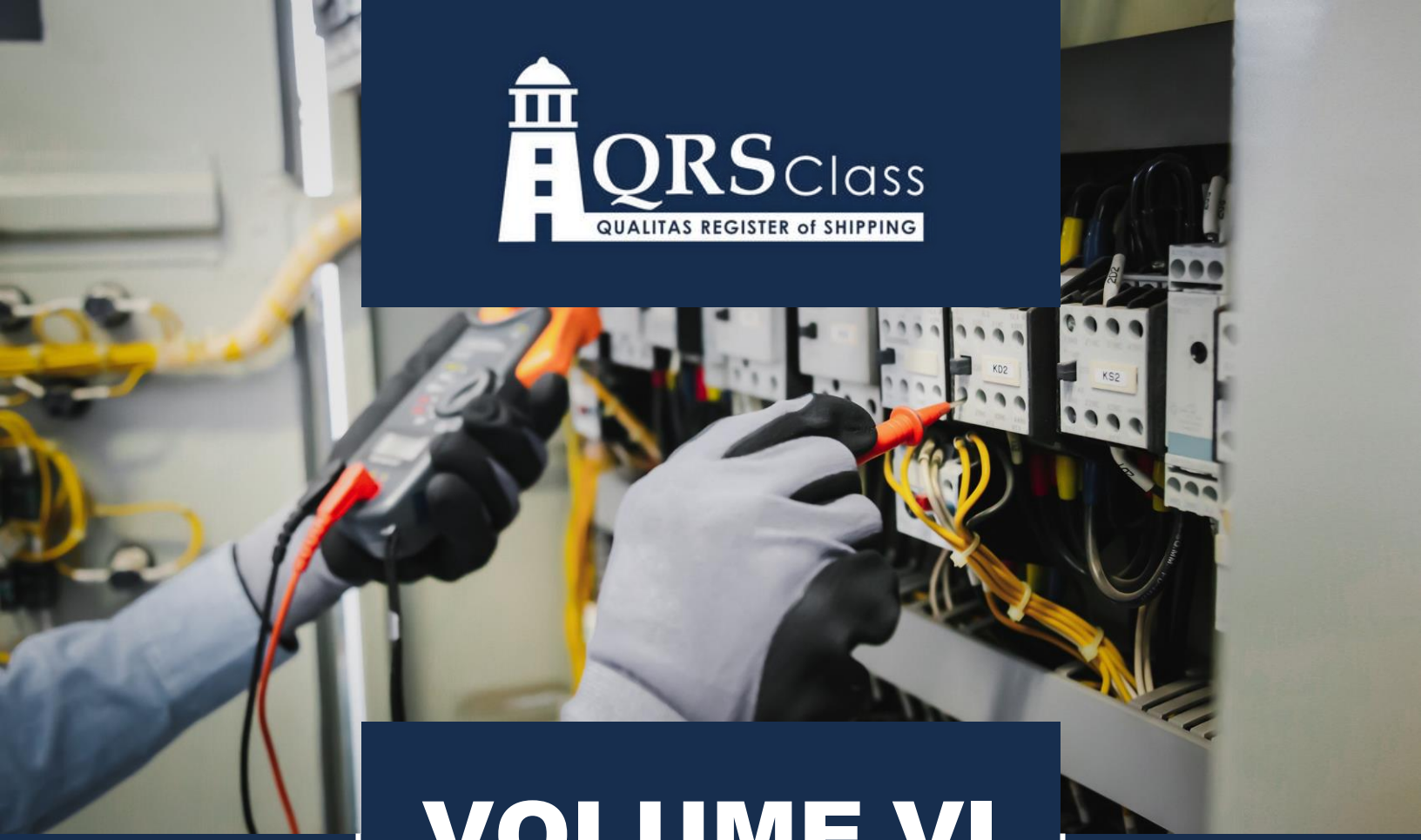

QRS Class
QUALITAS REGISTER of SHIPPING

VOLUME VI

Electrical Installations

The present edition of Electrical Installations, Volume VI has been approved by the General Manager and will enter in force on May 15, 2023.

The present edition of Electrical Installations is based on the 2016 edition taking into account the amendments developed immediately before publication.

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REVISION HISTORY 1

(Purely editorial amendments are not included in the Revision History)

Amended paras / chapters / sections	Information on amendments	Entry-into force date
Section 9	Add - Minimum Cable Conductor Size	24.02.2025
Section 11	Modify - Storage Batteries Located	24.02.2025

Electrical Installations

Section 1 General

1.1. Application

1.1.1. General

1.1.1.1. The requirements of this Chapter apply to electrical installations on ships. In particular, they apply to the components of electrical installations for:

- primary essential services
- secondary essential services
- essential services for special purposes connected with ships specifically intended for such purposes (cargo pumps on tankers, cargo refrigerating systems)
- services for habitability.

The other parts of the installation are to be so designed as not to introduce any risks or malfunctions to the above services.

1.1.2. References to other regulations and standards

1.1.2.1. *QRS Class* may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series.

It is to be noted however that, where the prescriptive requirements in the present Rules and such standards are not aligned, the prescriptive requirements in the present Rules take precedence and are to be applied.

1.1.2.2. When referred to by QRS Class, publications by the International Electrotechnical Commission (IEC) or other internationally recognized standards defined in this Chapter, are in principle those currently in force at the date of the contract for construction.

1.2. Documentation to be submitted.

1.2.1. The documents listed in Table 1 are to be submitted.

Table 1 : Documents to be submitted

No.	I/A	Documents to be submitted
1	A	General arrangement of electrical installation.
2	A	Single line diagram of main and emergency power and lighting systems.
3	I	Electrical power balance (main and emergency supply).

No.	I/A	Documents to be submitted
4	A	Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW).
5	A	Where the maximal short-circuit current on the main bus-bar is expected to exceed 50 kA for the main and emergency switchboards, justification of the main bus-bar and bracket strength related to induced electro-magnetic forces (except junction bars to the interrupting and protective devices).
6	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices.
7	A	Single line diagram and detailed diagram of the main switchboard.
8	A	Single line diagram and detailed diagram of the emergency switchboard.
9	A	Diagram of the most important section boards or motor control centers (above 100 kW).
10	A	Diagram of the supply for monitoring and control systems of propulsion motors and generator prime movers.
11	A	Diagram of the supply, monitoring and control systems of the rudder propellers.
12	A	Diagram of the supply, monitoring and control systems of CPP´s
13	A	Diagram of the general emergency alarm system, of the public address system and other intercommunication systems.

No.	I/A	Documents to be submitted
14	A	Detailed diagram of the navigation-light switchboard.
15	A	Diagram of the remote stop system (ventilation, fuel pump, fuel valves, etc.).
16	A	List of batteries including type and manufacturer, voltage and capacity, location and equipment and/or system(s) served, maintenance and replacement schedule (when used for essential and emergency services).
17	A (2)	Selectivity and coordination of the electrical protection.
18	A (3)	Single line diagram.
19	A (3)	Principles of control system and its power supply.
20	A (3)	Alarm and monitoring system including: ● list of alarms and monitoring points ● power supply diagram.
21	A (3)	Safety system including: ● list of monitored parameters for safety system ● power supply diagram.
22	I (3)	Arrangements and details of the propulsion control consoles and panels.
23	I (3)	Arrangements and details of electrical coupling.
24	I (3)	Arrangements and details of the frequency converters together with the justification of their characteristics.
25	I (3)	Arrangements of the cooling system provided for the frequency converter and motor enclosure.
26	A (3)	Test program for converters and rotating machines having rated power > 3 MW, dock and sea trials.

No.	I/A	Documents to be submitted
(1) A : To be submitted for approval I : To be submitted for information. (2) For high voltage installations. (3) For electric propulsion installations.		

1.3. Definitions

1.3.1. General

1.3.1.1. Unless otherwise stated, the terms used in this Chapter have the definitions laid down by the IEC standards. The definitions given in the following requirements also apply.

1.3.2. Essential services

1.3.2.1. Essential services are subdivided in primary and secondary services.

1.3.3. Primary essential services

Primary essential services are those which need to be maintained in continuous operation such as the following:

- steering gear
- actuating systems of CPP´s

- scavenging air blowers, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps
- forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations
- azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps
- electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- electric generators and associated power sources supplying the above equipment
- hydraulic pumps supplying the above equipment
- viscosity control equipment for heavy fuel oil
- control, monitoring and safety devices/systems for equipment for primary essential services
- speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion
- starting equipment of diesel engines and gas turbines.
- The main lighting system

1.4. Secondary essential services

Secondary essential services are those services which need not necessarily be in continuous operation such as the following:

- windlasses
- thrusters
- fuel oil transfer pumps and fuel oil treatment equipment

- lubrication oil transfer pumps and lubrication oil treatment equipment
- preheaters for heavy fuel oil
- sea water pumps
- starting air and control air compressors
- bilge, ballast and heeling pumps
- fire pumps and other fire-extinguishing medium pumps
- ventilation fans for engine and boiler rooms
- services considered necessary to maintain dangerous cargo in a safe condition
- navigation lights, aids and signals
- internal safety communication equipment
- fire detection and alarm systems
- electrical equipment for watertight closing appliances
- electric generators and associated power supplying the above equipment
- hydraulic pumps supplying the above mentioned equipment
- control, monitoring and safety for cargo containment systems
- control, monitoring and safety devices/systems for equipment for secondary essential services.
- cooling system of environmentally controlled spaces.

1.5. Services for habitability

i) Services for habitability are those intended for minimum comfort conditions for people on board including cooking, heating, refrigeration, sanitation, ventilation, fresh water and energy to supply these systems.

1.6. Safety voltage

i) A voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer.

ii) A voltage which does not exceed 50 V d.c. between conductors or between any conductor and earth in a circuit isolated from higher voltage circuits.

1.7. Low-voltage systems

i) Alternating current systems with rated voltages greater than 50 V r.m.s. up to 1000 V r.m.s. inclusive and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 50 V up to 1500 V inclusive.

1.8. High-voltage systems

i) Alternating current systems with rated voltages greater than 1000 V r.m.s. and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 1500 V.

1.9. Basic insulation

i) Insulation applied to live parts to provide basic protection against electric shock.

1.10. Supplementary insulation

i) Insulation applied to provide protection against electric shock in the event of a failure of basic insulation.

1.11. Double insulation

1.11.1. Insulation comprising both basic insulation and supplementary insulation.

1.12. Earthing

i) The earth connection to the general mass of the hull of the ship in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

1.13. Normal operational and habitable condition

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

1.14. Emergency condition

i) A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.

1.15. Main source of electrical power

i) A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable condition.

1.16. Dead ship condition

i) The condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to absence of power.

1.17. Main switchboard

i) A switchboard supplied by the main source of electrical power and intended to distribute power to the ship’s services.

1.18. Emergency switchboard

i) A switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power and is intended to distribute electrical energy to the emergency services.

1.19. Emergency source of electrical power

i) A source of electrical power, intended to supply the emergency switchboard in the event of failure of the main source.

1.20. Distribution board

i) A switchgear and controlgear assembly arranged for the distribution of electrical energy to final sub-circuits.

1.21. Final sub-circuit

i) That portion of a wiring system extending beyond the final required overcurrent protective device of a board.

1.22. Hazardous areas

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

ii) Hazardous areas are classified in zones based upon the frequency and the duration of the occurrence of explosive atmosphere.

iii) Hazardous areas for explosive gas atmosphere are classified in the following zones:

- Zone 0: an area in which an explosive gas atmosphere is present continuously or is present for long periods

- Zone 1: an area in which an explosive gas atmosphere is likely to occur in normal operation
- Zone 2: an area in which an explosive gas atmosphere is not likely to occur in normal operation

1.23. High fire risk areas

i) The high fire risk areas are defined as follows:

a) machinery spaces, except spaces having little or no fire risk.
b) spaces containing fuel treatment equipment and other highly flammable substances
c) galleys and pantries containing cooking appliances
d) laundry with drying equipment

1.24. Certified safe-type equipment

i) Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

1.25. Voltage and frequency transient

i) Voltage transient is a sudden change in voltage (excluding spikes) which goes outside the nominal voltage tolerance limits and returns to

and remains inside these limits within a specified recovery time after the initiation of the disturbance.

ii) Frequency transient is a sudden change in frequency which goes outside the frequency tolerance limits and returns to and remains inside these limits within a specified recovery time after initiation of the disturbance.

1.26. Environmental categories

i) Electrical equipment is classified into environmental categories according to the temperature range, vibration levels, and resistance to chemically active substances, to humidity, and to EMC required for installation in bridge and deck zones.

1.27. Black out situation

i) 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 (compressed air, starting current from batteries, etc.) are available.

Electrical Installations

Section 2 General Design Requirements

2.1. Environmental conditions

a) General

i) The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

In particular, the conditions shown in the tables in this Article are to be taken into account.

b) Ambient air temperatures

i) For ships classed for unrestricted navigation, the ambient air temperature ranges shown in Table 1 are applicable in relation to the various locations of installation.

Table 1 Ambient air temperature

Location	**Temperature range, in °C**
Enclosed spaces	+ 5 + 45
Inside consoles or fitted on combustion engines and similar	+ 5 + 55
Air conditioned areas	+ 5 + 40

Location	Temperature range, in °C
Exposed decks	25 + 45

ii) For ships classed for service in specific zones, QRS Class may accept different ranges for the ambient air temperature (for ships operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to + 40°C instead of + 45°C).

c) Humidity

i) For ships classed for unrestricted service, the humidity ranges shown in Table 2 are applicable in relation to the various locations of installation.

