 The wording "switchboard which is produced in series having the identical type with its first unit" referred to in **2.5.10, Part H of the Rules** means those switchboards which are manufactured according to the same process at the same plant and which comply with the following requirements:

(1) The outer dimensions, internal volume and ventilation method of generator panels (including synchronization panels) are almost the same.

(2) The types and ratings of circuit breakers and switches for generators are the same, and the dimensions, layout and structure of busbars and connecting conductors are almost the same.

(3) The load currents of busbars and connecting conductors are almost the same or less.

(4) The layout of the mounting devices in the board that generate heat (e.g. transformers, relays, fuses, and resistors) is almost the same, and the total power consumption is almost the same or less.

(5) The structure and arrangement of the terminals are almost the same except for the control circuits, instrument circuits, etc.

2 The procedures for omitting the temperature rise tests specified in **2.5.10, Part H of the Rules** are the same as those specified for rotating machines in **H2.4.15-2(1) to (7)**; however, the term "rotating machines" is to be read as "switchboards". In addition, the checklist given in **H2.4.15-2(7)** is to be checklist (**CL-SB-H**) prepared by the manufacturer.

3 The wording "auxiliary apparatus" referred to in **2.5.10(3), Part H of the Rules** means the indicator lights, small transformers, relays, etc. which are connected between different poles or phases.

4 In the requirements given in **2.5.10(3), Part H of the Rules**, instruments and auxiliary apparatuses can be removed for high voltage tests of switchboards. However, it is necessary to carry out a high voltage test on individual instrument and auxiliary apparatus, and to comply with the requirements given in **2.5.10(3), Part H of the Rules**.

5 Except where otherwise specified, the requirements given in **2.5.10(3), Part H of the Rules** need not be applied to electronic equipment or apparatuses incorporated into switchboards that are not directly connected to the main circuit of the switchboard and the main power distribution circuits on board the ship.

H2.8 Controlgears for Motors and Magnetic Brakes

H2.8.1 Controlgears for Motors

The wording "their equivalent" in **2.8.1-5, Part H of the Rules** means those methods in which each pole fuse of the main circuit can be easily removed and stored by the person in charge is permitted.

H2.8.4 Shop Tests

1 The wording "each controlgear and magnetic brakes which is produced in series having identical type with its first unit" in **2.8.4, Part H of the Rules** means those controlgears and magnetic brakes which are manufactured according to the same process at the same plant and which comply with the following:

(1) Outer dimensions, internal volume and ventilation method of containers such as boards and boxes are to be almost the same.

(2) The types and ratings of circuit breakers, switches, and electromagnetic contactors of the main circuit are to be the same, and the dimensions, layout, connections, and terminal structures of the main circuit conductors are to be almost the same.

(3) The load current of the main circuit is to be almost the same or less.

(4) The layout of the mounting devices in the board that generate heat such as transformers, relays, fuses, and resistors are to be almost the same, and the total power consumption is to be almost the same or less.

2 The procedure for omitting the temperature rise tests, etc. specified in **2.8.4, Part H of the Rules** is the same as that specified for rotating machines in **H2.4.15-2(1)** to **(7)**; however, the term "rotating machines" is to be read as "controlgears for motors". In addition, the checklist given in **H2.4.15-2(7)** is to be checklist (**CL-ST-H**) prepared by the manufacturer.

3 High voltage tests are to be in accordance with **H2.5.10-3** to **-5** as far as practicable.

H2.9 Cables

H2.9.3 Choice of Protective Coverings

1 The term "metallic sheath" represents stainless steel and copper sheaths. In cases where the use of ordinary steel or light metal alloy sheaths is intended, adequate protection against corrosion is to be provided.

2 The term "hygroscopic insulation" specified in **2.9.3(2), Part H of the Rules** means mineral insulation.

H2.9.6 Voltage Drop

1 Voltage drop calculations are to be carried out by using the following formulae as standards:

(1) In the case of *d.c.* circuits

$$\textit{Voltage drop}\ (\%) = \frac{R_{20} \times K \times 2L \times I \times 100}{V}$$

(2) In the case of *a.c.* circuits

Single phase *a.c.* circuits $\quad \textit{Voltage drop}\ (\%) = \left(\frac{R_{20} \times K \times 2L \times I \times 100}{V}\right) \times \delta$

Three phase *a.c.* circuits $\quad \textit{Voltage drop}\ (\%) = \left(\frac{R_{20} \times K \times 2L \times I \times 100}{V}\right) \times \frac{1.73}{2} \times \delta$

L : length of cable for single passage (m)

I : maximum load current (A)

V : circuit voltage (V)

R_{20} : *d.c.* resistance at 20 °C (Ω/m)

K : temperature factor at the maximum allowable temperature of conductor

70 °C : 1.20

75 °C : 1.22

90 °C : 1.28

95 °C : 1.30

δ : factor of voltage drop (*See* **Table H2.9.6-1**)

2 In the circuits of electric motors, voltage drop is to be calculated by taking into account the starting currents of those electric motors with the largest capacity. Furthermore, in the circuits of generators, approximately 115 % of rated currents are to be regarded as maximum loads, so it is recommended that voltage drops are to be controlled to 1 % or less as far as practicable. Also, voltage drop in the circuits of accumulator batteries, shore connections, etc. is to be controlled to 2 % or less as far as practicable.

Table H2.9.6-1 Factor (δ) of *a.c.* Voltage Drops in Rubber Insulated Cables

Nominal sectional area of conductor (mm^2)	Power factor (%)							Inductance (mH/km)
	100	95	90	85	80	75	70	
1.5	1.00	0.95	0.90	0.85	0.81	0.76	0.71	0.370
2.5	1.00	0.95	0.91	0.86	0.81	0.76	0.71	0.341
4	1.00	0.96	0.91	0.86	0.81	0.76	0.71	0.317
6	1.00	0.96	0.91	0.86	0.82	0.77	0.72	0.299
10	1.00	0.96	0.92	0.87	0.83	0.78	0.73	0.279
16	1.00	0.97	0.93	0.89	0.84	0.79	0.75	0.263
25	1.00	0.98	0.95	0.90	0.86	0.82	0.77	0.259
35	1.00	0.99	0.96	0.92	0.88	0.84	0.80	0.250
50	1.00	1.01	0.98	0.95	0.91	0.87	0.83	0.248
70	1.00	1.03	1.02	0.99	0.96	0.93	0.89	0.240
95	1.00	1.07	1.06	1.04	1.02	0.99	0.96	0.240
120	1.01	1.10	1.11	1.10	1.08	1.06	1.03	0.235
150	1.01	1.13	1.15	1.15	1.14	1.12	1.10	0.235
185	1.02	1.18	1.21	1.23	1.23	1.22	1.20	0.234
240	1.04	1.26	1.32	1.35	1.36	1.37	1.36	0.230
300	1.05	1.35	1.43	1.48	1.51	1.53	1.53	0.229

H2.9.11 Precaution against Fire

1 In cases where the installation work of cables in enclosed spaces or semi-enclosed spaces of ships meet either of the following requirements, such work may be regarded as complying with the requirements given in **2.9.11-1, Part H of the Rules**. However, item **(2)(c)** below is to be approved by the Society in accordance with the requirements given in **Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**. Furthermore, in cases where the use of cables is limited to specific applications, approval by the Society may be given on a case by case basis.

(1) In cases where one cable is installed independently, the following requirements are to be complied with:

(a) The distance between cables is to be of 5 *times* or more that of the diameter of the larger cable; and,

(b) The distance between one cable and bunched cables is to be 5 *times* the diameter of the largest. (the minimum distance is to be equal to or greater than the width of the bunched cables); or,

(c) Adequate fire stops are to be provided between the independently installed cables and the other cables.

(2) In cases where bunched cables are installed, the following requirements are to be complied with:

(a) In cases where flame retardant cables in a bunched condition which have passed the test of Category *A*, *IEC* 60332-3-22:2018 are to be used.

(b) In cases where cables other than those specified in **(a)** above are used, the following means are to be taken:

i) Fire stops as required for cable penetration through ***B*** class divisions or better are to be provided at every two decks or every 6 *m* or less for vertical cable runs and for horizontal cable runs at every 14 *m* or less. In cases where partition plates are used as fire stops instead of bulkheads, decks or ceilings, such plates are to be steel plates with 3 *mm* thickness or more, and their dimensions, for cables installed vertically, are to be twice or more the width of any bunched cables and for those cables installed horizontally, their dimensions are to be the same or greater than the width of any bunched cables. Furthermore, in cases where cable ways are provided in close proximity to bulkheads, decks or ceilings with distances smaller than the required dimensions of the partition plates, the dimensions of those partition plates facing hull structures may be limited to the distance between them and such hull structures.

ii) In cases where cables are installed in enclosed type cable trunks, ducts or conduits, cable inlets and outlets are to be sealed by fire stops corresponding to those required for cable penetrations through ***A*** class or ***B*** class divisions or better.

iii) Those fire stops specified in **i)** above are to be taken also at those locations specified below:

1) Main and emergency switchboard cable inlets/outlets
2) Centralized control console cable inlets/outlets of main propulsion plants and essential auxiliary machinery
3) Engine control room cable inlets/outlets

iv) In cargo spaces, excluding those specified in **4.8, Part H of the Rules**, those fire stops specified in **i)** above are to be taken at cable penetrations such as bulkheads, decks, notwithstanding those locations specified in **i)** above.

(c) In cases where the effectiveness of any alternative means for preventing flame propagation are considered to be equivalent to or better than the effectiveness of any of those specified in **(b)** above, such methods may be used. However, in cases where fire protective coatings are applied to vertical cable runs, such coatings are to be applied to the entire length of such vertical runs.

2 In cases where those installation works specified in **-1** above are taken to prevent the spreading of fire, such works are not to cause any deterioration of cables. If insulation materials or paints are used, they are to have heat-resistant properties equal or greater than those of the cables.