Table 2 Humidity

Location	Humidity
General	95% up to 45°C 70% above 45°C
Air conditioned areas	Different values may be considered on a case-by-case basis

d) Sea water temperatures

i) The temperatures shown in Table 3 are applicable to ships classed for unrestricted service.

ii) For ships classed for service in specific zones, QRS Class may accept different values for the sea water temperature (for ships operating outside the tropical belt, the maximum sea water temperature may be assumed as equal to + 25°C instead of + 32°C).

Table 3 : Water temperature

Coolant	**Temperature range, in °C**
Sea water	0 + 32

e) Salt mist

i) The applicable salt mist content in the air is to be 1mg/m^3.

f) Inclinations

i) The inclinations applicable are those shown in Table 4.

QRS Class may consider deviations from these angles of inclination taking into consideration the type, size and service conditions of the ships.

Table 4 : Inclination of ship

Type of machinery, equipment or component	Angles of inclination, in degrees (1)			
	Athwartship		Fore-and-aft	
	static	dynamic (4)	static	dynamic (5)
Machinery and equipment relative to main electrical power installation	15	22,5	5	7,5
Machinery and equipment relative to the emergency power installation and crew safety systems (emergency source of power, emergency fire pumps, etc.)	22,5 (2)	22,5 (2)	10	10
Switchgear and associated electrical and electronic components and remote control systems (3)	22,5	22,5	10	10

1. Athwartship and fore-and-aft angles may occur simultaneously in their most unfavorable combination.
2. In the case of gas carriers or chemical tankers, the emergency power supply must also remain operable with the ship flooded to a final athwartship inclination up to a maximum of 30°.
3. No undesired switching operations or functional changes may occur up to an angle of inclination of 45°.
4. The period of dynamic inclination may be assumed equal to 10 s.
5. The period of dynamic inclination may be assumed equal to 5 s.

g) Vibrations

i) In relation to the location of the electrical components, the vibration levels given in Table 5 are to be assumed.

ii) The natural frequencies of the equipment, their suspensions and their supports are to be outside the frequency ranges specified.

Where this is not possible using a suitable constructional technique, the equipment vibrations are to be dumped so as to avoid unacceptable amplifications.

Table 5 : Vibration levels

Location	**Frequency range, in Hz**	**Displacement amplitude, in mm**	**Acceleration amplitude g**
Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2,0 to 13,2 from 13,2 to 100	1,0	 0,7
On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6	 4,0
Masts	from 2,0 to 13,2 from 13,2 to 50	3,0	 2,1

2.2. Quality of power supply

a) General

i) All electrical components supplied from the main and emergency systems are to be so designed and manufactured that they can operate satisfactorily under normally occurring variations in voltage and frequency.

b) A.C. distribution systems

i) For alternating current components the voltage and frequency variations of power supply shown in Table 6 are to be assumed.

Table 6 : Voltage and frequency variations of power supply in A.C.

Parameter	**Variations**	
	Continuous	**Transient**
Voltage	+ 6% 10%	20% (recovery time: 1,5 s)
Frequency	5%	10% (recovery time: 5 s)

c) D.C. distribution systems

i) For direct current components the power supply variations shown in Table 7 are to be assumed.

Table 7 Voltage variations in D.C.

Parameters	**Variations**
Voltage tolerance (continuous)	10%
Voltage cyclic variation	5%
Voltage ripple (a.c. r.m.s. over steady d.c. voltage)	10%

ii) For direct current components supplied by electrical battery the following voltage variations are to be assumed:

- +30% to 25% for components connected to the battery during charging
- +20% to 25% for components not connected to the battery during charging.

iii) Any special system, such as electronic circuits, whose function cannot operate satisfactorily within the limits shown in the tables should not be supplied directly from the system but by alternative means, such as, through stabilized supply.

d) Harmonic distortions

i) For components intended for systems without substantially static converter loads and supplied by synchronous generators, it is assumed

that the total voltage harmonic distortion does not exceed 5%, and the single harmonic does not exceed 3% of the nominal voltage.

ii) For components intended for systems fed by static converters, and/or systems in which the static converter load predominates, it is assumed that:

1) the single harmonics distortion does not exceed 5% of the nominal voltage up to the 15th harmonic of the nominal frequency, decreasing to 1% at the 100th harmonic and that
2) the total harmonic distortion does not exceed 8%.

iii) Higher values for the harmonic content in the propulsion plant may be accepted where all installed equipment and systems have been designed for a higher specified limit. This relaxation on limits is to be documented (harmonic distortion calculation report).

2.3. Electromagnetic susceptibility

a)

i) For electronic type components such as sensors, alarm panels, automatic and remote control equipment, protective devices and speed regulators, the conducted and radiated disturbance levels are to be assumed.

ii) Electrical and electronic equipment on the bridge and in the vicinity of the bridge, not required neither by classification rules nor by International Conventions and liable to cause electromagnetic disturbance, shall be of type which fulfill test requirements.

2.4. Materials

a) General

i) In general, and unless it is adequately protected, all electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials which are not subject to deterioration in the atmosphere and at the temperatures to which they are likely to be exposed. Particular consideration is to be given to sea air and oil vapor contamination.

ii) Where the use of incombustible materials or lining with such materials is required, the incombustibility characteristics may be verified by means of the test cited in IEC Publication 60092-101 or in other recognised standards.

b) Insulating materials for windings

i) Insulated windings are to be resistant to moisture, sea air and oil vapor unless special precautions are taken to protect insulants against such agents.

ii) The insulation classes given in Table 8 may be used in accordance with IEC Publication 60085.

Table 8 Insulation Classes

Class	**Maximum continuous operating temperature, in °C**
A	105

Class	Maximum continuous operating temperature, in °C
E	120
B	130
F	155
H	180

2.5. Construction

a) General

i) All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

ii) The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also considering its arrangement on board.

iii) Enclosures are to be of adequate mechanical strength and rigidity.

iv) Enclosures for electrical equipment are generally to be of metal; other materials may be accepted for accessories such as connection boxes, socket-outlets, switches and luminaires. Other exemptions for enclosures or parts of enclosures not made of metal will be specially considered by *QRS Class*.

v) Cable entrances are not to impair the degree of protection of the relevant enclosure.

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

vii) All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

b) Degree of protection of enclosures

i) Electrical equipment is to be protected against the ingress of foreign bodies and water.

ii) The degrees of protection are to be in accordance with:

1) IEC Publication No. 60529 for equipment in general
2) IEC Publication No. 60034-5 for rotating machines.

2.6. Protection against explosion hazard

a) Protection against explosive gas or vapor atmosphere hazard

i) Electrical equipment intended for use in areas where explosive gas or vapor atmospheres may occur (oil tankers, liquefied gas carriers, chemical tankers, ro-ro spaces, paint stores, ballast water management systems etc.), is to be of a "safe type" suitable for the relevant flammable atmosphere and for shipboard use.

ii) The following “certified safe type” equipment is considered:

1) intrinsically-safe: Ex(ia) - Ex(ib)
2) flameproof: Ex(d)
3) increased safety: Ex(e)
4) pressurized enclosure: Ex(p)
5) encapsulated: Ex(m)
6) sand filled: Ex(q)
7) special protection: Ex(s) (apparatus not conforming with IEC 60079 may be considered safe by a national or other authorized body for use in potentially explosive atmospheres. In such cases, the apparatus is identified with the symbol “s”)
8) oil-immersed apparatus (only when required by the application): Ex(o).

iii) Other equipment complying with types of protection may be considered by QRS Class, such as:

1) simple electrical apparatus and components (thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules
2) electrical apparatus specifically designed and certified by the appropriate authority for use in Zone 0 or specially tested for Zone 2 (type “n” protection)
3) equipment the type of which ensures the absence of sparks and arcs and of “hot spots” during its normal operation
4) pressurized equipment

5) equipment having an enclosure filled with a liquid dielectric, or encapsulated.

b) Protection against combustible dust hazard

i) Electrical appliances intended for use in areas where a combustible dust hazard may be present are to be arranged with enclosures having a degree of protection and maximum surface temperature suitable for the dust to which they may be exposed.

Electrical Installations

Section 3 System Design

3.1. Supply systems and characteristics of the supply

a) Supply systems

i) The following distribution systems may be used:

a. on d.c. installations:

- two-wire insulated
- two-wire with one pole earthed

b. on a.c. installations:

- three-phase three-wire with neutral insulated
- three-phase three-wire with neutral directly earthed or earthed through an impedance
- three-phase four-wire with neutral directly earthed or earthed through an impedance
- single-phase two-wire insulated
- single-phase two-wire with one phase earthed.

ii) Alternate Distribution systems will be considered by QRS Class on a case by case basis.

iii) The hull return system of distribution is not to be used for power, heating or lighting in any ship of 1600 gross tonnage and upwards.

b) Maximum voltages

i) The maximum voltages for both alternating current and direct current low-voltage systems of supply for the ship's services are given in Table 1.

ii) Voltages exceeding those shown will be specially considered in the case of specific systems.

Table 1 Maximum voltages for various ship services

Use		**Maximum voltage V**
For permanently installed and connected to fixed wiring	Power equipment	1000
	Heating equipment (except in accommodation spaces)	500
	Cooking equipment	500
	Lighting	250
	Space heaters in accommodation spaces	250
	Control, communication (including signal lamps) and instrumentation equipment	250

Use		Maximum voltage V
For permanently installed and connected by flexible cable	Power and heating equipment, where such connection is necessary because of the application (moveable cranes, hoisting gear, etc.)	1000
For socket-outlets supplying	Portable appliances which are not hand-held during operation (refrigerated	1000
	containers) by flexible cables	
	Portable appliances and other consumers by flexible cables	250
	Equipment requiring extra precaution against electric shock where a isolating	250
	transformer is used to supply one appliance	
	Equipment requiring extra precaution against electric shock with or without a safety	50
	transformer	

3.2. Sources of electrical power

a) General

i) Electrical installations are to be such that:

a) All electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions and for

the preservation of the cargo will be assured without recourse to the emergency source of electrical power.

b) Electrical services essential for safety will be assured under various emergency conditions.

c) When a.c. generators are involved, attention is to be given to the starting of squirrel-cage motors connected to the system, particularly regarding the effect of the magnitude and duration of the transient voltage change produced due to the maximum starting current and the power factor. The voltage drop due to such starting current is not to cause any motor already operating to stall or have any adverse effect on other equipment in use.

b) Main source of electrical power

i) A main source of electrical power is to be provided, of sufficient capability to supply all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions and for the preservation of the cargo without recourse to the emergency source of electrical power.

ii) The main source of electrical power is to consist of at least two generating sets. The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary. Such capacity is, in addition, sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

iii) Those services necessary to provide normal operational conditions of propulsion and safety include primary and secondary essential services.

iv) Further to the provisions above, the generating sets shall be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets shall be capable of providing the electrical services necessary to start the main propulsion plant from a “dead ship” condition.

v) Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services and, if necessary, secondary essential services and those provided for habitability, should be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.

vi) Where the electrical power is normally supplied by one generator, provision is to be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s) of sufficient capacity to supply the primary essential services and to ensure the safety of the ship, with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of the stand-by generator is to be preferably within 30 seconds, but in any case, not more than 45 seconds after loss of power.

vii) Load shedding or other equivalent arrangements should be provided to protect the generators required in the present Article against sustained overload.

viii) The arrangement of the ship's main source of electrical power shall be such that essential services can be maintained regardless of the speed and direction of rotation of the main propulsion machinery or shafting.

ix) Generators driven by the propulsion plant (shaft generators) which are intended to operate at constant speed (CPP´s) may be accepted as forming part of the main source of electrical power if, in all sailing and maneuvering conditions including the propeller being stopped, the capacity of these generators is sufficient to provide electrical power demand. They are to be not less effective and reliable than the independent generating sets.

x) Shaft generator installations may be used as additional sources of electrical power.

vi) Where transformers, converters or similar appliances constitute an essential part of the electrical supply system, the system is to be so arranged as to ensure the same continuity of supply as stated in this sub-article.

xii) Where single phase transformers are used, only one spare element is required if special precautions are taken to rapidly replace the faulty one.

xiii) Generators and generator systems, having the ship propulsion machinery as their prime mover but not forming part of the ship

main source of electrical power, may be used whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions.

c) Emergency source of electrical power

i) A self-contained emergency source of electrical power shall be provided.

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

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

iv) The emergency source of electrical power shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least basic services for the period specified, if they depend upon an electrical source for their operation.

v) The transitional source of emergency electrical power, where required, is to be of sufficient capacity to supply at least basic services for half an hour, if they depend upon an electrical source for their operation.

vi) An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged.

vii) If the services which are to be supplied by the transitional source receive power from an accumulator battery by means of semiconductor converters, means are to be provided for supplying such services also in the event of failure of the converter (providing a bypass feeder or a duplication of converter).

viii) Where electrical power is necessary to restore propulsion, the capacity of the emergency source shall be sufficient to restore propulsion to the ship in conjunction with other machinery as appropriate from a dead ship condition within 30 min. after the blackout.

ix) Where the emergency source of power is necessary to restore the main source of electrical power, provisions are to be made to allow a manual restart of a main generating set in case of failure of the emergency source.

x) Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements, where provided.

xi) The emergency source of electrical power may be either a generator or an accumulator battery.

xii) The transitional source of emergency electrical power shall consist of an accumulator battery which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour.

xiii) Where the emergency and/or transitional emergency loads are supplied from a battery via an electronic converter or inverter, the maximum permitted d.c. voltage variations are to be taken as those on the load side of the converter or inverter.

xiv) If the emergency generator is fitted with control, alarm and safety systems based on electronic equipment, these systems are to be so arranged that, when in failure, there is still a possibility to operate the emergency generator manually.

d) Use of emergency generator in port

i) To prevent the generator or its prime mover from becoming overloaded when used in port, arrangements are to be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

ii) The prime mover is to be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as requested for the prime mover for main power generation and for unattended operation.

iii) The fuel oil supply tank to the prime mover is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for 18 hours of emergency services.

iv) The prime mover is to be designed and built for continuous operation and should be subjected to a planned maintenance scheme ensuring that it is always available and capable of fulfilling its role in the event of an emergency at sea.

v) Fire detectors are to be installed in the location where the emergency generator set and emergency switchboard are installed.

vi) Means are to be provided to readily change over to emergency operation.

vii) Control, monitoring and supply circuits for the purpose of the use of the emergency generator in port are to be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services.

viii) Instructions are to be provided on board to ensure that, even when the vessel is underway, all control devices (valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard.