3 The "cables for power, lighting, internal communications, signals and navigational aids of essential and emergency services" specified in **2.9.11-2, Part H of the Rules** are generally those used for the equipment specified in the following **(1)** to **(5)**:

(1) Motors of auxiliary machinery used for steering gears and main propulsion;
(2) All the lighting systems on board ship;
(3) Internal communications, signals and navigational aids specified in **H2.2.8-1**;
(4) Emergency sources of electrical power, lighting, internal communications, signals and navigational aids required by **3.3.2-2, Part H of the Rules**; and
(5) Other equipment as deemed necessary by the Society.

4 The wording "fires in adjacent spaces" in **2.9.11-2, Part H of the Rules** generally means those fires from which temperature-time curves are obtainable in those standard fire tests defined in Paragraph 47, Regulation 3, Chapter II-2, the Annex to the *SOLAS* Convention.

H2.9.12 Cables in Hazardous Areas

1 Hazardous areas generally mean the following areas:

(1) Hazardous areas specified in **4.2.3, Part H** and **1.1.5(23), Part N**
(2) Cargo holds specified in **4.8, Part H of the Rules**
(3) Cargo holds specified in **4.9, Part H of the Rules**
(4) Hazardous areas specified in **19.3, Part R of the Rules**
(5) Battery rooms, paint lockers and flammable gas bottle rooms such as acetylene gas bottle storage rooms

2 Protections for cables to be installed in those hazardous areas specified in **-1** above are to comply with the following requirements:

(1) Cables to be installed in hazardous areas specified in **-1(1)** above may be regarded to have the protection specified in **2.9.12, Part H of the Rules** if the relevant requirements given in **4.2, Part H of the Rules** are complied with.
(2) Cables to be installed in cargo holds, etc. specified in **-1(2)** and **(3)** above may be respectively regarded to have the protection specified in **2.9.12, Part H of the Rules** if the relevant requirements given in **4.8** and **4.9, Part H of the Rules** are complied with.
(3) Cables to be installed in the hazardous areas specified in **-1(4)** above may be regarded to have the protection specified in **2.9.12, Part H of the Rules** if the relevant requirements given in **Chapter 19, Part R of the Rules** are complied with.
(4) Protection for cables to be installed in each compartment specified in **-1(5)** above are to comply with the following requirements:
    (a) Cables are, as a rule, to be metal armoured ones.
    (b) Protection for preventing any mechanical damage to cables is to be provided as necessary.

H2.9.13 Earthing of Metallic Coverings

Earthing of metallic coverings of cables may comply with the requirements as specified below:

(1) Cable sheaths and armour may be earthed with earthing glands designed so as to allow effective earthing. Glands are to be installed in such a manner that they are securely fixed to earthed metal structures with good electrical contacts.
(2) Conduits may be earthed by being screwed into metal enclosures, or by nuts on both sides of the walls of such metallic

enclosures, provided any surfaces in contact are clean and free from rust, scale or paint and that such enclosures are securely earthed. Connections are to be painted immediately after assembly in order to inhibit corrosion.

(3) Cable sheaths, armour and conduits may be earthed by means of clamps or clips of corrosion resistant materials making effective contact with sheaths or armour and earth metals in lieu of those procedures specified in **(1)** and **(2)** above.

(4) All contacts of metal conduits, ducts and metal sheaths of cables used for earth continuity are to be soundly made and, in cases where necessary, are to be protected against corrosion.

H2.9.14 Supports and Fixing of Cables

1 "Cable supports" is a general term for casings (pipes, ducts, etc.), trays, hangers and so on.

2 The wording "to be made of flame-retardant material" in **2.9.14-3(3)(a), Part H of the Rules** means those clips which have passed flame-retardant tests in accordance with the standard *UL*94 (categories V-0, V-1, V-2) or the equivalent thereto.

3 The wording "arranged so as to prevent any cables from becoming slack" in **2.9.14-3(3)(b), Part H of the Rules** means reinforcement by metallic cable clips arranged at intervals of 1 to 2 *m* in consideration the outside diameter of the cable.

4 The wording "any tests otherwise specified by the Society" referred to in **2.9.14-3(4)(a), Part H of the Rules** are those tests specified in **3.4.2, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

5 The wording "those tests" referred to in **2.9.14-3(4)(f), Part H of the Rules** are those safe working load tests specified in **3.4.2(3), Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

H2.9.15 Penetration of Bulkheads and Decks

1 In verifying the watertightness and gas-tightness at cable penetrations, the construction and characteristics of materials of the cables are to be considered.

2 Cable penetrations through ***A*** class bulkheads or decks are to be approved by the Society in accordance with the requirements given in **Chapter 1, Part 4 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

3 Compounds used in cable penetrations through ***B*** class bulkheads or decks are to be non-combustible compounds approved by the Society. In cases where compounds are used to fill sealing boxes or coamings, the length of the filled part is to be at least 50 *mm* or more.

4 Those compounds approved to be used at cable penetrations through ***A*** class bulkheads or decks under the requirements specified in **-2** above may be regarded as non-combustible compound meetings the requirements given in **-3** above.

5 Cable penetrations which are required to be watertight may be verified, for example, in accordance any of the following **(1)** to **(3)**.

(1) Confirmation as to whether watertightness is assured by a construction method in accordance with standards such as *JIS*.

(2) The watertightness tests specified in item 10(1), **Table B2.7, Part B of the Rules.**

(3) Approval in accordance with **Chapter 1, Part 4 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

6 Penetrations which are approved as fire protection materials, watertight penetrations, or gas-tight penetrations in accordance with the Rules and Regulations of the Society are to be installed and maintained in accordance with the requirements of the relevant type approval certification.

H2.9.18 Cables in Refrigerated Spaces

1 In cases where non-metal sheaths are used for cables installed in refrigerated spaces, materials which are not aged at the lowest temperatures such refrigerated spaces are to be selected and cables are to be installed in such a manner that they are not subjected to any mechanical damage.

2 *PVC* sheathed cables to be installed in refrigerated spaces below -10 °C are to pass low temperature tests which use a testing temperature of the lowest temperatures of such refrigerated spaces plus an additional -5 °C. In cases where numbers in the ones-columns of such testing temperatures are greater than 0 but less than or equal to 5, such numbers are to be rounded up to 5. In cases where numbers in the ones-columns of such testing temperatures are greater but less than or equal to 10, such numbers are to be rounded up to 10.

3 Polychloroprene rubber sheathed cables or chlorosulphonated polyethylene sheathed cables to be installed in refrigerated spaces below -30 °C are to pass those low temperature tests which apply to *PVC* sheated cables.

H2.9.20 Terminals, Joints and Branches of Cables

1 The wording "in cases where deemed appropriate by the Society" in **2.9.20-1, Part H of the Rules** refers to cases where a

cable connection is installed by splicing which consists of a conductor connector, replacement insulation, replacement cable sheath, and, where applicable, replacement armour and shielding, and establishes electrical continuity in conductors, armour, or screens, under the following conditions:

(1) In cases where cables are installed in structural sub-assemblies

(2) In cases where circuits are extended or shortened in a ship which will undergo remodeling

(3) In cases where a damaged section of cables is replaced

(4) Splicing is not to be used for propulsion cables and cables in hazardous locations. However, with respect to cables in hazardous locations, cases where Society approval is obtained are excluded

(5) Other cases deemed appropriate by the Society

2 In **-1** above, splicing is to comply with the following **(1)** to **(7)**:

(1) The conductors are to be connected using a compression type butt connector. In such cases, a one-cycle compression tool and proper dies are to be used. Long barrel butt connectors with conductor stops are to be used for conductor sizes of 6 mm^2 or larger.

(2) The splices for multi conductor cables are to be staggered in such a way that the connectors for each conductor are not contiguous to the connector of an adjacent conductor. In addition, no more than is necessary to ensure a proper connection of the cable insulation is to be removed.

(3) Replacement insulation that has the same or a greater thickness than that of the cable insulation and the same or better thermal and electrical properties of the cables.

(4) For screened cables, replacement screenings are to be provided and such screenings are to be secured by a method that does not exert more pressure than necessary to establish adequate electrical contact. Screened cables are to have at least a 13 *mm* overlap between any replacement shielding material and the original screening material.

(5) Replacement cable sheath materials are to have physical properties that are the same as, or equivalent to, the cable sheath. Replacement cable sheaths are to be centered over the splices and to overlap the existing cable sheaths by at least 51 *mm*. Replacement cable sheaths are to be installed so that a watertight seal with the existing cable sheaths is created.

(6) The electrical continuity of any cable armour is to be re-established by a jumper of wire or braid, or replacement armour of the same metal.

(7) For cables with a sheath over the armour, a replacement covering is to be used.

3 The wording "to retain the original electrical, mechanical, flame-retardant and, in cases where necessary, fire-resisting properties of the cable" in **2.9.20-5, Part H of the Rules** means that connections and branching of cables are to be made within enclosures with no possibility of any outward spreading of fire by internal short-circuits or other causes. In addition, the type of enclosure is to be selected from those meeting the requirement given in **H2.1.3-4** according to installation location.

H2.10 Transformers for Power and Lighting

H2.10.4 Modification of the Limits of Temperature Rise

The wording "in those cases where deemed appropriate by the Society" in **2.10.4-2, Part H of the Rules** means that limits of temperature rise may be modified as follows:

(1) In cases where forced cooling is provided and the temperatures of cooling water at the inlets of air coolers are not higher than 32 °C, limits of temperature rise may be set 13 *K* higher than those limits specified in **Table H2.17, Part H of the Rules**.

(2) In cases where forced cooling is provided and the temperatures of cooling water at the inlets of coolers are higher than 32 °C, limits of temperature rise may be determined by the Society on a case by case basis.

H2.10.6 Shop Tests

1 The wording "transformers which are produced in a series of identical types" referred to in **2.10.6, Part H of the Rules** means those transformers which are the same in terms of rated capacity, voltage, current, dimension, method for cooling and thermal class, and which are produced at the same factory by the same production method.

2 The procedures for omitting the temperature rise tests specified in **2.10.6, Part H of the Rules** are the same as those specified for rotating machines in **H2.4.15-2(1)** to **(7)**; however, the term "rotating machines" is to be read as "transformers". In addition, the checklist given in **H2.4.15-2(7)** is to be checklist (**CL-TF-H**) prepared by the manufacturer.

3 Calculations for voltage regulation specified in **2.10.6(2), Part H of the Rules** may be performed using the following method.

$$\text{Voltage regulation } (\%) = q_r + \frac{{q_x}^2}{200}$$

q_r : voltage drop (%) caused by register

Single-phase: $q_r = \frac{P_{75}}{EI} \times 100$ or $q_r = \frac{P_{115}}{EI} \times 100$

Three-phase: $q_r = \frac{P_{75}}{\sqrt{3}EI} \times 100$ or $q_r = \frac{P_{115}}{\sqrt{3}EI} \times 100$

q_x : voltage drop (%) caused by reactance

$$q_x = \frac{E_x}{E} \times 100$$

P_t : load loss (W) to rated capacity at t °C

P_{75} : load loss (W) to rated capacity converted to 75 °C

P_{115} : load loss (W) to rated capacity at 115 °C

E_z : Impedance voltage (V), namely, the voltage at primary terminals when measuring P_t

E_x : Reactance voltage (V)

Single-phase: $E_x = \sqrt{{E_z}^2 - (\frac{P_t}{I})^2}$

Three-phase: $E_x = \sqrt{{E_z}^2 - (\frac{P_t}{\sqrt{3}I})^2}$

E : Rated primary voltage (V)

I : Rated primary current (A)

In the above equation, P_{75} applies to insulating materials of thermal classes A, E and B of insulating materials, while P_{115} applies to insulating materials of thermal classes F and H.

H2.11 Accumulator Batteries

H2.11.1 General

1 Accumulator batteries of adequate discharge rates are to be selected according to their application.

2 In cases where alkali batteries are installed, specifications including construction, performance, method of installation, etc. are to be submitted for Society approval at each time of installation.

H2.11.3 Location

1 Accumulator batteries are not to be located in high temperature or low temperature areas, or any areas exposed to steam, water or oil vapours.

2 The term "large batteries" in **2.11.3-2, Part H of the Rules** means those accumulator batteries connected to battery charging facilities with outputs of 2 kW or more. Outputs of such battery charging facilities are to be the product of the rated currents of semiconductor converters and the nominal voltage of battery groups. Deck boxes may be naturally ventilated. Natural ventilation by means of ducts of ample dimensions, terminating at least 1.25 m above in goose-necks, mushroom-heads or their equivalent will be sufficient. Holes for air inlets are to be provided on at least two opposite sides of these boxes.

3 Accumulator batteries connected to battery charging facilities with capacities in the range of 0.2 to 2 kW are to be placed in battery boxes installed within battery compartments or on the upper deck or upward. In cases where such batteries are unable to be installed in such areas, the following requirements are to be complied with:

(1) Batteries are to be placed in storage boxes or on shelves provided at adequate areas;

(2) Batteries are to be placed in open states within machinery spaces; or,

(3) Batteries are to be placed in compartments with good air ventilation.

4 Accumulator batteries connected to battery charging facilities with capacities of 0.2 kW or less may be placed in open states at adequate areas or may be placed in battery boxes.

H2.11.5 Ventilation

1 In cases where accumulator batteries are arranged in two tiers or more, all shelves are to have not less than 50 mm in space, front and back, for the circulation of air.

2 It is recommended that ventilation systems for those compartments containing accumulator batteries connected to battery

charging facilities with outputs of 2 *kW* or more be mechanical exhaust-ventilation types.

3 The ventilation fans which are "to be constructed and to be made of such materials so as to render any sparking impossible in the event of impellers touching fan casings" specified in **2.11.5-3, part H of the Rules** mean those ventilation fans complying with the requirements given in **R4.5.4-1(2)**. For the purpose of this requirement, protection screens of not more than 13 *mm* square mesh are to be fitted in the inlet and outlet ventilation openings of the ducts fitted with such fans on the open deck.

H2.11.6 Electrical Equipment

Explosion-protected electrical equipment certified as Explosion Class *d*3 and Ignition Group *G*1 or higher as specified in the Recommended Practices for Explosion-Protected Electrical Installations in General Industries (NIIS-TR-NO.39 (2006)) issued by National Institute of Industrial Safety in Japan, may be treated as equivalent to those grouped into Apparatus Group *II*C and Temperature Class *T*1 or higher as specified in *IEC* 60079.

H2.12 Semiconductor Converters for Power

H2.12.1 General

The wording "standards are to be deemed appropriate by the Society" given in **2.12.1-2, Part H of the Rules** means the current versions of *IEC* 60146 and *IEC* 61800.

H2.12.4 Shop Tests

1 Regarding the temperature rise tests for semiconductor element connections mentioned in **2.12.4(1), Part H of the Rules**, temperature rise measurements for individual element parts such as cooling fins, cases and coolant parts, etc. may be accepted. However, such temperature rise tests may be carried out on the aforementioned element parts only in cases where manufacturers specify in advance that the temperature rise of semiconductor element connections will not exceed their maximum allowable temperature if the temperature rise of their parts is within allowable limits.

2 With respect to **2.12.4(2), Part H of the Rules**, tests which may inadvertently inflict serious damage on the protective devices of semiconductor elements may be omitted in cases where the proper operation of semiconductor element protective fuses, etc. can be confirmed.

3 With respect to **2.12.4(3), Part H of the Rules**, test voltages for high voltage tests may be in accordance with **Table H2.12.4-1.** The test voltage is to be applied for one minute; however, one second may be allowed for products produced in a series of identical types from the second unit onward.

Table H2.12.4-1 Test voltages for high voltage tests

Rated *a.c.* voltage (*V*)	Test voltage	
	a.c. r.m.s (*V*)	*d.c* (*V*)
≤ 50	1,250	1,770
100	1,300	1,840
150	1,350	1,910
300	1,500	2,120
600	1,800	2,550
1,000	2,200	3,110
> 1,000	3,000	4,250
3,600	10,000	14,150
7,200	20,000	28,300
12,000	28,000	39,600
17,500	38,000	53,700

Note:

1. Interpolation is permitted.

H2.15 Heating and Cooking Equipment

H2.15.1 Construction

1 Protection guards of heating elements are to be of robust construction and be so fitted that they cannot be brought into contact with any current-carrying parts of such electric heating equipment. Openings of such protection guards are to be small enough not to allow standard test fingers to come in contact with heating elements.

2 Live parts of cooking appliances are to be protected so that the cooking utensils cannot be brought into contact with them.

3 Heating elements dipped in liquids for service are to be protected with corrosion resistant metal sheaths.

4 In cases where heating elements are used in baths, they are to be arranged so as not to cause any electric shocks while taking bath. Furthermore, their operating switches are to be of the multi-pole linked type and also indicator lamps and warning signs are to be provided.

5 Portable cooking heaters are to be of such shape or so weighted that they cannot be easily overturned.

H2.16 Explosion-protected Electrical Equipment

H2.16.1 General

1 The wording "the standard deemed appropriate by the Society" in **2.16.1, Part H of the Rules** means *IEC* 60079 (the latest edition).

2 Explosion-protected electrical equipment listed below may be treated as equivalent to those complying with *IEC* 60079.

(1) Explosion-protected electrical equipment complying with the following latest standards for marine use:
  (a) *JIS* F 8009: Shipbuilding - General requirements for electrical apparatus for explosive gas atmospheres
  (b) *JIS* F 8422: Shipbuilding - Flameproof ceiling lights

(2) Explosion-protected electrical equipment complying with the following latest standards for industrial use:
  (a) *JIS* C 60079-0: Electrical apparatus for explosive gas atmospheres - Part 0: General requirements
  (b) *JI*S C 60079-1: Electrical apparatus for explosive gas atmospheres - Part 1: Flameproof enclosures "d"
  (c) *JIS* C 60079-2: Electrical apparatus for explosive gas atmospheres - Part 2: Pressurized enclosures "p"
  (d) *JIS C* 60079-6: Electrical apparatus for explosive gas atmospheres - Part 6: Oil-immersed apparatus
  (e) *JIS* C 60079-7: Electrical apparatus for explosive gas atmospheres - Part 7: Increased safety "e"
  (f) *JIS C* 60079-11: Electrical apparatus for explosive gas atmospheres - Part 11: Intrinsically safety "i"

(3) Explosion-protected electrical equipment complying with the "Recommended Practices for Explosion-Protected Electrical Installations in General Industries (JNIOSH-TR-NO.43 (2018))" issued by National Institute of Occupational Safety and Health in Japan.

(4) Explosion-protected electrical equipment certified to comply with the "Recommended Practices for Explosion-Protected Electrical Installations in General Industries (NIIS-TR-NO.39 (2006))" issued by National Institute of Industrial Safety in Japan. However, the use of such equipment may be restricted because those explosive gases or vapours for which the equipment is designed, could not be completely consistent with those of equipment complying with *IEC* 60079.

H2.16.3 Materials

The wording "materials which minimize the risk of sparks by friction" in **2.16.3-2, Part H of the Rules** means those materials that sparking caused by the friction or impact of steels do not prompt any ignition explosion of those explosive gases or vapours for which such equipment is designed, and whose non-sparking characteristics have been confirmed in accordance with *JIS M* 7002: Non-ignition testing methods for non-sparking beryllium copper alloy tools.