3.3. Distribution

a) Earthed distribution systems

i) System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts.

ii) Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance or insulation resistance measurements.

iii) Generator neutrals may be connected in common, provided that the third harmonic content of the voltage waveform of each generator does not exceed 5%.

iv) Where a switchboard is split into sections operated independently or where there are separate switchboards, neutral earthing is to be provided for each section or for each switchboard. Means are to be provided to ensure that the earth connection is not removed when generators are isolated.

v) Where for final sub-circuits it is necessary to locally connect a pole (or phase) of the sub-circuits to earth after the protective devices (in automation systems or to avoid electromagnetic disturbances), provision (d.c./d.c. converters or transformers) is to be made such that current unbalances do not occur in the individual poles or phases.

b) Insulated distribution systems

i) Every insulated distribution system, whether primary or secondary, for power, heating or lighting, shall be provided with a device capable of continuously monitoring the insulation level to earth (i.e.

the values of electrical insulation to earth) and of giving an audible and visual indication of abnormally low insulation values.

c) Distribution systems with hull return

i) Where the hull return system is used, if permitted, all final sub-circuits, i.e. all circuits fitted after the last protective device, shall be two-wire. The hull return is to be achieved by connecting to the hull one of the busbars of the distribution board from which the final sub- circuits originate.

d) General requirements for distribution systems

i) The distribution system is to be such that the failure of any single circuit will not endanger or impair primary essential services and will not render secondary essential services inoperative for longer periods.

ii) No common switchgear (contactors for emergency stop) is to be used between the switchboard's busbars and two primary non duplicated essential services.

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

e) Main distribution of electrical power

i) Where the main source of electrical power is necessary for propulsion of the ship, the main busbar is to be divided into at least two parts which are normally to be connected by circuit breakers or other approved means such as circuit breakers without tripping mechanisms or disconnecting links or switches by means of which busbars can be split safely and easily.

ii) Two or more units serving the same consumer (main and standby lubricating oil pumps) are to be supplied by individual separate circuits without the use of common feeders, protective devices or control circuits.

iii) A main electric lighting system which shall provide illumination throughout those parts of the ship normally accessible to and used by crew shall be supplied from the main source of electrical power.

f) Emergency distribution of electrical power

i) The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short-circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

ii) In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the

emergency switchboard to ensure that power shall be available to the emergency circuits.

iii) Internal communication equipment required in an emergency includes generally for communication between the bridge and the engine room, the steering gear room and the radio communication station and the Public Address system.

iv) Internal signals required in an emergency generally include general alarm and watertight door indication.

v) In a ship engaged regularly in voyages of short duration, i.e. voyages where the route is no greater than 20 nautical miles offshore or where the vessel has a class notation “Coastal Navigation”, QRS Class may, if satisfied that an adequate standard of safety would be attained, accept a lesser period than 18-hours, but not less than 12 hours.

g) Shore supply

i) Where arrangements are made for supplying the electrical installation from a source on shore or elsewhere, a suitable connection box is to be installed on the ship in a convenient location.

ii) Permanently fixed cables of adequate rating are to be provided for connecting the box to the main switchboard.

iii) Where necessary for systems with earthed neutrals, the box is to be provided with an earthed terminal for connection between the

shore's and ship's neutrals or for connection of a protective conductor.

iv) The connection box is to contain a circuit-breaker or a switch-disconnector and fuses.

v) Means are to be provided for checking the phase sequence of the incoming supply in relation to the ship's system.

vi) The cable connection to the box is to be provided with at least one switch-disconnector on the main switchboard.

vii) The shore connection is to be provided with an indicator at the main switchboard to show when the cable is energized.

viii) At the connection box, notice is to be provided giving information on nominal voltage and frequency of installation.

ix) The switch-disconnector on the main switchboard is to be interlocked with the main generator circuit-breakers in order to prevent its closure when any generator is supplying the main switchboard.

x) Adequate means are to be provided to equalize the potential between the hull and the shore when the electrical installation of the ship is supplied from shore.

h) Supply of motors

i) A separate final sub-circuit is to be provided for every motor required for an essential service (and for every motor rated at 1 kW or more).

ii) Each motor is to be provided with control gear ensuring its satisfactory starting.

iii) Efficient means are to be provided for the isolation of the motor and its associated control gear from all live poles of the supply.

iv) Unless automatic restarting is required, motor control circuits are to be designed so as to prevent any motor from unintentional automatic restarting after a stoppage due to overcurrent tripping or a fall in or loss of voltage, if such starting is liable to cause danger. Where reverse-current braking of a motor is provided, provision is to be made for the avoidance of reversal of the direction of rotation at the end of braking, if such reversal may cause danger.

i) Specific requirements for special power service

i) All power circuits terminating in a bunker or cargo space are to be provided with a multiple-pole switch outside the space for disconnecting such circuits.

j) Reefer containers

i) Where the ship is intended to carry a large number of refrigerated containers, provision of suitable means for preventing earth faults on containers from affecting the main distribution system is to be

made (galvanic isolation, tripping of the faulty circuit).

k) Power supply to final sub-circuits: socket outlet and lighting

i) Final sub-circuits for lighting supplying more than one lighting point and for socket-outlets are to be fitted with protective devices having a current rating not exceeding 16 A.

ii) In critical spaces there is to be more than one final sub-circuit for lighting such that failure of any one circuit does not reduce the lighting to an insufficient level.

iii) All lighting circuits terminating in a bunker or cargo space are to be provided with a multiple-pole switch outside the space for disconnecting such circuits.

iv) Final sub-circuits for lighting in accommodation spaces may include socket-outlets. In that case, each socket-outlet counts for two lighting points.

l) Navigation lights

i) Navigation lights are to be connected separately to a distribution board specially reserved for this purpose.

ii) The distribution board is to be supplied from two alternative circuits, one from the main source of power and one from the emergency source of power.

iii) Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board.

iv) Where there are double navigation lights, i.e. lights with two lamps or where for every navigation light a spare is also fitted, the connections to such lights may run in a single cable provided that means are foreseen in the distribution board to ensure that only one lamp or light may be supplied at any one time.

v) Each navigation light is to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of the light. If an audible device alone is fitted, it is to be connected to a separate source of supply from that of the navigation lights, for example an accumulator (storage) battery.

m) General emergency alarm system

i) An electrically operated bell or klaxon or other equivalent warning system installed for sounding the general emergency alarm signal, is to comply with the requirements of this sub-article.

ii) The general emergency alarm system is to be supplemented by either a public address system or other suitable means of communication.

iii) Entertainment sound system is to be automatically turned off when the general alarm system is activated.

iv) The system is to be continuously powered and is to have an automatic change-over to a standby power supply in case of loss of normal power supply.

v) The system is to be powered by means of two circuits, one from the ship's main supply and the other from the emergency source of electrical power.

vi) The system is to be capable of operation from the navigation bridge and, except for the ship’s whistle, also from other strategic points.

vii) The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

viii) The alarm system is to be audible throughout all the accommodation and normal crew working spaces.

ix) The minimum sound pressure level for the emergency alarm tone in interior and exterior spaces is to be 80 dB (A) and at least 10 dB (A) above ambient noise levels occurring during normal equipment operation with the ship underway in moderate weather.

x) In cabins without a loudspeaker installation, an electronic alarm transducer, a buzzer or similar, is to be installed.

xi) The sound pressure level at the sleeping position in cabins and in cabin bathrooms is to be at least 75 dB (A) and at least 10 dB (A) above ambient noise levels.

n) Public address system

i) The public address system is to be a loudspeaker installation enabling the broadcast of messages into all spaces where people on board are normally present.

ii) Where the public address system is used to supplement the general emergency alarm system, it is to be continuously powered from the emergency source of electrical power.

iii) The system is to allow for the broadcast of messages from the navigation bridge and from other places on board the ship as deemed necessary.

iv) The system is to be protected against unauthorized use.

v) The system is to be installed with regard to acoustically marginal conditions and not require any action from the addressee.

vi) Where an individual loudspeaker has a device for local silencing, an override arrangement from the control station(s), including the navigating bridge, is to be in place.

o) Combined general emergency alarm-public address system

i) Where the public address system is the only means for sounding the general emergency alarm signal and the fire alarm, the following are to be satisfied:

1) the system automatically overrides any other non emergency input system when an emergency alarm is required

2) the system automatically overrides any volume control provided to give the required output for the emergency mode when an emergency alarm is required
3) the system is arranged to prevent feedback or other interference
4) the system is arranged to minimize the effect of a single failure so that the alarm signal is still audible (above ambient noise levels) also in the case of failure of any one circuit or component, by means of the use of:
    a) multiple amplifiers
    b) segregated cable routes to public rooms, alleyways, stairways and control stations
    c) more than one device for generating electronic sound signal
    d) electrical protection for individual loudspeakers against short-circuits.

p) Control and indication circuits

i) Control and indicating circuits relative to primary essential services are to be branched off from the main circuit in which the relevant equipment is installed. Equivalent arrangements may be accepted by QRS Class.

ii) Control and indicating circuits relative to secondary essential services and to non-essential services may be supplied by distribution systems reserved for the purpose to the satisfaction of QRS Class.

q) Power supply to the speed control systems of main propulsion engines

i) Electrically operated speed control systems of main engines are to be fed from the main source of electrical power.

ii) Where more than one main propulsion engine is foreseen, each speed control system is to be provided with an individual supply by means of separate wiring from the main switchboard or from two independent section boards.

iii) In the case of propulsion engines which do not depend for their operation on electrical power, i.e. pumps driven from the main engine, the speed control systems are to be fed both from the main source of electrical power and from an accumulator battery for at least 15 minutes or from a similar supply source.

r) Power supply to the speed control systems of generator sets

i) Each electrically operated control and/or speed control system of generator sets is to be provided with a separate supply from the main source of electric power and from an accumulator battery for at least 15 minutes or from a similar supply source.

ii) The speed control system of generator sets is to be supplied from the main switchboard or from independent section boards.

s) Installation of water-based local application fire-fighting systems

i) The system is to be capable of manual release.

ii) The activation of the fire-fighting system is not to result in loss of electrical power or reduction of the maneuverability of the ship.

iii) The system and its components are to be designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in machinery spaces. Components within the protected spaces are to be designed to withstand the elevated temperatures which could occur during a fire.

iv) Systems requiring an external power source are to be supplied by the main power source.

v) In case of activation of the system, an alarm is to be activated.

t) Integrated cargo and ballast systems on tankers

i) Integrated electric systems used to drive both cargo and ballast pumps on tankers, including control and safety systems, are to comply with specific requirements.

u) Harmonic distortion for ship electrical distribution system including harmonics filters

i) Where harmonic filters are installed on main busbars of electrical distribution systems, other than those installed for single application frequency drives such as pump motors, the ships are to be fitted with facilities to continuously monitor the levels of harmonic distortion experienced on the main busbar. The crew is to be

alerted when the level of harmonic distortion exceeds the acceptable limits.

ii) Where the electrical distribution system on board a ship includes harmonic filters the system integrator of the distribution system is to show, by calculation, the effect of a failure of a harmonic filter on the level of harmonic distortion experienced.

iii) The system integrator of the distribution system is to provide QRS Class, for information, with guidance documenting permitted modes of operation of the electrical distribution system while maintaining harmonic distortion levels within acceptable limits during normal operation as well as following the failure of any combination of harmonic filters

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

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

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

vii) Additional protection for the individual capacitor element such as relief valve or overpressure disconnector in order to protect against damage from rupturing may be considered, depending on

the type of capacitors used.

3.4. Degrees of protection of the enclosures

a) General

i. The minimum required degree of protection for electrical equipment, in relation to the place of installation, is generally that specified in Table 2.

ii. Equipment supplied at nominal voltages in excess of 500 V and accessible to non-authorised personnel (equipment not located in machinery spaces or in locked compartments under the responsibility of the ship's officers) is to have a degree of protection against touching live parts of at least IP 4X.

iii. The enclosures of electrical equipment for the monitoring and control of watertight doors which are situated below the bulkhead deck are to provide suitable protection against the ingress of water.

In particular, the minimum required degree of protection is to be:

1. IP X7 for electric motors, associated circuits and control components

2. IP X8 for door position indicators and associated circuit components

3. IP X6 for door movement warning signals.

vii. This requirement applies to ships with service notation bulk carrier, ore carrier or combination carrier and provided with a dewatering system. The enclosures of electrical equipment for the dewatering system installed in any of the forward dry spaces are to provide protection to IPX8 standard for a water head equal to the height of the space in which the electrical equipment is installed for a time duration of at least 24 hours.