H2.16.4 Construction

The wording "any other items deemed necessary by the Society" in **2.16.4-5, Part H of the Rules** means the following:

(1) Pressurized protected type electrical equipment
  (a) Inside volume of such equipment
  (b) Pressure and volume of the protection air or gases at the intake sides of such equipment
  (c) Pressure of the protection air or gases at outlet sides of such equipment (for ventilated types only)
  (d) Allowable maximum pressure of the protection air or gases for equipment cases

(2) Intrinsically safe type electrical equipment (except single equipment such as detectors)
  (a) Ratings of intrinsically safe circuits
  (b) Ratings of non-intrinsically safe circuits
  (c) Limitations of usage
  (d) Cautions for apparatuses having non-intrinsically safe circuits which are not to be installed in hazardous areas and not to be modified and remodeled onto wirings and components in the case of combined installations
  (e) Circuit diagrams including positions of connection terminals for intrinsically safe circuits and non-intrinsically safe circuits in combined installations
(3) Types of lighting bulbs and their wattages for lighting fittings

H2.16.5 Special Requirements

The wording "any requirements otherwise specified by the Society" in **2.16.5, Part H of the Rules** means the following:

(1) Flameproof type electrical equipment
  (a) In cases where flameproof lighting fittings are fitted by penetrating through bulkheads, they are to be installed so as not to impair the integrity of the bulkheads.
  (b) In cases where drain discharging devices are provided to enclosures of flameproof constructions, they are to be constructed so as not to impair any flameproof characteristics even when such devices are in their open position.
  (c) In cases where waterproof packing is provided to flameproof constructions, it is to be constructed so as not to impair any flameproof joints, such as the length of flame paths and gaps etc., caused by water intrusion.
  (d) In cases where cables are connected to terminal boxes by the cable pipe connecting method, sealing fittings are to be provided near such terminal boxes.
(2) Increased safety type electrical equipment
  (a) Enclosures of increased safety lighting fittings are to be of robust construction made of non-hygroscopic flame-retardant or incombustible materials; and, they are also to be of watertight construction or the equivalent thereto.
  (b) In cases where increased safety type motors or transformers are used, efficient protection for overloads and overheating is to be provided. Especially in the case of squirrel cage induction motors, additional protection is to be provided so as not to use it over an allowable amount of restraint time and abnormal temperature rise do not occur under restraint conditions of such rotors.
  (c) In cases where there are limitations of usage in order to maintain explosion protecting performance, Society approval for such usage is necessary.
(3) Intrinsically safe type electrical equipment
  (a) Intrinsically safe electrical equipment is to be installed independently against general electrical equipment. In cases where the combined installation with general equipment is necessary, earthed metallic partitions are to be provided between such equipment.
  (b) Wires for intrinsically safe circuits are to be measured in order so that they can be easily distinguished from those of other circuits. And, such wires are also to be separated by a distance of 50 *mm* or more from those for other circuits and to be shielded electrically, if necessary.
  (c) Connection terminals for intrinsically safe circuits and non-intrinsically safe circuits in combined installations are to comply with either of the following:
    i) Connection terminals for both circuits are to be installed individually in circuit boards separated by a distance of 50 *mm* from each other.
    ii) Earthed metallic partitions having efficient mechanical strength and insulation are to be provided between the connection terminals of both circuits.
  (d) Even if electrical faults occur in general circuits other than intrinsically safe circuits, the functions of safety barriers are to keep operating.
  (e) Safety barriers are to be located in non-hazardous areas.
  (f) Safety barriers are to be structured by at least two of the same components unless one component specified below is used. In cases where one of the components has broken, explosion protecting performance is to be maintained.
    i) Power Transformers

The insulation between first and second field windings is to be ensured by earthed partitions made of copper. And, field windings are to have efficient insulation performance.

ii) Current Limitation Resistors

The surfaces of such resistors are to be covered by synthetic resins or resistors are to be embedded in formed resins.

iii) Blocking Condensers

Condensers are to be structured by two solid dielectric type capacitors connected with each other in a series and which have high reliability. Electrolytic capacitors including tantalum types are not to be used.

(4) Pressurized protected type electrical equipment

(a) In cases where air is used as the pressurized medium, air inlets are to be located in safe spaces.

(b) In cases where air or inert gas is used as the pressurized medium, interlock devices are to be provided to ensure the displacement of air within the apparatus of at least 10 *times* the free volume of its enclosure and thus to obtain the required pressure before it can be energized.

(c) Pressurized protected electrical equipment is to be automatically disconnected from sources of electrical power in any event of the loss of pressure within its enclosure. However, if such arrangements increase the risk of hazard to ships, it may be permitted for such losses of pressure to operate alarm devices only.

(5) Encapsulation type electrical equipment

(a) In cases where some protection components are installed in order to limit temperature rises, setting values are not to be changed.

(b) In cases where there are limitations of usage in order to maintain explosion protecting performance, Society approval for such usage is necessary.

(6) Powder filling type electrical equipment

(a) Enclosures are to be at least IP54 or higher as specified in **H2.1.3-4**. If it is an IP55 or higher grade, breathing devices are to be provided.

(b) Powder materials used to fill enclosures are to be quartz or solid glass particles and have efficient insulation performance.

(c) The total stored energy of all capacitors in enclosures is not to exceed 20 *J* during normal operation.

(d) In cases where there are limitations of usage in order to maintain explosion protecting performance, Society approval for such usage is necessary.

(7) Oil immersion type electrical equipment

(a) Oil level indicating devices are to be provided so that liquid levels can be easily checked when such equipment is in service.

(b) Live parts of electrical equipment are to be immersed to depths of not less than 25 *mm* below the surfaces of protective liquids.

(c) In cases where connecting cables are dipped into protective liquids, they are to be oil resistant types.

(d) In cases where there are limitations of usage in order to maintain explosion protecting performance, Society approval for such usage is necessary.

H2.17 High Voltage Electrical Installation

H2.17.3 Construction and Location

1 The wording "standards deemed appropriate by the Society" in **2.17.3-1, Part H of the Rules** means the current standards of the *International Electrotechnical Commission* (*IEC*) listed below or any equivalent thereto.

(1) Transformers

IEC 60076 *Power transformers*

(2) Switchboards and control boards

IEC 62271-1 *High-voltage switchgear and controlgear - Part 1: Common specifications*

IEC 62271-200 *High-voltage switchgear and controlgear - Part 200:*

A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

IEC 62271-201 *High-voltage switchgear and controlgear - Part 201:*

AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

(3) High voltage circuit breakers

IEC 62271-100 *High-voltage switchgear and controlgear - Part 1: High-voltage alternating current circuit breakers*

(4) High voltage fuses

IEC 60282-1 *High-voltage fuses - Part 1: Current limiting fuses, - Part 2: Expulsion fuses*

(5) High voltage switches

IEC 62271-103 *High-voltage switchgear and controlgear - Part 103: Switches for rated voltages above 1 kV up to and including 52 kV*

(6) High voltage *a.c.* contactors

IEC 62271-106 *High-voltage switchgear and controlgear - Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

(7) Current transformers and voltage transformers

IEC 61869-1 *Instrument transformers - Part 1: General requirements*

2 The phrase "sufficient width allowing such access" in **2.17.3-7, Part H of the Rules** means, in principle, a width of at least 1 *m*. However, in cases where operation and maintenance can be properly preformed, the width of the passageway may be reduced as long as it is greater or equal to 0.5 *m*.

3 In applying **2.17.3-22, Part H of the Rules**, refer to the values of the **Table H2.17.3-3** in cases where using intermediate values for minimum air clearances.

Table H2.17.3-3 Minimum Air Clearances

Nominal voltage (*V*)	Minimum air clearances (*mm*)
Exceeding 1,000 and 3,000 (3,300) or less	55
4,000	66.7
5,000	78.4
6,000 (6,600)	90
7,000	97.5
8,000	105
9,000	112.5
10,000 (11,000)	120
11,000	128
12,000	136
13,000	144
14,000	152
15,000	160

H2.17.6 Testing

The clause "the standards deemed appropriate by the Society" in **2.17.6-2, Part H of the Rules** refers to Appendix A of *IEC* 62271-200.

H2.18 Tests after Installation On Board

H2.18.2 Performance Tests

Where the load tests for emergency generators specified in **2.18.2-1(3), Part H of the Rules** are carried out, load tests which supply actual services are to be performed in addition to full-rated load tests using water resistance, etc. During load tests which supply actual services, both automatically started services and manually started services are to be tested as close as possible to actual conditions, in order to demonstrate power supply suitability.

H3 DESIGN OF INSTALLATIONS

H3.2 Main Sources of Electrical Power and Lighting Systems

H3.2.1 Main Sources of Electrical Power

1 Generators driven by main propulsion machinery (hereinafter referred to as "shaft driven generator systems") are to comply with the following requirements **(1)** to **(7)** if they are provided as one of the main sources of electrical power specified in **3.2.1-1, Part H of the Rules**:

(1) Voltage fluctuations (see *IEC* 60092-301:1980) and frequency fluctuations of shaft driven generator systems are to be maintained within those specified limits given in **Table H3.2.1-1** under all weather conditions during sailing and maneuvering as well as when vessels are stopped and are in crash astern conditions.

(2) In cases where there is the loss of any one of the main generators in service, they are to be such that generating capacity of those generators specified in **3.2.1-2, Part H of the Rules** are capable of being maintained under all of the sailing and maneuvering conditions specified in **(1)** above.

(3) Standby sets are to be in compliance with **H3.2.1-4**.

(4) In those ships which have bridge control devices for main propulsion machinery, running indicators of shaft driven generator systems are to be provided on navigating bridges.

(5) In cases where main sources of electrical power are such that operation of generating sets is to be changed over to those generating sets not depending upon propulsion plants according to ship speed (*e.g.* ahead, stop, astern), such changeovers need to be made both automatically along with the control of propulsion plants and by remote operation from those positions where such propulsion plants are being controlled. In such cases power supplies are not to be interrupted by such changeovers.

(6) Shaft driven generator systems are to be capable of providing sufficient short circuit currents to trip generator circuit-breakers taking into account any selective tripping of protective devices for distribution systems on board.

(7) Protection is to be arranged in order to safeguard shaft driven generator systems in case of a short circuit in main busbars. Shaft driven generator systems are to be suitable for further use after fault clearances of the short circuit.

2 The wording "those services necessary to provide normal operational conditions of propulsion and safety" in **3.2.1-2, Part H of the Rules** means the following services:

(1) Those services which need to be in continuous operation to maintain propulsion and steering. Examples of such services are as follows:

(a) Steering gears

(b) Pumps for controllable pitch propellers

(c) Accessories for main and auxiliary engines (scavenging air blowers, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps, cooling water pumps, etc.)

(d) Accessories for boilers (forced draught fans, feed water pumps, condensate pumps, burning pumps, etc.)