Table 2 Minimum required degrees of protection

Condition in location	Example of location	Switch-board, control gear, motor starters	Genera-tors	Motors	Trans-formers	Lumi-naires	Heating appli-ances	Cooking appli-ances	Socket outlets	Accesso-ries (switches, connection boxes)
Danger of touching live parts only	Dry accommodation spaces, dry control rooms	IP 20	X	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Danger of dripping liquid and/or moderate mechanical damage	Control rooms, wheel-house, radio room	IP 22	X	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
	Engine and boiler rooms above floor	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
	Steering gear rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44

Condition in location	Example of location	Switch-board, control gear, motor starters	Genera-tors	Motors	Trans-formers	Lumi-naires	Heating appli-ances	Cooking appli-ances	Socket outlets	Accesso-ries (switches, connection boxes)
	Emergency machinery rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44
	General storerooms	IP 22	X	IP 22	IP 22	IP 22	IP 22	X	IP 22	IP 44
	Pantries	IP 22	X	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
	Provision rooms	IP 22	X	IP 22	IP 22	IP 22	IP 22	X	IP 44	IP 44
	Ventilation ducts	X	X	IP 22	X	X	X	X	X	X
Increased danger of liquid and/or mechanical damage	Bathrooms and / or showers	X	X	X	X	IP 34	IP 44	X	IP 55	IP 55
	Engine and boiler rooms below floor	X	X	IP 44	X	IP 34	IP 44	X	X	IP 55
	Closed fuel oil separator rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	X	IP 55
	Closed lubricating oil separator rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	X	IP 55
Increased danger of liquid and	Ballast pump rooms	IP 44	X	IP 44	IP 44	IP 34	IP 44	X	IP 55	IP 55
	Refrigerated rooms	X	X	IP 44	X	IP 34	IP 44	X	IP 55	IP 55

Condition in location	Example of location	Switch-board, control gear, motor starters	Genera-tors	Motors	Trans-formers	Lumi-naires	Heating appli-ances	Cooking appli-ances	Socket outlets	Accesso-ries (switches, connection boxes)
mechanical damage	Galleys and laundries	IP 44	X	IP 44	IP 44	IP 34	IP 44	IP 44	IP 44	IP 44
	Public bathrooms and shower	X	X	IP 44	IP 44	IP 34	IP 44	X	IP 44	IP 44
Danger of liquid spraying, presence of cargo dust, serious mechanical damage, aggressive fumes	Shaft or pipe tunnels in double bottom	IP 55	X	IP 55	IP 55	IP 55	IP 55	X	IP 56	IP 56
	Holds for general cargo	X	X	IP 55	X	IP 55	IP 55	X	IP 56	IP 56
	Ventilation trunks	X	X	IP 55	X	X	X	X	X	X
Danger of liquid in massive quantities	Open decks	IP 56	X	IP 56	X	IP 55	IP 56	X	IP 56	IP 56

b) Installation of electrical and electronic equipment in engine rooms protected by fixed water- based local application fire-fighting systems

i. Unless it is essential for safety or operational purposes, electrical and electronic equipment is not to be located within areas protected

by water based fire fighting systems and in adjacent areas where water may extend.

- The electrical and electronic equipment located within areas protected by water based firefighting systems and those within adjacent areas exposed to direct spray are to have a degree of protection not less than IP44.

3.5. Diversity (demand) factors

a. General

i. The cables and protective devices of final sub-circuits are to be rated in accordance with their connected load.

ii. Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor.

iii. A diversity (demand) factor may be applied provided that the known or anticipated operating conditions in a particular part of an installation are suitable for the application of diversity.

3.6. Environmental categories of the equipment

a. Environmental categories

i. For ships operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to + 40°C instead of + 45°C.

3.7. Electrical protection

a) General requirements for overcurrent protection

i. Electrical installations are to be protected against accidental overcurrents including short-circuit.

The choice, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection in order to ensure as far as possible:

1. continuity of service in the event of a fault, through coordinated and discriminative action of the protective devices

2. elimination of the effects of faults to reduce damage to the system and the hazard of fire as far as possible.

ii. Devices provided for overcurrent protection are to be chosen according to the requirements, especially regarding overload and short-circuit.

iii. Systems are to be such as to withstand the thermal and electrodynamic stresses caused by the possible overcurrent, including short-circuit, for the admissible duration.

b) Short-circuit currents

i. In calculating the maximum prospective short-circuit current, the source of current is to include the most powerful configuration of generators which can be simultaneously connected (as far as permitted by any interlocking arrangements), and the maximum number of motors which are normally simultaneously connected in the system.

The maximum number of generators or transformers is to be evaluated without taking into consideration short-term parallel operation, provided that suitable interlock is foreseen.

ii. Short-circuit current calculations are to be performed in accordance with a method recognized by QRS Class, such as that given in IEC Publication 61363-1.

iii. Converters used for power supply are to supply a short-circuit current sufficient for selective tripping of downstream protective devices without sustaining any internal damage. An automatic bypass may be used to achieve such selective tripping.

c) Selection of equipment

i. Circuit-breakers of withdrawable type are required where they are not suitable for isolation.

ii. Equipment is to be chosen based on its rated current and its making/breaking capacity.

iii. In the selection of circuit-breakers with intentional short-time delay for short-circuit release, those of utilization category B are to be used and they are to be selected also taking into account their rated short-time withstand current capacity (Icw).

For circuit-breakers without intentional short-time delay for short-circuit release, circuit breakers of utilization category A may be used and they are to be selected according to their rated service short-circuit breaking capacity (Ics).

iv. For duplicated essential services and non-essential services, circuit-breakers may be selected according to their ultimate short-circuit breaking capacity (Icu).

v. For switches, the making/breaking capacity is to be in accordance with utilization category AC-22 A or DC-22 A (in compliance with IEC Publication 60947-3).

vi. For fuse-switch disconnectors or switch-disconnector fuse units, the making/breaking capacity is to be in accordance with utilization categories AC-23 A or DC-23 A (in compliance with IEC Publication 60947-3).

d. Protection against short-circuit

i. Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

ii. The rated short-circuit breaking capacity of every protective device is to be not less than the maximum prospective value of the short-circuit current at the point of installation at the instant of contact separation.

iii. The rated short-circuit making capacity of every mechanical switching device intended to be capable of being closed on short-circuit is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

iv. Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short- circuit current liable to occur at the point of installation having regard to the time required for the short-circuit to be removed.

v. The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is permitted, provided that it is backed up on the generator side by a fuse or by a circuit-breaker having at least the necessary short-circuit rating and not being the generator circuit-breaker.

vi. The same fuse or circuit-breaker may back up more than one circuit-breaker where the circuits concerned do not involve essential services.

vii. The short-circuit performance of the back-up arrangement is to be equal to the requirements of IEC Publication 60947-2 for a single

circuit-breaker having the same short-circuit performance category as the backed-up circuit-breaker and rated for the maximum prospective short-circuit level at the supply terminals of the arrangement.

viii. Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuses and the circuit-breakers are of coordinated design, in order to ensure that the operation of the fuses takes place in due time so as to prevent arcing between poles or against metal parts of the circuit-breakers when they are submitted to overcurrents involving the operation of the fuse.

ix. When determining the performance requirements for the above-mentioned back-up protection arrangement, it is permissible to take into account the impedance of the various circuit elements of the arrangement, such as the impedance of a cable connection when the backed-up circuit-breaker is located away from the back-up breaker or fuse.

e. Continuity of supply and continuity of service

i. The protection of circuits is to be such that a fault in one service does not cause the loss of any essential services.

ii. The protection of the emergency circuit is to be such that a failure in one circuit does not cause a loss of other emergency services.

f. Protection against overload

i. Devices provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

ii. The use of fuses up to 320 A for overload protection is permitted.

g. Localisation of overcurrent protection

i. Short-circuit protection is to be provided for every non-earthed conductor.

ii. Overload protection is to be provided for every non-earthed conductor; nevertheless, in insulated single-phase circuits or insulated three-phase circuits having substantially balanced loads, the overload protection may be omitted on one conductor.

iii. Short-circuit and overload protective devices are not to interrupt earthed conductors, except in the case of multiple disconnection devices which simultaneously interrupt all the conductors, whether earthed or not.

iv. Electrical protection is to be located as close as possible to the origin of the protected circuit.

h. Protection of generators

i. Generators are to be protected against short-circuits and overloads by multipole circuit-breakers. For generators not arranged to operate in parallel with a rated output equal to or less than 50 kVA,

a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

ii. When multipole switch and fuses are used, the fuse rating is to be maximum 110% of the generator rated current.

iii. For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in a permanently attended space.

iv. After disconnection of a generator due to overload, the circuit-breaker is to be ready for immediate reclosure.

v. Generator circuit-breakers are to be provided with a reclosing inhibitor which prevents their automatic reclosure after tripping due to a short-circuit.

vi. Generators having a capacity of 1500 kVA or above are to be equipped with a suitable protective device or system which, in the event of a short-circuit in the generator or in the supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker (by means of differential protection).

vii. Where the main source of electrical power is necessary for the propulsion of the ship, load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

viii. Arrangements are to be made to disconnect or automatically reduce the excess load when the generators are overloaded in

such a way as to prevent a sustained loss of speed and/or voltage. The operation of such device is to activate a visual and audible alarm. A time delay of 5-20 s is considered acceptable.

ix. When an overload is detected the load shedding system is to disconnect automatically, after an appropriate time delay, the circuits supplying the non-essential services and, if necessary, the secondary essential services in a second stage.

x. Alternating current generators arranged to operate in parallel are to be provided with reverse-power protection. The protection is to be selected in accordance with the characteristics of the prime mover.

xi. Generators are to be provided with an undervoltage protection which trips the breaker if the voltage falls to 70%-35% of the rated voltage.

xii. Generators are to be provided with overvoltage protection to avoid damage to the connected equipment.

i. Protection of circuits

i. Each separate circuit shall be protected against short-circuit and against overload, unless otherwise specified in these Rules or where QRS Class may exceptionally otherwise permit.

ii. Each circuit is to be protected by a multipole circuit-breaker or switch and fuses against overloads and short-circuits.

iii. Circuits for lighting are to be disconnected on both non-earthed conductors. Single-pole disconnection of final sub-circuits with both poles insulated is permitted only in accommodation spaces, when a differential protection is provided.

iv. The protective devices of the circuits supplying motors are to allow excess current to pass during transient starting of motors.

v. Final sub-circuits which supply one consumer with its own overload protection (for example motors), or consumers which cannot be overloaded (for example permanently wired heating circuits and lighting circuits), may be provided with short-circuit protection only.

vi. Steering gear circuits are to be provided with short-circuit protection only.

j. Protection of motors

i. Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable.

ii. For motors intended for essential services, the overload protection may be replaced by an overload alarm.

iii. The protective devices are to be designed so as to allow excess current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use.

iv. For continuous duty motors the protective gear is to have a time delay characteristic which ensures reliable thermal protection against overload.

v. The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105%

   a) 120% of the motor's rated full load current.

vi. For intermittent duty motors the current setting and the delay (as a function of time) of the protective devices are to be chosen in relation to the actual service conditions of the motor.

vii. Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

viii. Motors rated above 1 kW are to be provided with:

   1. undervoltage protection, operative on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted or
   2. undervoltage release, operative on the reduction or failure of voltage, so arranged that the motor restarts automatically when power is restored after a power failure.

ix. The automatic restart of a motor is not to produce a starting current such as to cause excessive voltage drop.

x. The under voltage protective devices are to allow the motor to be started when the voltage exceeds 85% of the rated voltage and are to intervene without fail when the voltage drops to less than approximately 20% of the rated voltage, at the rated frequency and with a time delay as necessary.

k. Protection of storage batteries

i. Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers.

ii. Emergency batteries supplying essential services are to have short-circuit protection only.

l. Protection of shore power connection

i. Permanently fixed cables connecting the shore connection box to the main switchboard are to be protected by fuses or circuit-breakers.

m. Protection of measuring instruments, pilot lamps and control circuits

i. Measuring circuits and devices (voltage transformers, voltmeters, voltage coils of measuring instruments, insulation monitoring devices etc.) and pilot lamps are to be protected against short-circuit by means of multipole circuit-breakers or fuses.

ii. Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole

circuit-breakers or fuses on each pole not connected to earth. Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side. The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

iii. Where a fault in a pilot lamp would impair the operation of essential services, such lamps are to be protected separately from other circuits such as control circuits.

iv. Circuits whose failure could endanger operation, such as steering gear control feeder circuits, are to be protected only against short-circuit.

v. The protection is to be adequate for the minimum cross-section of the protected circuits.

n. Protection of transformers

i. The primary winding side of power transformers is to be protected against short-circuit and overload by means of multipole circuit-breakers or switches and fuses.

ii. The protection against short-circuit is to be such as to ensure the selectivity between the circuits supplied by the secondary side of the transformer and the feeder circuit of the transformer.

iii. When transformers are arranged to operate in parallel, means are to be provided so as to trip the switch on the secondary winding

side when the corresponding switch on the primary side is open.

3.8. System components

a. General

i. The components of the electrical system are to be dimensioned such as to withstand the currents that can pass through them during normal service without their rating being exceeded.

ii. The components of the electrical system are to be designed and constructed so as to withstand for the admissible duration the thermal and electrodynamic stresses caused by possible overcurrents, including short-circuit.

3.9. Electrical cables

a. General

i. All electrical cables and wiring external to equipment shall be at least of a flame-retardant type.

ii. Cables and insulated wiring are generally to be chosen and installed in accordance with IEC Publications 60092-352, as well with the provisions of this Chapter.

b. Choice of insulation

i. The maximum rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to occur or to be produced in the space where the cable is installed.

ii. The maximum rated conductor temperature for normal and short-circuit operation, for the type of insulating compounds normally used for shipboard cables, is not to exceed the values stated in Table 4. Special consideration will be given to other insulating materials.

iii. PVC-ST2 insulated cables are not to be used either in refrigerated spaces, or on decks exposed to the weather of ships classed for unrestricted service.

iv. Mineral insulated cables will be considered on a case by case basis.