(e) Thrusters (including their accessories) forming part of main propulsion machinery

In addition, those thrusters used for dynamic positioning systems (*DPS*) are to be treated as those forming part main propulsion machinery.

(f) Electrical equipment for electric propulsion plants

(g) Electric generators used for **(a)** through **(f)** above

(h) Hydraulic pumps used for **(a)** through **(f)** above

(i) Viscosity control equipment for heavy fuel oil

(j) Control, monitoring and safety systems used for **(a)** through **(i)** above

(2) Those services which are necessary for maintaining the vessel safety. Examples of such services are as follows:

(a) Windlasses

(b) Fuel oil transfer pumps

(c) Lubricating oil transfer pumps

(d) Pre-heaters for heavy fuel oil
(e) Starting air compressors
(f) Bilge, ballast and heeling pumps
(g) Fire pumps
(h) Ventilating fans for engine rooms
(i) Services considered necessary for maintaining safe conditions in dangerous spaces
(j) Navigation lights, aids and signals
(k) Internal safety communication equipment
(l) Fire detection systems
(m) Lighting systems
(n) Electrical equipment for watertight closing appliances
(o) Electric generators used for **(a)** through **(n)** above
(p) Hydraulic pumps used for **(a)** through **(n)**
(q) Control, monitoring and safety systems used for **(a)** through **(p)** above

3 In **3.2.1-5** and **3.3.2-3, Part H of the Rules**, procedures from dead ship conditions to starting main propulsion plants are to comply with those requirements specified in **D1.3.1-3**.

4 Provisions for maintaining or immediately restoring electrical power to any equipment for propulsion and steering specified in **3.2.1-3, Part H of the Rules** are to comply with following:

(1) In cases where the electrical power can normally be supplied by one generator, the following requirements are to be complied with:
  (a) Adequate provisions are to be made for automatic starting and connecting to main switchboards of standby generators of sufficient capacities to permit propulsion and steering and to ensure ship safety with automatic restarting of important auxiliaries including sequential operations in cases where there has been a loss of electrical power to those generators in operation.
  (b) The amount of time for automatic starting and connecting to main switchboards of those standby generators specified in **(a)** above is to be not more than a period of 45 *seconds* after any loss of power.
(2) If electrical power is normally simultaneously supplied by more than one generator in parallel operations, provisions are to be made to ensure that, in cases where there is a loss of electrical power to any one of these generating sets, all remaining ones are kept in operation without any overloads to permit propulsion and steering, and to ensure ship safety. (See **2.3.6, Part H of the Rules**)
(3) Other provisions deemed appropriate by the Society.

Table H3.2.1-1 Voltage and Frequency Fluctuations for Shaft Driven Generator Systems

Type of fluctuations	Fluctuations	
	Permanent	Transient
Voltage	± 2.5 %	-15 %, 20 % (± 3 % within 1.5 *sec*)
Frequency	± 5 %	± 10 % (within 5 *sec*)

H3.2.2 Number and Ratings of Transformers

1 In cases where transformers are to supply power to those electrical auxiliary services necessary for maintaining normal operational and habitable conditions of ships, at least two transformers are to be provided. However, in the case of transformers used exclusively for specific loads in cases where such is deemed acceptable by the Society, one set of transformers may be accepted.

2 The capacities of those transformers specified in **-1** above are to be such that any power feeding for those services specified in **H3.2.1-2**, even in the event of failure on one set of transformers, is available. Furthermore, at least minimum habitable conditions are to be secured regarding any equipment related to cooking, heating, provision refrigeration, mechanical ventilation, sanitary and fresh water services.

3 Notwithstanding those requirements given in **-1** above, one set of transformers is acceptable if the respective primary and

secondary sides of three single phase transformers are formed by delta connections, and power can be supplied if necessary by transformers of *V* connections in cases where either one of the transformers fails.

4 Arrangements of transformers are to be as follows: (*See* **Fig. H3.2.2-1**)

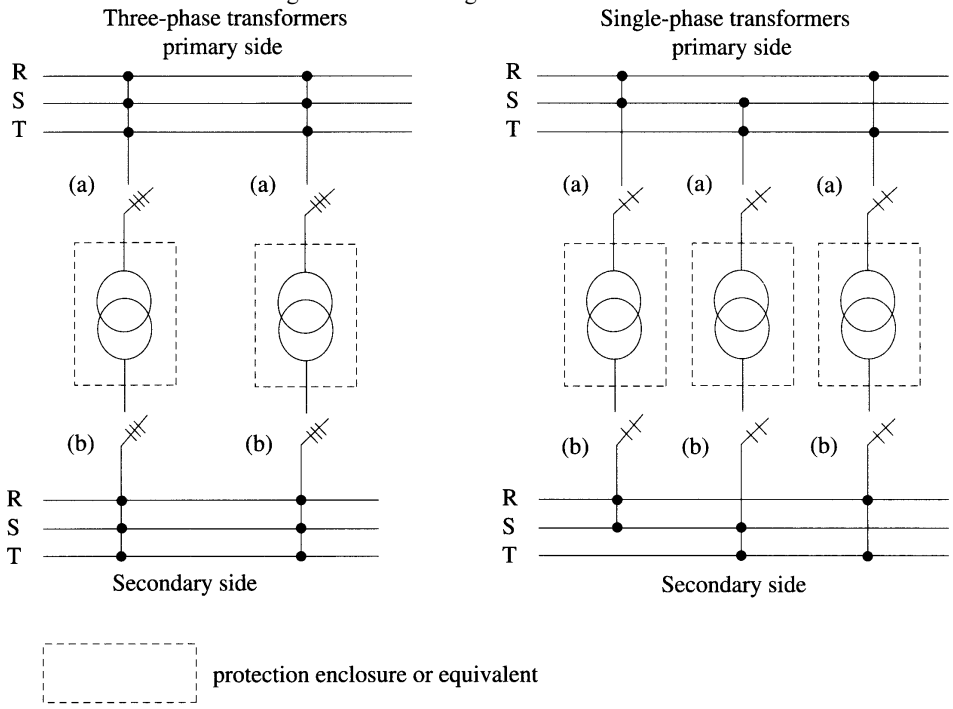
(1) Transformers are to be located as separate units with separate enclosures or the equivalent thereto.

(2) Transformers are to be served by separate circuits on their primary and secondary sides.

(3) Primary circuits are to be provided with protection devices and multipole isolating switches.

(4) Secondary circuits are to be provided with multipole isolating switches.

Fig. H3.2.2-1 Arrangement of Transformers



(a) a protection device and multipole isolating switch
(b) a multipole isolating switch

H3.2.3 Lighting Systems

The passageways, stairways and exits specified in **3.2.3-3(2), Part H of the Rules** include those passageways, stairways and exits that lead to muster stations and launching stations illuminated by the lighting specified in **3.2.3-3(1), Part H of the Rules**.

H3.2.4 Location of Main Switchboards

The locations of those main switchboards specified in **3.2.4, Part H of the Rules** are to comply with the requirements given in **(1)** to **(3)** below. In cases where these requirements are applied, "machinery spaces" are regarded as those spaces extending to extreme main transverse watertight bulkheads, bounding any spaces containing main and auxiliary propulsion machinery, boilers serving the needs of propulsion, and all permanent coal bunkers. In the case of unusual arrangements, such boundaries are to be as deemed appropriate by the Society.

(1) Those main generating stations specified in **3.2.4, Part H of the Rules** are to be located within machinery spaces, i.e. within extreme main transverse watertight bulkheads. Any bulkheads between such extreme main transverse watertight bulkheads are regarded as to be not separating any equipment in main generating stations provided that there is access between such separated spaces.

(2) Main switchboards are to be located as close as practicable to those main generating stations specified in **(1)** above, within the same machinery spaces and the same vertical and horizontal fire boundaries.

(3) In cases where essential services for steering and propulsion are supplied from section boards, these boards and any transformers, converters and similar appliances constituting an essential part of electrical power supply systems are also to satisfy the requirement given in **(2)** above.

H3.3 Emergency Sources of Electrical Power

H3.3.1 General

1 In cases where ships are under the following conditions, they are regarded as being under exceptional conditions for the short period specified in **3.3.1-4, Part H of the Rules**, and emergency generators may be used to supply electrical power to non-emergency circuits.

(1) Blackout conditions

(2) Dead-ship conditions

(3) Routine use for testing

(4) Short-term parallel operations with main sources of electrical power for the purpose of load transfers

(5) In cases where emergency generators are used to supply electrical power to ship mains during laytime in port (permitted only for those satisfying **-2** below)

2 In cases where emergency generators are used to supply electrical power to ship mains during laytime in port, such emergency generators and their associated equipment are to comply with the following requirements:

(1) In order to prevent generators or their prime mover from becoming overloaded when used during laytime in port, arrangements are to be provided to shed sufficient non-emergency loads in order to ensure continuous safe operation.

(2) Prime movers are to be equipped with devices for those alarms and automatic trips specified in **18.5.2, Part D of the Rules** (excluding **(2)** and **(5)** in cases where local control stations are not unattended).

(3) Fuel oil supply tanks to prime movers are to be provided with low level alarms, arranged at levels ensuring sufficient fuel oil capacities for emergency services for the period of time required by **3.3.2, Part H of the Rules**. In addition, such alarms are to be activated in those spaces specified in **(2)** above.

(4) Fire detectors complying with **Chapter 20, Part R of the Rules** are to be installed in spaces where emergency generator sets and emergency switchboards are installed.

(5) Means are to be provided to allow electrical power supplies to be readily changed over into emergency operations.

(6) Control, monitoring and supply circuits for the purpose of using emergency generators during laytime in port are to be arranged and protected so that any electrical faults will not influence the operations of main and emergency services. In cases where necessary for safe operation, emergency switchboards are to be fitted with switches to isolate circuits.

(7) Instructions are to be provided on board to ensure that all control devices, *e.g.*, valves, switches, are in their correct positions for independent emergency operations and during laytime in port.

H3.3.2 Capacities of Emergency Sources of Power

"VHF radio installations, MF radio installations, *INMARSAT* Ship Earth Stations and MF/HF radio installations as required by Chapter IV, the Annex to the *SOLAS* Convention" as specified in **3.3.2-2(4)(b), Part H of the Rules** are those installations which are required by *GMDSS (Global Maritime Distress and Safety System)*.

H3.3.3 Kind and Performance of Emergency Sources of Electrical Power

1 Those automatic starting systems specified in **3.3.3(1)(c), Part H of the Rules** are to comply with the following requirements:

(1) Sources of stored energy are to have such capacities which are capable of starting prime movers at least 6 times.

(2) In cases where automatic starting systems are of the consecutive start type, the number of starts is to be three or less.

(3) In the case of automatic starting systems, means are to be provided to hold reserves of sources of energy capable of starting prime movers an additional three times after making any initial consecutive starts.

2 With respect to those requirements given in **3.3.3(2)(a), Part H of the Rules**, in cases where inverters or converters are connected to output circuits of batteries (consumer sides), maximum permitted voltage fluctuations may be taken as those specified in **Table H2.1(a)** or **Table H2.1(b)**, **2.1.2-3, Part H of the Rules** respectively, notwithstanding any voltage drops of such batteries.

H3.3.4 Transitional Sources of Emergency Electrical Power

With respect to the requirements **3.3.4(1), Part H of the Rules**, in cases where inverters or converters are connected to output circuits of batteries (consumer sides), those requirements specified in **H3.3.3-2** may be applied.

H3.4 Starting Arrangements for Emergency Generating Sets

H3.4.1 General

In **3.4.1-1, Part H of the Rules**, room heaters or heating devices are to be provided as means deemed adequate by the Society for ensuring failfree starts of emergency generating sets at any time.

H3.8 Spare Parts, Tools and Instruments

H3.8.1 Spare Parts

1 In the cases of electric or electrohydraulic steering gears equipped with two or more electric motors or motor-generators, those spare armatures or stators specified in **3.8.1-4, Part H of the Rules** may be omitted.

2 The requirements given in **3.8.1-4, Part H of the Rules** do not apply to those electric motors used for steering control systems.

H4 ADDITIONAL REQUIREMENTS FOR SHIPS CARRYING SPECIAL CARGOES

H4.2 Tankers, Ships Carrying Liquefied Gases in Bulk and Ships Carrying Dangerous Chemicals in Bulk

H4.2.3 Hazardous Areas

1 The wording "those requirements otherwise specified by the Society" in **4.2.3-4, Part H of the Rules** means the categorization technique specified in 4.1.4 in *IEC* 60092-502 (1999). This technique categorizes those hazardous areas adjacent to any spaces (standard hazardous areas) in which flammable or explosive gas atmospheres are present or likely to occur after taking into account the effectiveness of any sources of release and ventilation (refer to **Fig. H4.2.3-1**). In addition, the wording "those requirements otherwise specified by the Society" in **4.2.3-4, Part H of the Rules** also means **R4.5.3-5** and **R11.6.2, Part R of the Guidance**.

2 The wording "those requirements otherwise specified by the Society" in **4.2.3-5, Part H of the Rules** means the following requirements:

(1) Enclosed spaces with openings or doors, other than those with bolted, gastight or watertight openings which are kept closed under seagoing conditions, to Zone 1 or 2 areas are to be categorized the same as those hazardous areas in which such openings or doors are located. However, those cases specified in **(2)** to **(4)** below are excluded.

(2) Enclosed spaces which have doors to adjacent Zone 1 areas may be categorized as Zone 2 areas provided that such spaces comply with all of the following requirements:

(a) Doors are to be gastight self-closing type doors and notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with all of the following requirements are to be provided so that any air inside such spaces flows into Zone 1 areas in cases where such doors are opened.

i) This ensures that there is no accumulation of any gases or vapours in such ventilated spaces and secures the safety of the crew's working environment.

ii) Audible and visual alarms are to be activated in continually manned spaces, e.g. navigation bridges or machinery control rooms, in cases where ventilation device failures have occurred.

iii) Any ducts used for the ventilation of hazardous areas are to be separate from those used for the ventilation of non-hazardous areas.

(3) Those enclosed spaces specified in **(a)** and **(b)** below which have openings into adjacent Zone 1 areas may be categorized as non-hazardous areas.

(a) Doors are to be doubly protected gas-tight doors forming air-locks with both self-closing devices and without holding back arrangements. Notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with all of the following requirements are to be provided so that spaces are pressurized against hazardous areas.

i) A minimum overpressure of 25 *Pa* with respect to such adjacent hazardous spaces is to be maintained at all points inside such spaces and its associated ducts at which leaks are liable to occur when all doors and windows are closed.

ii) In cases where spaces are not suitably pressurized as in **i)** above, *e.g.* during initial start-up or after shut-down conditions, no electrical installations other than those permitted by **4.2.4, Part H of the Rules** (hereinafter referred to as "permitted electrical installations") are to be turned on unless internal atmospheres are ensured as being non-hazardous (any concentration of explosive gases or vapours in such spaces is below 30 % of lower explosive limits) or prior purging of a sufficient duration of time which allows internal atmospheres to be considered as non-hazardous is performed.

iii) Monitoring devices are to be provided to ensure the satisfactory functioning of pressurization of such spaces. In cases where flow-monitoring devices are used, it is to be verified that either required pressurization levels are maintained with any doors or other openings open, or that alarms are activated if any door or other opening has not been closed.

iv) In cases where those pressurization levels required by **i)** above are not maintained, alarms are to be activated in any continually manned spaces, *e.g.* navigation bridges or machinery control rooms, and permitted electrical installations are to be automatically switched off. However, essential electrical equipment for ship safety or personnel safety are to be permitted and set to avoid any automatic switch-off.

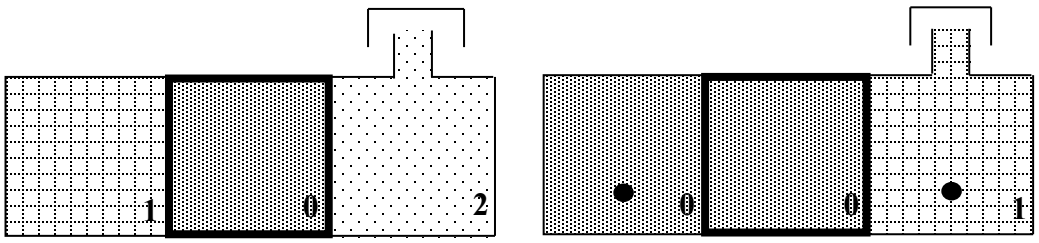
v) Any ducts used for the ventilation of hazardous areas are to be separate from those used for the ventilation of non-hazardous areas.

(4) Enclosed spaces which have doors into adjacent Zone 2 areas may be categorized as non-hazardous areas provided that such spaces comply with all of the following requirements:

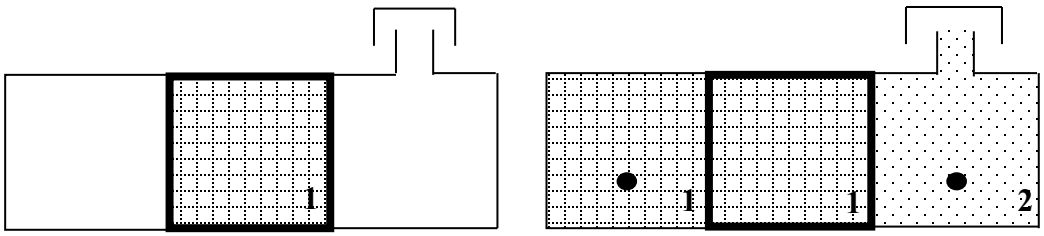
(a) Doors are to be gastight self-closing type doors, opening into such spaces inside and notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with those requirements given in **(2)(b)i)** to **iii)** above are to be provided so that any air inside such spaces flows into Zone 2 areas in cases where such doors are opened.

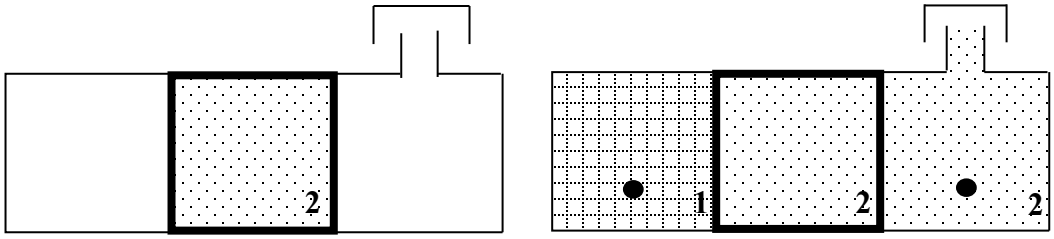
Fig. H4.2.3-1 Hazardous Areas adjacent to Standard Hazardous Areas



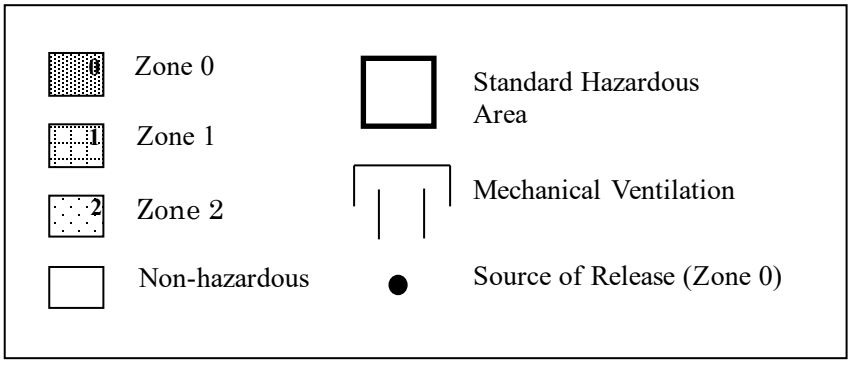
(a) In cases where the standard hazardous area is Zone 0



(b) In cases where the standard hazardous area is Zone 1



(c) In cases where the standard hazardous area is Zone 2



H4.2.4 Electrical Installations in Hazardous Areas

1 Hull fittings complying with those requirements given in **4.2.4-1(2)(e), Part H of the Rules** are to be totally enclosed gastight types or to be housed in gastight enclosures. In addition, they are not to be located adjacent to any cargo tanks. Any of their associated cables are to be installed in heavy gauge galvanized steel pipes up to upper decks and their connection joints are to be gastight types.