Table 4 Maximum rated conductor temperature

Type of insulating compound	**Maximum rated conductor temperature, in °C**	
	Normal operation	**Short-circuit**
a) Thermoplastic: - based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	70	150
b) Elastomeric or thermoset:		

Type of insulating compound	Maximum rated conductor temperature, in °C	
	Normal operation	Short-circuit
- based upon ethylene-propylene rubber or similar	90	250
- based upon high modulus or hard grade ethylene propylene rubber	90	250
- based upon cross-linked polyethylene	90	250
- based upon silicone rubber	95	350
- based upon ethylene-propylene rubber or similar halogen-free	90	250
- based upon high modulus or hard grade halogen-free ethylene propylene rubber	90	250
- based upon halogen-free cross-linked polyethylene	90	250
- based upon halogen-free silicone rubber	95	350
- based upon cross-linked polyolefin material for halogen-free cables	90	250

c. Choice of protective covering

i. The conductor insulating materials are to be enclosed in an impervious sheath of material appropriate to the expected ambient conditions where cables are installed in the following locations:

1. on decks exposed to the weather
2. in damp or wet spaces
3. in refrigerated spaces
4. in machinery spaces and, in general
5. where condensation water or harmful vapor may be present.

ii. Where cables are provided with armor or metallic braid such as those in hazardous areas, an overall impervious sheath or other means to protect the metallic elements against corrosion is to be provided.

iii. An impervious sheath is not required for single-core cables installed in tubes or ducts inside accommodation spaces, in circuits with maximum system voltage 250 V.

iv. In choosing different types of protective coverings, due consideration is to be given to the mechanical action to which each cable may be subjected during installation and in service. If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected by an armor or by installation inside pipes or conduits.

v. Single-core cables for a.c. circuits with rated current exceeding 20 A are to be either non-armoured or armored with non- magnetic material.

d. Cables in refrigerated spaces

i. Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical

damage. If an armor is applied on the sheath, the armor is to be protected against corrosion by a further moisture-resistant covering.

e. Cables in circuits required to be operable under fire condition

i. 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
10. remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

ii. Where cables for services specified in 9.6 (i) including their power supplies pass through high fire risk areas, they are to be so arranged so that a fire in any of these areas does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

- Cables being of a fire resistant type are to be installed and run continuous to keep fire integrity within high fire risk area
- 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.
- Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

iii. Cables connecting fire pumps to the emergency switchboard shall be of a fire-resistant type where they pass through high fire risk areas.

f. Cables for submerged bilge pumps

i. Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cable is to be impervious-sheathed and armored, is to be installed in continuous lengths from above the bulkhead to the motor terminals and is to enter the air bell from the

bottom.

g. Internal wiring of switchboards and other enclosures for equipment

i. For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath).

h. Current carrying capacity of cables

i. The current carrying capacity for continuous service of cables given in Table 5 to Table 9 is based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

ii. Values other than those shown in Table 5 to Table 9 may be accepted provided they are determined on the basis of calculation methods or experimental values approved by QRS Class.

iii. When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Table 10 may be applied to the current carrying capacity in Table 5 to Table 9.

iv. Where more than six cables are bunched together in such a way that there is an absence of free air circulating around them, and the cables can be expected to be under full load simultaneously, a correction factor of 0,85 is to be applied.

v. Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service such mooring winches or bow thruster propellers,

the current carrying capacity obtained from Table 5 to Table 9 may be increased by applying the corresponding correction factors given in Table 11.

vi. The current carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors but the cables must have equal impedance, equal cross-section, equal maximum permissible conductor temperatures and follow substantially identical routing or be installed in close proximity. Connections in parallel are only permitted for cross-sections of 10 mm2 or above. When equal impedance can not be assumed, a correction factor of 0,9 is to be applied to the current carrying capacity.

Table 5 Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 60°C (ambient temperature 45°C)

Nominal section, in mm2	**Number of conductors**		
	1	**2**	**3 or 4**
1,5	10	9	7
2,5	17	14	12
4	23	20	16
6	29	25	20
10	40	34	28
16	54	46	38
25	71	60	50

Nominal section, in mm2	Number of conductors		
	1	2	3 or 4
35	88	75	62
50	110	94	77
70	135	115	95
95	164	139	115
120	189	161	132
150	218	185	153
185	248	211	174
240	292	248	204
300	336	286	235
400	dc: 390 ac: 380	dc: 332 ac: 323	dc: 273 ac: 266
500	dc: 450 ac: 430	dc: 383 ac: 366	dc: 315 ac: 301
630	dc: 520 ac: 470	dc: 442 ac: 400	dc: 364 ac: 329

Table 6 Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 85°C (ambient temperature 45°C)

Nominal section, in mm2	Number of conductors		
	1	2	3 or 4
1,5	21	18	15
2,5	28	24	20
4	38	32	27
6	49	42	34
10	67	57	47
16	91	77	64
25	120	102	84
35	148	126	104
50	184	156	129
70	228	194	160
95	276	235	193
120	319	271	223
150	367	312	257
185	418	355	293
240	492	418	344
300	565	480	396
400	dc: 650	dc: 553	dc: 455

Nominal section, in mm2	Number of conductors		
	1	2	3 or 4
	ac: 630	ac: 536	ac: 441
500	dc: 740 ac: 680	dc: 629 ac: 578	dc: 518 ac: 476
630	dc: 840 ac: 740	dc: 714 ac: 629	dc: 588 ac: 518

Table 7 Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 70°C (ambient temperature 45°C)

Nominal section, in mm2	Number of conductors		
	1	2	3 or 4
1,5	15	13	11
2,5	21	18	15
4	29	25	20
6	37	31	26
10	51	43	36
16	68	58	48
25	90	77	63
35	111	94	78
50	138	117	97

Nominal section, in mm2	Number of conductors		
	1	2	3 or 4
70	171	145	120
95	207	176	145
120	239	203	167
150	275	234	193
185	313	266	219
240	369	314	258
300	424	360	297
400	dc: 500 ac: 490	dc: 425 ac: 417	dc: 350 ac: 343
500	dc: 580 ac: 550	dc: 493 ac: 468	dc: 406 ac: 385
630	dc: 670 ac: 610	dc: 570 ac: 519	dc: 469 ac: 427

Table 8 Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 90°C (ambient temperature 45°C)

Nominal section (mm2)	Number of conductors		
	1	2	3 or 4
1,5	23	20	16

Nominal section (mm2)	Number of conductors		
	1	2	3 or 4
2,5	30	26	21
4	40	34	28
6	52	44	36
10	72	61	50
16	96	82	67
25	127	108	89
35	157	133	110
50	196	167	137
70	242	206	169
95	293	249	205
120	339	288	237
150	389	331	272
185	444	377	311
240	522	444	365
300	601	511	421
400	dc: 690 ac: 670	dc: 587 ac: 570	dc: 483 ac: 469
500	dc: 780 ac: 720	dc: 663 ac: 612	dc: 546 ac: 504
630	dc: 890 ac: 780	dc: 757 ac: 663	dc: 623 ac: 546

Table 9 Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 95°C (ambient temperature 45°C)

Nominal section (mm2)	Number of conductors		
	1	2	3 or 4
1,5	26	22	18
2,5	32	27	22
4	43	37	30
6	55	47	39
10	76	65	53
16	102	87	71
25	135	115	95
35	166	141	116
50	208	177	146
70	256	218	179
95	310	264	217
120	359	305	251
150	412	350	288
185	470	400	329
240	553	470	387
300	636	541	445
400	dc: 760	dc: 646	dc: 532

Nominal section (mm2)	Number of conductors		
	1	2	3 or 4
	ac: 725	ac: 616	ac: 508
500	dc: 875 ac: 810	dc: 744 ac: 689	dc: 612 ac: 567
630	dc: 1010 ac: 900	dc: 859 ac: 765	dc: 707 ac: 630

Table 10 Correction factors for various ambient air temperatures

Maximum conductor temperature, in °C	Correction factors for ambient air temperature of:										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
60	1,29	1,15	1,00	0,82							
65	1,22	1,12	1,00	0,87	0,71						
70	1,18	1,10	1,00	0,89	0,77	0,63					
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58				
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53			
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50		
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 11 Correction factors for short-time loads

1/2-hour service		1-hour service		Correction factor
Sum of nominal cross-sectional areas of all conductors, in mm2		Sum of nominal cross-sectional areas of all conductors, in mm2		
Cables with metallic sheath and armored cables	Cables with non-metallic sheath and non-armored cables	Cables with metallic sheath and armored cables	Cables with non-metallic sheath and non-armored cables	
up to 20	up to 75	up to 80	up to 230	1,06
21 - 41	76 - 125	81 - 170	231 - 400	1,10
41 - 65	126 - 180	171 - 250	401 - 600	1,15
66 - 95	181 - 250	251 - 430	601 - 800	1,20
96 - 135	251 - 320	431 - 600		1,25
136 - 180	321 - 400	601 - 800		1,30
181 - 235	401 - 500			1,35
236 - 285	501 - 600			1,40
286 - 350				1,45

i. Minimum nominal cross-sectional area of conductors

i. In general the minimum allowable conductor cross-sectional areas are those given in Table 12.

ii. The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm2. In such a case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

Table 12 Minimum nominal cross-sectional areas

Service	**Nominal cross-sectional area, in mm2**	
	External wiring	**Internal wiring**
Power, heating and lighting systems	1,0	1,0
Control circuits for power plant	1,0	1,0
Control circuits other than those for power plant	0,75	0,5
Control circuits for telecommunications, measurement, alarms	0,5	0,2
Telephone and bell equipment, not required for the safety of the ship or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

j. Choice of cables

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

ii. The nominal cross-sectional area of each cable is to be sufficient to satisfy the following conditions with reference to the maximum anticipated ambient temperature:

1. the current carrying capacity is to be not less than the highest continuous load carried by the cable

2. the voltage drop in the circuit, by full load on this circuit, is not to exceed the specified limits

3. the cross-sectional area calculated based on the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

iii. The highest continuous load carried by a cable is to be calculated based on the power requirements and of the diversity factor of the loads and machines supplied through that cable.

iv. When the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard busbars to any point in the installation is not to exceed 6% of the nominal voltage.

v. For battery circuits with supply voltage less than 55 V, this value may be increased to 10%.

vi. For the circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.

3.10. Electrical installations in hazardous areas

a. Electrical equipment

i. No electrical equipment is to be installed in hazardous areas unless QRS Class is satisfied that such equipment is:

ii. essential for operational purposes

iii. of a type which will not ignite the mixture concerned

iv. appropriate to the space concerned, and

v. appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

vi. Where electrical equipment of a safe type is permitted in hazardous areas it is to be selected with due consideration in regards to risk of explosive dust concentration and risk of explosive atmosphere.

vii. Where electrical equipment is permitted in hazardous areas, all switches and protective devices are to interrupt all poles or phases and, where practicable, to be located in a non-hazardous area unless specifically permitted otherwise.

- Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

viii. Electrical installations in hazardous areas are to be inspected by skilled personnel at their initial installation. The requirements of IEC 60079-17 apply.

ix. For electrical equipment installed in Zone 0 hazardous areas, only the following types are permitted:

- Certified intrinsically safe apparatus Ex(ia)
- Simple electrical apparatus and components such as thermocouples, photocells, strain gauges, junction boxes, switching devices, included in intrinsically-safe circuits of category “ia” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority
- Equipment specifically designed and certified by the appropriate authority for use in Zone 0.

x. For electrical equipment installed in Zone 1 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 0
- certified intrinsically-safe apparatus Ex(ib)
- simple electrical apparatus and components such as thermocouples, photocells, strain gauges, junction boxes, switching devices, included in intrinsically-safe circuits of category “ib” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority

- certified flameproof Ex(d)
- certified pressurised Ex(p)
- certified increased safety Ex(e)
- certified encapsulated Ex(m)
- certified sand filled Ex(q)
- certified specially Ex(s)
- through runs of cable.

xi. For electrical equipment installed in Zone 2 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 1
- tested specially for Zone 2
- pressurized, and accepted by the appropriate authority
- encapsulated, and accepted by the appropriate authority
- the type which ensures the absence of sparks and arcs and of "hot spots" during its normal operation.

xii. When apparatus incorporates a number of types of protection, it is to be ensured that all are suitable for use in the zone in which it is located.

b. Certified safe type documentation

i. Safe type certificates or equivalent documentation issued by an accredited or recognized certification body and established on a basis at least equivalent to the IEC 60079 series publication are to be submitted for each electrical equipment located in hazardous areas.

ii. For intrinsically safe circuits, a document describing the system is to be submitted to QRS Class, specifying the items of electrical equipment and the electrical parameters of the system, including those of interconnecting wiring. This document is not required in case a certificate defining the parameters for the complete intrinsically safe system is available. The requirements of IEC 60079-14 apply.

c. Electrical cables

i. Electrical cables are not to be installed in hazardous areas except as specifically permitted.

ii. All cables installed in Zone 0 or in Zone 1 are to be sheathed with at least one of the following:

iii. a non-metallic impervious sheath in combination with braiding or other metallic covering

iv. a copper or stainless steel sheath (for mineral insulated cables only).

v. All cables installed in non-weather exposed Zone 2 areas are to be provided with at least a non-metallic external impervious sheath.

vi. Cables of intrinsically safe circuits are to have a metallic shielding with at least a non-metallic external impervious sheath.

vii. The circuits of a category “ib” intrinsically safe system are not to be contained in a cable associated with a category “ia” intrinsically safe system required for a hazardous area in which only category “ia” systems are permitted.

d. Electrical installations in battery rooms

i. Only lighting fittings may be installed in compartments assigned solely to large-vented storage batteries.

ii. Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

iii. Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

e. Electrical installations in paint stores or enclosed spaces leading to paint stores

i. Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services. Certified safe type equipment only is acceptable. Cables (through runs or termination cables) of armored type or installed in metallic conduits are to be used.

ii. In the areas on the open deck within 1 m of inlet and exhaust ventilation openings of paint stores or 3 m of exhaust mechanical ventilation outlets of such spaces, all electrical equipment installed must be of paint store type, Class Ex(n), non-arc generating,
non-high temperature, and vapor proof.

iii. Minimum requirements are explosion group II B and temperature class T3.

iv. Switches, protective devices and motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and are preferably to be located in a non-hazardous space.

f. Hazardous area classification

i. The paint stores and supply and exhaust ventilation ducts serving such spaces are to be classified as Zone 1

ii. Areas on open deck within 1 m of inlet and exhaust ventilation openings of paint stores or within 3 m of exhaust mechanical ventilation outlets of such spaces are to be classified as Zone 2

iii. Enclosed spaces giving access to paint stores may be considered as non-hazardous, provided that:

- the door to the paint store is a gastight door with self-closing devices without holding back arrangements. A watertight door may be considered as being gastight

- the paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area, and
- warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

g. Electrical installations in stores for welding gas (acetylene) bottles

i. The following equipment may be installed in stores for welding gas bottles provided that it is of a safe type appropriate for Zone 1 area installation:

   a. lighting fittings

   b. ventilator motors where provided.

ii. Electrical cables other than those pertaining to the equipment arranged in stores for welding gas bottles are not permitted.

iii. Electrical equipment for use in stores for welding gas bottles is to have minimum explosion group IIC and temperature class T2.