2 The wording "other electrical equipment deemed appropriate by the Society" in **4.2.4-1(3)(b), Part H of the Rules** means one of the following:

(1) Electrical equipment of type "n" protection in accordance with *IEC* 60079-15 (the latest edition)

(2) Electrical equipment of a gas enclosed type which is certified by an appropriate authority

(3) Electrical equipment of a type which ensures the absence of any sparks or arcs as well as no surface parts having temperatures which during normal operation may cause the ignition of any gases or vapours from cargoes

3 The wording "it is to be confirmed that such equipment is safe to use in explosive gas atmospheres" in **4.2.4-2, Part H of the Rules** means the following:

(1) In the case of tankers which carry only crude or product oil, explosion-protected electrical equipment complying with the requirements given in **2.16, Part H of the Rules** and certified as Apparatus Group *II*A, Temperature Class *T*3 or higher as specified in *IEC* 60079-0 or Explosion Class *d*1, Ignition Group *G*3 or higher as specified in the Recommended Practices for Explosion-Protected Electrical Installations in General Industries (NIIS-TR-NO.39 (2006)) issued by National Institute of Industrial Safety in Japan and approved by the Society in accordance with those requirements given in **1.2.1-4, Part H of the Rules** or their equivalent thereto, or any types of equipment which may not cause the ignition of any gases or vapours from cargoes

(2) In the case of ships which carry liquefied gases in bulk, any equipment complying with those requirements given in **10.2.4, Part N of the Rules**

(3) In the case of ships which carry dangerous chemicals in bulk, any equipment complying with those requirements given in **10.1.5, Part S of the Rules**

4 In the case of small ships, in cases where parts of fore castle decks are contained within any hazardous areas on open decks over all cargo tanks to the full breadth of the ship plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above deck, electrical equipment having enclosures with a degree of protection at least IP55 other than explosion-protected types may be installed in such areas subject to the following requirements **(1)** and **(2)** instead of those requirements given in **4.2.4-2, Part H of the Rules**.

(1) Steel type gas barrier walls without any openings are to be provided on forecastle decks.

(2) The height of gas barrier walls is to be 2.4 *m* or more from open decks and the breadth is to be the full breadth of the forecastle deck at those gas barrier walls specified in **(1)** above.

5 In applying **4.2.4-4, Part H of the Rules**, "Society approval" includes the drop test specified in *IEC* 60079-0.

6 In applying **4.2.4-5, Part H of the Rules**, "corrosion is to be expected" means, for example, those cables installed on open decks.

H4.2.6 Ventilation

1 With respect to the requirements specified in **4.2.6-3, Part H of the Rules**, protection screens of not more than 13 *mm* square mesh are to be fitted in the inlet and outlet ventilation openings of the ducts fitted with such fans on the open deck.

2 The wording "standards deemed appropriate by the Society" in **4.2.6-5, Part H of the Rules** refers to *IEC* 60092-502, which means that the arrangements of air intakes and exhaust outlets serving artificial ventilation systems are to comply with the following requirements.

(1) Air intakes serving artificial ventilation systems

(a) Air intakes for hazardous areas are to be located in areas which, in the absence of the considered inlet, would be non-hazardous.

(b) Air intakes for non-hazardous areas are to be located in non-hazardous areas at least 1.5 *m* from the boundaries of any hazardous area.

(2) Exhaust outlets serving artificial ventilation systems

(a) Exhaust outlets for hazardous areas are to be located in open areas which, in the absence of the considered outlet, would be of the same or a lesser hazard than the ventilated space.

(b) Exhaust outlets for non-hazardous areas are to be located in non-hazardous open areas.

H4.2.7 Maintenance for Explosion-protected Electrical Equipment

The wording "maintenance deemed appropriate by the Society" in **4.2.7, Part H of the Rules** means the following:

(1) Maintenance carried out by those procedures given in **Annex H4.2.7**

(2) Any repairs or overhaul of equipment (if necessary)

(3) Confirmation of explosion-protected performance in cases where any modifications, additions or adjustments to equipment are carried out

H4.3 Tankers and Ships Carrying Dangerous Chemicals in Bulk Having a Flashpoint Not Exceeding 60 °C

H4.3.1 Classification of Hazardous Areas

1 Examples of those hazardous areas specified in **4.3.1, Part H of the Rules** are shown in **Fig. H4.3.1(1)** to **Fig. H4.3.1(3)**.

Fig. H4.3.1(1) Example of Zone 0

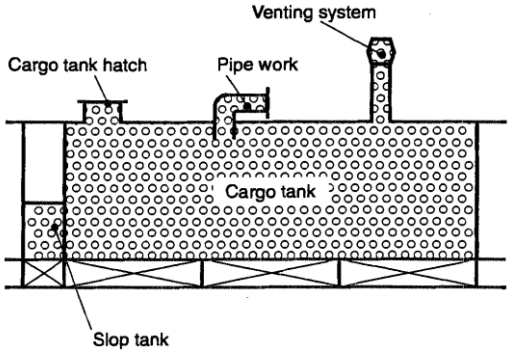


Fig. H4.3.1(2) Example of Zone 1

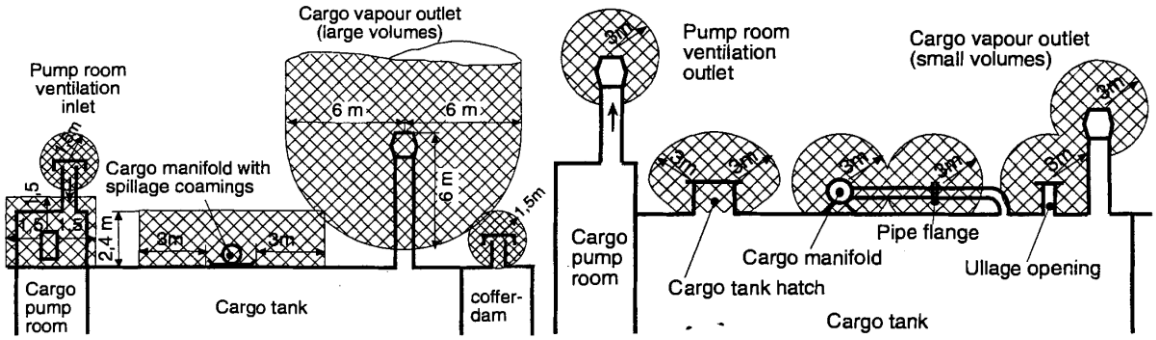
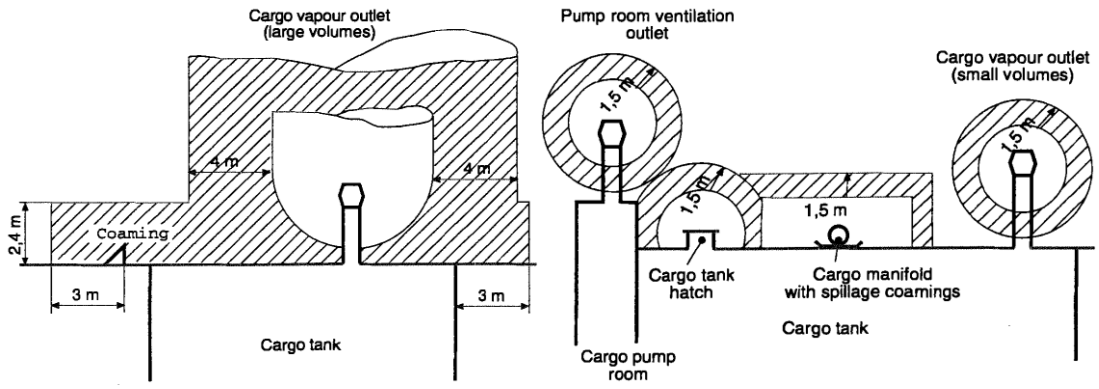


Fig. H4.3.1(3) Example of Zone 2



2 The wording "requirements otherwise specified by the Society" in **4.3.1(3)(a), Part H of the Rules** means that **R11.6.2, Part R of the Guidance** applies and not **4.3.1(3)(a), Part H of the Rules**.

H4.7 Ships Carrying Liquefied Gases in Bulk

H4.7.1 Classification of Hazardous Areas

1 Examples of those hazardous areas specified in **4.7.1, Part H of the Rules** are shown in **Fig.H4.7.1(1)** to **Fig.H4.7.1(3)**.

Fig. H4.7.1(1) Example of Zone 0

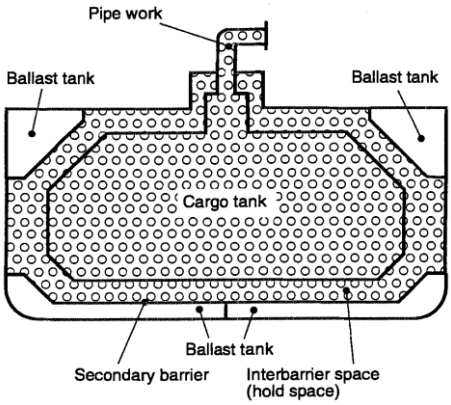


Fig. H4.7.1(2) Example of Zone 1

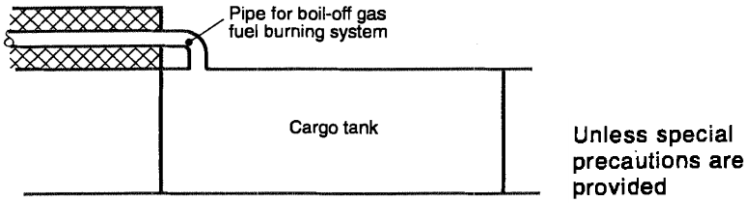
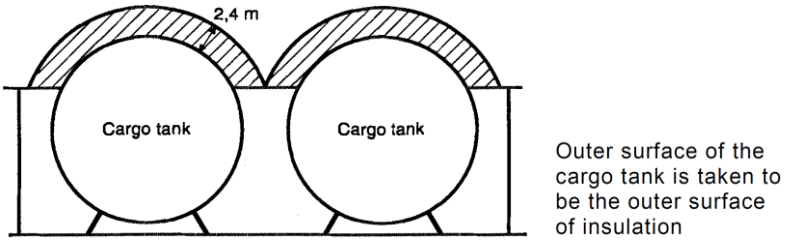


Fig. H4.7.1(3) Example of Zone 2



2 The wording "requirements otherwise specified by the Society" in **4.7.1(3)(a), Part H of the Rules** means that **R11.6.2, Part R of the Guidance** applies and not **4.7.1(3)(a), Part H of the Rules**.