Electrical Installations

Section 4 Rotating Machines

1. Constructional and operational requirements for generators and motors

2. Mechanical construction

i. Shafts are to be made of material complying with the provisions of NR216 Materials and Welding, where rolled products are allowed in place of forgings, with those of NR216 Materials and Welding.

ii. Where welded parts are foreseen on shafts and rotors, the provisions of NR216 Materials and Welding are to apply.

iii. Sleeve bearings are to be efficiently and automatically lubricated at all running speeds. Provision is to be made for preventing the lubricant from gaining access to windings or other insulated or bare current carrying parts.

iv. Means are to be provided to prevent bearings from being damaged by the flow of currents circulating between them and the shaft. According to the manufacturer's requirements, electrical insulation of at least one bearing is to be considered.

v. For surface-cooled machines with an external fan installed on the open deck, adequate protection of the fan against icing is to be provided.

vi. When liquid cooling is used, the coolers are to be so arranged as to avoid entry of water into the machine, whether by leakage or condensation in the heat exchanger, and provision is to be made for the detection of leakage.

vii. Rotating machines whose ventilation or lubrication system efficiency depends on the direction of rotation are to be provided with a warning plate.

3. Sliprings, commutators and brushes

i. Sliprings and commutators with their brushgear are to be so constructed that undue arcing is avoided under all normal load conditions.

ii. The working position of brushgear is to be clearly and permanently marked.

iii. Sliprings, commutators and brushgear are to be readily accessible for inspection, repairs and maintenance.

4. Terminal connectors

i. Suitable, fixed terminal connectors are to be provided in an accessible position for connection of the external cables.

ii. All terminal connectors are to be clearly identified with reference to a diagram.

iii. The degree of protection of terminal boxes is to be adequate to that of the machine.

5. Special requirements for generators

6. Prime movers, speed governors and overspeed protection

i. Prime movers for generators are to comply with relevant requirements.

vii. A.c. generators

viii. Alternators are to be so constructed that, when started up, they take up the voltage without the aid of an external electrical power source.

ix. The voltage wave form is to be approximately sinusoidal, with a maximum deviation from the sinusoidal fundamental curve of 5% of the peak value.

x. Each alternator is to be provided with automatic means of voltage regulation.

xi. When a.c. generators are operated in parallel, the reactive loads of the individual generating sets are not to differ from their proportionate share of the total reactive load by more than 10% of the rated reactive power of the largest machine, or 25% of that of the smallest machine, whichever is the lesser.

h. Approval of generating sets

i. A generating set is considered as a whole system including prime mover engine and its auxiliaries (for fuel oil, turbo compressor, lubricating oil, cooling circuits, alternator, and its auxiliaries, if any (lubricating and cooling system...),

engine control system, speed governor and associated sensors, an automatic voltage regulator, a coupling system, and cabling

j. Components are to be type approved. Case by case approvals may be admitted at the discretion of QRS Class.

k. Documentation for system assembly is to be provided with a list of components, general electrical diagram, coupling system and torsional Vibration Calculation.

l. The rated power of the generating set is to be appropriate for its actual use.

m. The entity responsible of assembling the generating set is to install a rating plate marked with at least the following information:

n. the generating set manufacturer's name or mark

o. the set serial number

p. the set date of manufacture (month/year)

q. the rated power (both in kW and KVA) with one of the prefixes COP, PRP (or, only for emergency generating sets, LTP) as defined in ISO 8528-1:2018

r. the rated power factor

s. the set rated frequency, in Hz

t. the set rated voltage, in V

u. the set rated current, in A

v. the mass, in kg.

ix. Testing of rotating machines

x. General

xi. All machines are to be tested by the manufacturers.

xii. All tests are to be carried out according to IEC 60092-301.

xiii. The manufacturer is to issue a test report giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the machine, as well as the results of the tests required.

iv. All electric motors rated at or above 100 kW and alternators rated at or above 100 kVA intended for essential services are to be type approved or case-by-case approved and surveyed by QRS Class during testing and, if appropriate, during manufacturing. Tested machines are to be individually certified by QRS Class.

v. All electric motors rated below 100 kW and alternators rated below 100 kVA intended for essential services are to be type approved or case-by-case approved. Individual works' certificate is to be issued by the manufacturer and detailed test report submitted to QRS Class.

vi. For rotating machines intended for non essential services, individual works' certificate is to be issued by the manufacturer and detailed test report made available and submitted upon request.

11. Shaft material

i. Shaft material for electric propulsion motors and for main engine driven generators where the shaft is part of the propulsion shafting is to be certified by QRS Class.

ii. Shaft material for other machines is to be in accordance with recognized international or national standard.

12. Tests

i. Type test are to be carried out on a prototype machine or on the first batch of machines, and routine tests carried out on subsequent machines in accordance with Table 1.

ii. Where the test procedure is not specified, the requirements of IEC 60034-1 apply.

Table 1 : Tests to be carried out on electrical rotating machines

No	Tests	a.c. Generators		Motors	
		Type test	Routine test	Type test	Routine test
1	Examination of the technical documentation, visual inspection in compliance with design drawings	X	X	X	X
2	Insulation resistance measurement (stator and rotor windings)	X	X	X	X

No	Tests	a.c. Generators		Motors	
		Type test	Routine test	Type test	Routine test
3	Winding resistance measurement (stator and rotor)	X	X	X	X
4	Verification of the voltage regulation system	X	X		
5	Rated load test and temperature rise measurement	X		X	
6	Overcurrent test	X			
7	Overtorque test			X	
8	Verification of steady short-circuit conditions	X			
9	Overspeed test	X	X	X	
10	Dielectric strength test (stator and rotor windings)	X	X	X	X
11	No load test	X	X	X	X
12	Verification of degree of protection	X		X	
13	Verification of bearings	X	X	X	X

iii. Generating sets are to be submitted to be tested for load impact on system, alarms, and voltage regulation. Assembled generating sets of an electrical power of 100 kVA and over are to be tested at manufacturer premises

prior installation on board. When the whole assembled generating set cannot be tested at the Manufacturer's premises, those tests are to be carried out after installation and assembly on board.

13. Description of test

14. Technical documentation and visual inspection

i. Technical documentation of machines rated at 100 kW (kVA) and over are to be available for examination by the Surveyor.

ii. A visual inspection of the machine is to be made to ensure, as far as practicable, that it complies with the technical documentation.

15. Insulation resistance measurement

a. Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

b. all current carrying parts connected together and earth

c. all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Table 2. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

Table 2 : Minimum insulation resistance

Rated voltage Un V	Minimum test voltage V	Minimum insulation resistance M
Un = 250	2 Un	1
250 < Un 1000	500	1
1000 < Un 7200	1000	Un/1000 + 1
7200 < Un 15000	5000	Un/1000 + 1

16. Winding resistance measurement

i. The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

17. Verification of the voltage regulation

i. The alternating current generator, together with its voltage regulation system, is to be verified in such a way that, at all loads from no load running to full load.

ii. When the generator is driven at rated speed and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage.

iii. The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1.5 s. For

emergency sets, these values may be increased to plus or minus 4% in not more than 5 s.

iv. In the absence of precise information concerning the maximum values of the sudden loads, the following conditions may be assumed: 60% of the rated current with a power factor of between 0,4 lagging and zero to be suddenly switched on with the generator running at no load, and then switched off after steady-state conditions have been reached.

18. Rated load test and temperature rise measurements

i. The temperature rises are to be measured at the rated out-put, voltage and frequency and for the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC 60034-1, or by means of a combination of other tests.

ii. The limits of temperature rise above ambient air temperature of 45°C for air-cooled machines are those given in Table 3.

Table 3 : Temperature rise limits for air-cooled machines based on an ambient temperature of 45°C

No	Part of machines	Temperature rise, in °C, by class of insulation				
		A	E	B	F	H
1	a) a.c. windings of machines having outputs of 5000 kW (or kVA) or more	55 60		75 80	95 100	120 125

No	Part of machines	Temperature rise, in °C, by class of insulation				
		A	E	B	F	H
	b) a.c. windings of machines having outputs of less than 5000 kW (or kVA)	55 60	70	75 85	100 105	120 125
2	Windings of armatures with commutators	45 55	60 70	65 75	80 100	100 120
3	Field windings 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
4	a) Field windings of synchronous machines with cylindrical rotors having d.c. excitation			85	105	130
	b) 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
	c) Low resistance field windings of more than one layer, and compensating windings	55	70	75	95	120
	d) Single-layer windings with exposed bare surfaces	60	75	85	105	130
5	Permanently short-circuited, insulated windings	55	70	75	95	120
6	Magnetic core and other parts in contact with windings	55	70	75	95	120
7	Commutators and sliprings, open or enclosed	55	65	75	85	95

19. Overcurrent/overtorque test

i. Overcurrent test is to be carried out as a type test for generators, as required in IEC 60034-1. The overcurrent test is the proof of current capability of the windings, wires, connections etc. of each machine. AC Generators must be able to withstand a current equal to 1.5 times the rated current for no less than 30 seconds.

ii. Overtorque test is to be carried out as a type test for motors, as required in IEC 60034-1. The overtorque test is a proof of momentary excess torque capability of the machine. General purpose rotating machines must be able to withstand excess torque testing.

iii. In the case of machines for special uses such as wind-lasses, overload values other than the above may be considered.

xx. Verification of the steady short circuit current

xxi. It is to be verified that under steady state short-circuit conditions, the generator with its voltage regulating system can maintain, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

xxi. Overspeed test

xxii. Machines are to withstand the overspeed test as specified in IEC 60034-1.

22. Dielectric strength test

i. New and completed rotating machines are to withstand a dielectric test as specified in IEC 60034-1.

ii. For high voltage machines an impulse test is to be carried out on the coils.

iii. When it is necessary to perform an additional high voltage test, this is to be carried out after any further drying, with a test voltage of 80% of that specified in IEC 60034-1.

iv. Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.

v. Partially rewound windings are to be tested at 75% of the test voltage required for new machines. Prior to the test, the old part of the winding is to be carefully cleaned and dried.

vi. Following cleaning and drying, overhauled machines are to be subjected to a test at a voltage equal to 1,5 times the rated voltage, with a minimum of 500 V if the rated voltage is less than 100 V, and with a minimum of 1000 V if the rated voltage is equal to or greater than 100 V.

vii. A repetition of the high voltage test for groups of machines and apparatus is to be avoided if possible, but if a test on an assembled group of several pieces of new apparatus, each of which has previously passed its high voltage test, is per-formed, the test voltage to be applied to such assembled group is 80% of the lowest test voltage appropriate for any part of the group.

xxiii. No load test

xxiv. Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor while generators are to be

driven by a suitable means and excited to give rated terminal voltage.

xxiv. Verification of degree of protection

xxv. As specified in IEC 60034-5.

xxv. Verification of bearings

xxvi. Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by the Surveyor, to establish that the shaft is correctly seated in the bearing shells.

z. Additional tests for rotating machines used as propulsion motor or thruster

aa. General

bb. Rotating machines used as propulsion motor or thruster and developing a power of more than 1 MW are to be subjected to the following requirements and tests during their assembly:

cc. Rotor winding assembly

- dynamic balancing

b. Stator winding assembly

- dielectric test (after impregnation)
- insulation resistance measurement (after impregnation)

c. Frame

- visual examination in compliance with design drawings

- liquid penetrant test of 10% of the structure welds and 100% of the handling points.

d. Watercooler

- visual examination in compliance with design drawings
- performance test (see temperature rise measurement test)

e. Hydrostatic jacking unit

- pressure test
- working test under nominal conditions.