H4.9 Coal Carriers

H4.9.1 Electrical Installations in Cargo Holds

1 The wording "Electrical installations are to be explosion-protected types as deemed appropriate by the Society and they are to have enclosures for safe operation in coal dust" specified in **4.9.1-2(1), Part H of the Rules** means those meeting the requirements given in **2.16, Part H of the Rules** and those having intrinsically safe, flameproof or pressurized constructions certified as Apparatus Group *II*A and Temperature Class *T*4 or higher as specified in *IEC* 60079-0 or Explosion Class *d*1 and Ignition Group *G*4 or higher as specified in the Recommended Practices for Explosion-Protected Electrical Installations in General Industries (NIIS-TR-NO.39

(2006)) issued by National Institute of Industrial Safety in Japan, and having enclosures with a degree of protection of at least IP55 in accordance with **H2.1.3-4** or its equivalent thereto.

2 The wording "considered by the Society to be the equivalent of explosion–protected type electrical installations with regard to safety" specified in **4.9.1-2(1), Part H of the Rules** means those special type cargo lights which comply with *JIS F* 8442.

3 The wording "non-sparking types" specified in **4.9.1-2(4), Part H of the Rules** means those types complying with the requirements of **R4.5.4-1(2)**. For the purpose of this requirement, protection screens of not more than 13 *mm* square mesh are to be fitted in the inlet and outlet ventilation openings of the ducts fitted with such fans on the open deck.

4 In applying **4.9.1-2(3), Part H of the Rules**, "Any cables leading to electrical equipment installed in cargo holds" means that such cables are to comply with the requirements given in **4.2.4-5, Part H of the Rules**.

5 The wording "enclosures less likely to permit any ingress of coal dust" specified in **4.9.1-3(1), Part H of the Rules** means those enclosures with a degree of protection of at least IP55 in accordance with **H2.1.3-4**.

H5 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS

H5.1 General

H5.1.1 Scope

In **5.1.1-1, Part H of the Rules**, the exclusion of thrusters intended as auxiliary steering devices, booster and take-home devices may be acceptable.

H5.2 Propulsion Electrical Equipment

H5.2.1 General

The wording "designed considering the harmonic content effects" specified in **5.2.1-2, Part H of the Rules** means that designs in which the Total Harmonic Distortion (THD) on circuits connected to propulsion electric equipment satisfies the requirement given in **2.1.2-4, Part H of the Rules**.

H5.2.2 General Requirements for Propulsion Motors

1 The wording "current carrying components" specified in **5.2.2-1(5), Part H of the Rules** means, for example, cables, feeder circuits, and slip-rings.

2 The wording "restricted service" specified in **5.2.2-5, Part H of the Rules** means, for example, the opening of emergency air inlets fitted in the body of propulsion motors by the crew, etc. in order to maintain minimum cooling performance as well as the manoeuvring condition of operating such motors under low output.

H5.2.3 Construction and Arrangement of Propulsion Rotating Machines

The wording "thermometers for measuring cooling air temperatures" specified in **5.2.3-4, Part H of the Rules** means that it is measure exhaust side temperatures. Furthermore, the Society may accept the use of thermo-sensors fitted in the stator windings of propulsion rotators as a substitute means.

H5.2.5 Propulsion Semiconductor Convertors

1 The wording "means for monitoring effective forced cooling" specified in **5.2.5-3, Part H of the Rules** means, for example, those thermometers measuring cooling air temperatures.

2 The wording "sensors failure" specified in **5.2.5-5, Part H of the Rules** means line open faults, short-circuit, etc.

H5.2.6 Propulsion Transformers

In cases where specified in **5.2.6-6, Part H of the Rules**, the use of protection devices fitted in propulsion convertors may be acceptable as short-circuit protection for the secondary side.

H5.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits

H5.3.1 Composition of Electrical Equipment for Propulsion and Auxiliary Machinery for Propulsion

1 The wording "obtaining a navigable speed for the ship" specified in the main sentence of **5.3.1-1, Part H of the Rules** means the speed given in **D1.3.1-1, Part D of the Guidance for the Survey and Construction of Steel Ships**.

2 The wording "lubricating systems" specified in **5.3.1-1(4), Part H of the Rules** means lubricating oil pumps.

3 In cases where specified in **5.3.1-1(4), Part H of the Rules**, the installation of only one propulsion motor onboard ship may be acceptable on the condition that the following requirements are satisfied:

(1) Synchronous motors and induction motors are to be provided with two stator winding systems which can be disconnected from their respective propulsion convertor. Furthermore, such convertors are to be designed for at least 50 % nominal power of the propulsion drive system

(2) Permanent-magnet excited motors are to be provided with two stator winding systems which can be disconnected from their respective propulsion convertor.

(3) Propulsion motors are to be provided with means for substitution (emergency opening air flap etc.) in addition to those

temperature monitoring systems required in **5.2.3-3** and **-4, Part H of the Rules**, However, in cases where two cooling systems are installed, this requirement does not apply.

H6 SPECIAL REQUIREMENTS FOR SHIPS WITH RESTRICTED SERVICE, SMALL SHIPS AND FISHING VESSELS

H6.1 General

H6.1.1 Scope

Fishing vessels are those vessels defined by Regulation 2(i), Chapter I, *SOLAS* Convention.

H6.3 Electrical Installations of Ships Specified in 6.1.1(2), Part H of the Rules

H6.3.3 Main Source of Electrical Power

In applying the requirements of **3.2.1-3, Part H of the Rules**, the requirements of **H3.2.1-1(3)** and **(5)** may not apply to those generating sets driven by main propulsion machinery in which one of two generating sets is a main source of electrical power of ships other than **M0** classified ships.

Annex H4.2.7 GUIDANCE FOR THE MAINTENANCE FOR EXPLOSION-PROTECTED ELECTRICAL EQUIPMENT

1.1 General

1.1.1 Scope

The requirements in this Guidance apply to the periodical maintenance of explosion-protected electrical equipment installed in tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk.

1.1.2 Definitions

Definitions of the terms used in this Guidance are as follows:

(1) The wording "Connecting Surface" is the name given to connecting parts such as flat connecting parts, threaded parts, faucet joints, coupling parts, shaft penetrating part, etc.

(2) The wording "Container" means components such as boxes for storing electrical equipment, casings, glass globes for lighting, etc. which are of explosion-proof constructions.

1.2 Maintenance

1.2.1 Maintenance Items

The major maintenance items and expected conditions for explosion-protected electrical equipment are as follows. Additional maintenance items are to be required in cases where necessary.

(1) Flameproof type electrical equipment
  (a) There are to be no cracks, fractures or extensive corrosion to any containers
  (b) Container bolts are to be tight and none are to be broken or falling off
  (c) There is to be no corrosion and strain with respect to any connecting surfaces, and flange gap dimensions are to be within proper values
  (d) Cable lead-in parts of the cable entry devices of explosion-proof packing are to be tight and such packing is not to be corroded and worn out
  (e) Thread connecting parts of the cable entry devices using the conduit tube connecting method are to be tight and any compounds used for sealing fittings are to be sufficiently filled and not damaged
  (f) Guards for lighting are not to be damaged and deformed
  (g) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers

(2) Increased safety type electrical equipment
  (a) Any packing used to keep the sealed condition of containers is not to be corroded and worn out
  (b) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers
  (c) In cases where containers are filled with compounds, they are to be sufficiently filled and such compounds are not to be damaged

(3) Intrinsically safe type electrical equipment
  (a) On the inside of intrinsically safe type electrical equipment (*e.g.* power supply units) installed in non-hazardous areas, separation is to be maintained between terminals of intrinsically safe circuits and other circuits
  (b) There are to be no modifications made to any circuits in intrinsically safe type electrical equipment
  (c) Barriers are not to be damaged
  (d) Cable terminals connected to intrinsically safe type electrical equipment (*e.g.* sensors) installed in hazardous areas are to be separated from those terminals of other circuits in junction boxes

(4) Pressurized protected type electrical equipment
  (a) There are to be no cracks, fractures or extensive corrosion to any ducts, pipes and containers
  (b) Protective gas pressures and flows are to be adequate

(c) Any packing used to keep the sealed condition of containers is not to be corroded and worn out

(5) Encapsulation type electrical equipment

(a) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers

(b) There are to be no cracks, fractures or extensive corrosion to any containers

(c) Containers are to be sufficiently filled with resin and such resin is not to be damaged

(6) Powder filling type electrical equipment

(a) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers

(b) There are to be no cracks, fractures or extensive corrosion to any containers

(c) Ventilating openings on containers are to be in good condition

(d) Containers are to be uniformly filled with powder

(7) Oil immersion type electrical equipment

(a) There is to be no oil leakage from containers or cable lead-in parts

(b) Oil quantity is to be adequate

1.2.2 Regular Maintenance

Regular maintenance is to be carried out at least every year. Among the maintenance items specified in **1.2.1**, those which can be inspected visually are to be examined and it is to be confirmed that no visible unauthorized modifications have been made.

1.2.3 Close Maintenance

Close maintenance is to be carried out at least twice every five years. All of the maintenance items specified in **1.2.1** are to be examined by ladders and inspection tools. Furthermore, it is to be confirmed that the apparatus group and temperature class for which the explosion-protected electrical equipment is designed are correct and that there are no visible unauthorized modifications.