Electrical Installations

Section 5 Transformers

1. Constructional and operational requirements

2. Construction

i. Transformers, except those for motor starting, are to be double wound (two or more separate windings).

ii. Transformers are normally of the dry, air-cooled type.

iii. When a forced air cooling system is used, an alarm is to be activated in the event of its failure.

iv. Liquid-cooled transformers may be used provided that the liquid is non-toxic and of a type which does not readily support combustion, the construction is such that the liquid is not spilled in inclined position, temperature and pressure relief devices with an alarm are installed, drip trays or other suitable arrangements for collecting the liquid from leakages are provided and a liquid gauge indicating the normal liquid level range is fitted.

v. Transformers are to have enclosures with a degree of protection.

3. Terminals

i. Suitable fixed terminal connections are to be provided in an accessible position with sufficient space for convenient connection of the external cables.

ii. Terminals are to be clearly identified.

4. Voltage variation, short-circuit conditions and parallel operation

i. Under resistive load (cos = 1), the voltage drop from no load to full load is not to exceed 2,5%. For transformers with a power lower than 5 kVA per phase, this voltage drop is not to exceed 5%.

ii. In determining the voltage ratio and the impedance voltage of transformers, account is to be taken of the total permitted voltage drop from the main switchboard's busbars to the consumers.

iii. Transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a secondary terminal short-circuit for 2 s, with rated primary voltage and frequency. For transformers of 1 MVA and over, this is to be justified with appropriate tests or documentation.

iv. When transformers are so arranged that their secondary windings may be connected in parallel, their winding connections are to be compatible, their rated voltage ratios are to be equal (with tolerances allowed) and their short-circuit impedance values, expressed as a percentage, are to have a ratio within 0,9 to 1,1. When transformers are operating in parallel, the rated power of the smallest in the group is not to be less than half of the rated power of the largest one.

5. Electrical insulation and temperature rise

i. All windings of air-cooled transformers are to be suitably treated to resist moisture, air salt mist and oil vapors.

ii. The permissible limits of temperature rise with an ambient air temperature of 45°C for (natural or forced) air-cooled transformers are given in Table 1. The temperature rises shown for windings refer to measurement by the resistance method while those for the core refer to the thermometer method.

iii. For dry-type transformers cooled with an external liquid cooling system, the permissible limits of temperature rise with a sea water temperature of 32°C are 13°C higher than those specified in Table 1.

Table 1 Temperature rise limits for transformers

No	**Part of machine**	**Temperature rise by class of insulation, in ˚C**				
		A	**E**	**B**	**F**	**H**
1	Windings	55	70	75	95	120
2	Cores and other parts: a. in contact with the windings b. not in contact with the windings	a. the same values as for the windings b. in no case is the temperature to reach values such as to damage either the core itself or other adjacent parts or materials				

i. For liquid-cooled transformers, temperature rises shall be measured by the resistance method.

6. Insulation tests

i. Transformers are to be subjected to a high voltage test in accordance with the procedure defined in IEC publication 60076-3.

ii. The test voltage is to be applied between each winding under test and the other windings not under test, core and enclosure all connected.

iii. The r.m.s. value of the test voltage is to be equal to 2 U + 1000 V, with a minimum of 2500 V, where U is the rated voltage of the winding. The full voltage is to be maintained for 1 minute.

iv. Partially rewound windings are to be tested at 80% of the test voltage required for new machines.

v. The insulation resistance of a new, clean and dry transformer, measured after the temperature rise test has been carried out (at or near operating temperature) at a voltage equal to 500 V d.c., is to be not less than 5 M.

vi. Transformers are to be subjected to an induced voltage insulation test by applying to the terminals of the winding under test a voltage equal to twice the rated voltage. The duration of the test is to be 60 s for any test frequency fp up to and including twice the rated frequency fn.

7. Testing

8. General

i. Transformers intended for essential services are to be subjected to testing.

ii. The manufacturer is to issue a test report giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the transformer, as well as the results of the tests required.

iii. In the case of transformers which are completely identical in rating and in all other constructional details, it will be acceptable for the temperature rise test to be performed on only one transformer.

iv. Where the test procedure is not specified, the requirements of IEC 60076 apply.

v. The tests and, if appropriate, manufacture of transformers of 100 kVA and over (60 kVA when single phase) intended for essential services are to be attended by a Surveyor of QRS Class.

9. Tests on transformers

i. Tests to be carried out on transformers are specified in Table 2.

Table 2 Tests to be carried out on transformers

No	Tests	Type test	Routine test
1	Examination of the technical documentation, as appropriate, and visual inspection	X	X
2	Insulation resistance measurement	X	X
3	Measurement of winding resistance	X	X
4	Measurement of voltage ratio and check of phase displacement	X	X
5	Measurement of short-circuit impedance and load loss	X	X
6	Measurements of no-load loss and no load current	X	X
7	High voltage test	X	X
8	Induced voltage test	X	X
9	Temperature-rise measurement	X	

Electrical Installations

Section 6 Semiconductor Converters

1. Constructional requirements

1.1. Construction

i. Semiconductor converters are to comply with the relevant requirements for switchgear assemblies.

ii. The design of semiconductor converters is to comply with the requirements of IEC Publication 60146-1-1 with applicable requirements modified to suit marine installations.

iii. The design of semiconductor converters for power supply is to comply with the requirements of IEC 62040 series.

iv. The design of semiconductor converters for motor drives is to comply with the requirements of IEC 61800 series.

v. Where forced cooling is used, the temperature of the heated cooling medium is to be monitored.

vi. Where forced (air or liquid) cooling is provided, it is to be so arranged that the converter cannot be or remain loaded unless effective cooling is maintained.

vii. Stacks of semiconductor elements, and other equipment such as fuses, or control and firing circuit boards etc., are to be so arranged that they can be removed from equipment without dismantling the complete unit.

viii. Semiconductor converters are to be rated for the required duty having regard to the peak loads, system transient and overvoltage and to be dimensioned to withstand the maximum short-circuit currents foreseen at the point of installation for the time necessary to trip the protection of the circuits they supply.

1.2. Protection

i. Semiconductor elements are to be protected against short-circuit by means of devices suitable for the point of installation in the network.

ii. Overcurrent or overvoltage protection is to be installed to protect the converter. When the semiconductor converter is designed to work as an inverter supplying the network in transient periods, precautions necessary to limit the current are to be taken.

iii. Semiconductor converters are not to cause distortion in the voltage waveform of the power supply at levels exceeding the voltage waveform tolerances at the other user input terminals.

iv. An alarm is to be provided for tripping of protective devices against overvoltages and overcurrents in electric propulsion converters and for converters for the emergency source of power.

1.3. Parallel operation with other power sources

i. For converters arranged to operate in parallel with other power sources, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1.4. Temperature rise

i. The permissible limit of temperature rise of the enclosure of the semiconductors is to be assessed on the basis of an ambient air temperature of 45°C or sea water temperature of 32°C for water-cooled elements, taking into account its specified maximum permissible temperature value.

ii. The value of the maximum permissible temperature of the elements at the point where this can be measured (point of reference) is to be stated by the manufacturer.

iii. The value of the mean rated current of the semiconductor element is to be stated by the manufacturer.

1.5. Creepage and clearance distances

i. Creepage and clearance distances are to comply with the requirements specified in IEC 61800-5-1. An interpolation of the specified values is permitted for high voltage semiconductor converters.

2. Requirements for uninterruptible power system (UPS) units as alternative and/or transitional power

2.1. Design and construction

i. UPS units are to be constructed in accordance with IEC 62040-1, IEC 62040-2, IEC 62040-3, IEC 62040-4 and/or IEC 62040-5-3, as applicable, or an acceptable and relevant national or international standard.

ii. The operation of the UPS is not to depend upon external services.

iii. The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

iv. An external bypass is to be provided.

v. The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for power supply failure (voltage and frequency) to the connected load, earth fault, operation of battery protective device, when the battery is being discharged and when the bypass is in operation for on-line UPS units.

2.2. Location

i. The UPS unit is to be suitably located for use in an emergency.

ii. UPS units utilizing valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of IEC 62040-1, IEC 62040-2, IEC 62040-3, IEC 62040-4 and/or IEC 62040-5-3, as applicable, or an acceptable and relevant national or international standard.

2.3. Performance

i. The output power is to be maintained for the duration required for connected equipment.

ii. No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity.

iii. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

iv. On restoration of the input power, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

3. Testing

3.1. General

i. Converters intended for essential services are to be subjected to testing.

ii. The manufacturer is to issue a test report giving information on the construction, type, serial number and all technical data relevant to the converter, as well as the results of the tests required.

iii. The tests and, if appropriate, manufacture of converters of 50 kVA and over intended for essential services are to be attended by a Surveyor of QRS Class.

3.2. Tests on converters

i. Converters are to be subjected to tests in accordance with Table 1. Type tests are the tests to be carried out on a prototype converter or the first of a batch of converters, and routine tests are the tests to be carried out on subsequent converters of a particular type.

ii. The tests listed in Table 1 are to be performed in accordance with IEC 60146-1-1. The relevant requirements of IEC 61800- 5-1 and of IEC 62040-3 based on the equipment type also apply.

iii. Final approval of converters is to include complete function tests after installation on board, performed with all ship's systems in operation and in all characteristic load conditions.

Table 1 Tests to be carried out on static converters

No	Tests	Type test	Routine test
1	Examination of the technical documentation, as appropriate, and visual inspection including check of earth continuity	X	X
2	Light load function test to verify all basic and auxiliary functions	X	X
3	Rated current test	X	
4	Temperature rise measurement	X	
5	Insulation test (dielectric strength test and insulation resistance measurement)	X	X
6	Protection of the converters in case of failure of forced cooling system	X	X

3.3. Additional testing and survey for uninterruptible power system (UPS) units as alternative and/ or transitional power

i. UPS units of 50 kVA and over are to be surveyed by QRS Class during manufacturing and testing.

ii. Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum testing for functionality, including operation of alarms, ventilation rate and battery capacity.

iii. Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

3.4. Insulation test

The test procedure is specified in IEC Publication 60146.

Electrical Installations

Section 7 Storage Batteries and Chargers

1. **Constructional requirements for batteries**
2. **General**

i. The requirements of this Section apply to permanently installed storage batteries (not to portable batteries).
ii. Storage batteries may be of the lead-acid or nickel-alkaline type, due consideration being given to the suitability for any specific application. Other types of batteries of proven designs may be accepted by QRS on a case by case basis.
iii. Cells are to be assembled in suitable crates or trays equipped with handles for convenient lifting.

3. **Vented batteries**

i. Vented batteries are those in which the electrolyte can be replaced and freely releases gas during periods of charge and overcharge.
ii. Vented batteries are to be constructed to withstand the movement of the ship and the atmosphere (salt mist, oil etc.) to which they may be exposed.

iii. Battery cells are to be so constructed as to prevent spilling of electrolyte at any inclination of the battery up to 40° from the vertical.
iv. It is to be possible to check the electrolyte level and the pH.

4. **Valve-regulated sealed batteries**

i. Valve-regulated sealed batteries are batteries whose cells are closed under normal conditions but which have an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cells cannot normally receive addition to the electrolyte.

ii. Cell design is to minimize risks of release of gas under normal and abnormal conditions.
v. **Tests on batteries**
vi. The battery autonomy is to be verified on board in accordance with the operating conditions.

vi. **Battery maintenance**
vii. Where batteries are fitted for use for essential and emergency services, a schedule of such batteries is to be compiled and maintained. The schedule, which is to be reviewed by QRS Class, is to include at least, maintenance/replacement cycle dates, date(s) of last maintenance and/or replacement and for replacement batteries in storage, the date of manufacture and shelf life.

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

iii. Where vented type batteries replace valve-regulated sealed types, it is to be ensured that there is adequate ventilation and that QRS Class's requirements relevant to the location and installation of vented types batteries are complied with.

iv. Details of the schedule and of the procedures are to be included in the ship's safety management system and be integrated into the ship's operational maintenance routine, as appropriate, to be verified by QRS Class's surveyor.

7. Constructional requirements for chargers

8. Characteristics

i. Chargers are to be adequate for the batteries for which they are intended and provided with a voltage regulator.

ii. In the absence of indications regarding its operation, the battery charger is to be such that the completely discharged battery can be recharged to 80% capacity within a period of 10 hours without exceeding the maximum permissible charging current. A charging rate other than the above, such as fully charged within 6 hours for batteries for starting of motors, may be required in relation to the use of the battery.

iii. For floating service or for any other condition where the load is connected to the battery while it is on charge, the maximum battery voltage is not to exceed the safe value of any connected apparatus.

iv. The battery charger is to be designed so that the charging current is set within the maximum current allowed by the manufacturer when the battery is discharged and the floating current to keep the battery fully charged.

v. Trickle charging to neutralize internal losses is to be provided. An indication is to be provided to indicate a charging voltage being present at the charging unit.

vi. Protection against reversal of the charging current is to be provided.

vii. Battery chargers are to be constructed to simplify maintenance operation. Indications are to be provided to visualize the proper operation of the charger and for troubleshooting.

9. Tests on chargers

i. Battery chargers are to be subjected to tests in accordance with Table 1. Type tests are the tests to be carried out on a prototype charger or the first of a batch of chargers, and routine tests are the tests to be carried out on subsequent chargers of a particular type.

ii. The tests of battery chargers of 5 kW and over intended for essential services are to be attended by a Surveyor of QRS Class.

Table 1 : Tests to be carried out on battery chargers

No.	Tests	Type test	Routine test
1	Examination of the technical documentation, as appropriate, and visual inspection including check of earth continuity	X	X
2	Functional tests (current and voltage regulation, quick, slow, floating charge, alarms)	X	X

3	Temperature rise measurement	X	
4	Insulation test (dielectric strength test and insulation resistance measurement)	X	X

Electrical Installations

Section 8 Switchgear and Controlgear Assemblies

i. Constructional requirements for main and emergency switchboards
ii. Construction
iii. Construction is to be in accordance with IEC Publication 60092-302.
iv. Where the framework, panels and doors of the enclosure are of steel, suitable measures are to be taken to prevent overheating due to the possible circulation of eddy currents.

iii. Insulating material for panels and other elements of the switchboard is at least to be moisture-resistant and flame-retardant.
iv. Switchboards are to be of dead front type, with enclosure protection.
v. Switchboards are to be provided with insulated handrails or handles fitted in an appropriate position at the front of the switchboard. Where access to the rear is necessary for operational or maintenance purposes, an insulated handrail or insulated handles are to be fitted.
vi. Where the aggregate capacity of generators connected to the main busbars exceeds 100 kVA, a separate cubicle for each generator is to be arranged with flame-retardant partitions between the different cubicles. Similar partitions are to be provided between the generator cubicles and outgoing circuits.
vii. Instruments, handles or push-buttons for switchgear operation are to be placed on the front of the switchboard. All other parts which require operation are to be accessible and so placed that the risk of accidental

touching of live parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

viii. All parts of the switchboard are to be readily accessible for maintenance, repair or replacement. In particular, fuses are to be able to be safely inserted and withdrawn from their fuse-bases.

ix. Hinged doors which are to be opened for operation of equipment on the door or inside are to be provided with fixing devices for keeping them in open position.

x. Means of isolation of the circuit-breakers of generators and other important parts of the installation are to be provided so as to permit safe maintenance while the main busbars are alive.

xi. Where components with voltage exceeding the safety voltage are mounted on hinged doors, the latter are to be electrically connected to the switchboard by means of a separate, flexible protective conductor.

xii. All measuring instruments and all monitoring and control devices are to be clearly identified with indelible labels of durable, flame-retardant material.

xiii. The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device for each circuit is to be permanently indicated at the location of the fuse or protective device.

xiv. When Busbar Trunk systems are used outside switchboards, IACS Recommendation No.67: Test and Installation of busbar trunk systems may be taken as reference for design, installation and testing.

iii. Busbars and bare conductors

iv. Busbars are to be of copper or of copper-surrounded aluminum alloy if suitable for use in the marine environment and if precautions are taken to avoid galvanic corrosion.

ii. All connections are to be so made as to inhibit corrosion.

iii. Busbars are to be dimensioned in accordance with IEC Publication 60092-302. The mean temperature rise of busbars is not to exceed 45°C under rated current condition with an ambient air temperature of 45°C and is not to have any harmful effect on adjacent components. Higher values of temperature rise may be accepted to the satisfaction of QRS Class.

iv. The cross-section of neutral connection on an a.c. three-phase, four-wire system is to be at least 50% of the cross-section for the corresponding phases.

v. Bare main busbars, excluding the conductors between the main busbars and the supply side of outgoing units, are to have the minimum

clearances and creepage distances required to function properly and safely. The values shown apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.

vi. Reduced values as specified in IEC Publication 60092-302 may be accepted for type tested and partially type tested assemblies.

vii. Busbars and other bare conductors with their supports are to be mechanically dimensioned and fixed such that they can withstand the stresses caused by short-circuits.

viii. Busbars and bare conductors are to be protected, where necessary, against falling objects.

4. Internal wiring

i. All insulated conductors are to be of flexible construction and of the stranded type.

ii. Connections from busbars to protective devices are to be as short as possible. They are to be laid and secured in such a way to minimize the risk of a short-circuit.

iii. All conductors are to be secured to prevent vibration and are to be kept away from sharp edges.

iv. Connections leading to indicating and control instruments or apparatus mounted in doors are to be installed such that they cannot be mechanically damaged due to movement of the doors.

v. Non-metallic trays for internal wiring of switchboards are to be of flame-retardant material.

vi. Control circuits are to be installed and protected such that they cannot be damaged by arcs from the protective devices.

vii. Where foreseen, fixed terminal connectors for connection of the external cables are to be arranged in readily accessible positions.

5. Switchgear and controlgear

i. Switchgear and controlgear are to comply with IEC Publication 60947 series.

6. Auxiliary circuits

i. Auxiliary circuits are to be designed in such a manner that, as far as practicable, faults in such circuits do not impair the safety of the system. In particular, control circuits are to be designed so as to limit the dangers resulting from a fault between the control circuit and earth also taking account of the earthing system of their supply.

ii. Auxiliary circuits of essential systems are to be independent of other auxiliary circuits.

iii. Common auxiliary circuits for groups of consumers are permitted only when the failure of one consumer jeopardizes the operation of the entire system to which it belongs.

iv. Auxiliary circuits are to be branched off from the main circuit in which the relevant switchgear is used.

v. Means are to be provided for isolating the auxiliary circuits as well when the main circuit is isolated.

7. Instruments

i. The upper limit of the scale of every voltmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

ii. The upper limit of the scale of every ammeter is to be not less than 130% of the normal rating of the circuit in which it is installed.

iii. The upper limit of the scale of every wattmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

iv. Ammeters or wattmeters for use with a.c. generators which may be operated in parallel are to be capable of indicating 15% reverse-current or reverse power, respectively.

v. For wattmeters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.

vi. The rated value of the measure read, at full load, is to be clearly indicated on the scales of instruments.

vii. Frequency meters are to have a scale at least 5% of the nominal frequency.

viii. The secondary windings of instrument transformers are to be earthed.

ix. Each a.c. generator not operated in parallel is to be provided with 1 voltmeter, 1 frequency meter, 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read and 1 three-phase wattmeter in the case of generators rated more than 50 kVA.

x. Each a.c. generator operated in parallel is to be provided with 1 three-phase wattmeter1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read.

xi. For paralleling purposes the following are to be provided with 2 voltmeters (voltage measurements of each alternator and busbar), and 2 frequency meters (frequency measurements of each alternator and busbar).

xii. Each secondary distribution system is to be provided with one voltmeter.

xiii. Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems.

xiv. The main switchboard is to be fitted with a voltmeter or signal lamp indicating that the cable between the shore- connection box and the main switchboard is energized.

xv. For each d.c. power source such as converters, rectifiers and batteries, one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices.

viii. Synchronization of generators

ix. It is to be possible to synchronize each generator intended for parallel operation with two independent synchronizing devices. at least, one of these synchronizing devices is to be manual.

x. Provisions are to be made for manual speed control of the prime mover and manual voltage control of the generators at the place where the manual synchronization is carried out.

ix. Constructional requirements for section boards and distribution boards

x. Construction

xi. Section boards and distribution boards are to be constructed, insofar as applicable, as specified for main and emergency switchboards.

xii. All parts which require operation in normal use are to be placed on the front.

xiii. Distribution switchboards which are provided with two or more supply circuits arranged for automatic standby connection are to be provided with positive indication of which of the circuits is feeding the switchboard.

xiv. Where switchboard supplying essential services is provided with a forced air cooling system, the air temperature is to be monitored. An alarm is to be activated when temperature exceeds a preset value.

xi. Testing

xii. General

xiii. Switchboards are to be subjected to testing.

xiv. The manufacturer is to issue the relative test reports providing information concerning the construction, serial number and technical data relevant to the switchboard, as well as the results of the tests required.

xv. The tests are to be carried out prior to installation on board.

xvi. The test procedures are as specified in IEC Publication 60092-302.

xvii. The tests of main switchboards, emergency switchboards or switchboards rated above 100 kW are to be attended by a surveyor of QRS Class.

xiii. Inspection of equipment, check of wiring and electrical operation test

xiv. It is to be verified that the switchboard complies with the approved drawings, maintains the prescribed degree of protection, and is constructed in accordance with the relevant constructional requirements, in particular as regards creepage and clearance distances.

xv. The connections, especially screwed or bolted connections, are to be checked for adequate contact, possibly by random tests.

xvi. Depending on the complexity of the switchboard it may be necessary to carry out an electrical functioning test. The test procedure and the number of tests depend on whether the switchboard includes complicated interlocks, sequence control facilities, etc. In some cases it may be necessary to conduct or repeat this test following installation on board.

xiv. High voltage test

xv. The test is to be performed with alternating voltage at the assembly's rated frequency with a 25% tolerance.

xvi. The test voltage is to be applied between all live parts connected and exposed conductive parts and between each polarity and, all other polarities and exposed conductive parts connected together. During the high voltage test, measuring instruments, ancillary apparatus and electronic devices may be disconnected and tested separately in accordance with the appropriate requirements.

xvii. The test voltage is to have a substantially sinusoidal waveform and is not to exceed half of the full test value at the moment of application. It is then to be increased gradually within a few seconds to this full value and maintained for 60 seconds.

xv. Measurement of insulation resistance

xvi. Immediately after the high voltage test, the insulation resistance is to be measured using a device with a direct current voltage of at least 500 V.

xvii. The insulation resistance between all current carrying parts and earth (and between each polarity and the other polarities) is to be at least equal to 1 M.

Electrical Installations

Section 9 Cables

i. General

ii. Type approval

iii. Cables are to be of a type approved by QRS Class.

iii. Constructional requirements

iv. Construction

v. Cables and insulated wiring are generally to be constructed in accordance with the relevant recommendations of IEC Publications 60092-350, 60092-352, 60092-353, 60092-354, 60092-360, 60092-370 and 60092-376, as well as with the provisions of this Chapter.

vi. Mineral-insulated cables are to be constructed according to IEC Publication 60702.

vii. Optical fiber cables are to be constructed in accordance with IEC Publication 60794.

viii. Insulated wiring for auxiliary circuits of switchboards may be constituted by cables with a single conductor of the stranded type for all sections.

ix. The insulated wiring is to be at least of the flame-retardant type according to IEC Publication 60332-1-2.

x. When cables are laid in bunches, cable types are to be chosen in compliance with IEC Publication 60332-3-22 Category A, or other means are to be provided such as not to impair their original flame-retarding properties.

xi. Fire resistant cables are to be designed and tested in accordance with the relevant IEC Publication 60092-series standards. The minimum flame application time is to be at least 90 minutes. Fire resistant type cables are to be easily distinguishable.

v. Conductors

vi. Conductors are to be of annealed electrolytic copper with a resistivity not exceeding 17,241 mm2/km at 20°C according to IEC 60228.

vii. Individual conductor wires of rubber-insulated cables are to be tinned or coated with a suitable alloy.

ix. All conductors are to be stranded, except for cables of nominal cross-sectional area 2,5 mm2 and less (provided that adequate flexibility of the finished cable is assured).

viii. Minimum Cable Conductor Size
Conductors are not to be less than the following in cross sectional size:
1.0 mm2 (1,973.5 circ. mils) for power and lighting,
1.5 mm2 (2960.3 circ. mils) for motor feeder cables,
0.5 mm2 (986.8 circ. mils) for control cables,
0.5 mm2 (986.8 circ. mils) for essential or emergency signaling and communications cables, except for those assembled by the equipment manufacturer, and 0.35 mm2 (690.8 circ. mils) for nonessential communication cables, except for those assembled by the equipment manufacturer.

6. Insulating materials

i. The materials used for insulation are to comply with IEC Publication 60092-360 and to have the thicknesses specified for each type of cable in the relevant standard. The maximum permissible rated temperature is specified for the various materials.

ii. Alternate materials and thicknesses will be specially considered by QRS Class.

7. Inner covering, fillers and binders

i. The cores of a multicore cable are to be laid up. The spaces between the cores are to be filled so as to obtain an assembly having an essentially circular cross-section. The filling may be omitted in multicore cables having a conductor cross-sectional area not exceeding 4 mm2.

ii. When a non-metallic sheath is applied directly over the inner covering or the fillers, it may substitute partially for the inner covering or fillers.

8. Protective coverings (armour and sheath)

i. Metallic armor, if not otherwise protected against corrosion, is to be protected by means of a coating of protective paint.

ii. The paint is to be non-flammable and of adequate viscosity. When dry, it is not to flake off.

iii. The materials used for sheaths are to be in accordance with IEC Publication 60092-360 and are to have the thicknesses specified for each type of cable in the relevant standard.

9. Identification

i. Each cable is to have clear means of identification so that the manufacturer can be determined.

ii. Fire non propagating cables are to be clearly labelled with indication of the standard according to which this characteristic has been verified and, if applicable, of the category to which they correspond.

10. Testing

11. Type tests

i. Type tests are to be in accordance with the relevant IEC 60092-3. Series Publications and IEC 60332-1, IEC 60332-3 Category A, IEC 60331-1, IEC 60331-2, and IEC 60331-21 where applicable.

12. Routine tests

i. Every length of finished cable is to be subjected to testing.

ii. Visual inspection, check of conductor cross-sectional area by measuring electrical resistance, high voltage test, insulation resistance measurement and dimensional checks are to be carried out.

iii. The manufacturer is to issue a statement providing information on the type and characteristics of the cable, as well as the results of the tests required and the Type Approval Certificates.

iv. The test procedure is as specified in IEC Publication 60092-350.

v. Where an alternative scheme is recognized by QRS Class, surveyor attendance may not be required.

Electrical Installations

Section 10 Miscellaneous Equipment

1. Switchgear and controlgear, protective devices

b. General

i. Switchgear and controlgear are to comply with IEC Publication 60947.

c. Circuit-breakers

i. Power-driven circuit-breakers are to be equipped with an additional separate drive operated by hand.

ii. Power circuit-breakers with a making capacity exceeding 10 kA are to be equipped with a drive which performs the make operation independently of the actuating force and speed.

iii. Where the conditions for closing the circuit-breaker are not satisfied, such as if the undervoltage trip is not energized, the closing mechanism is not to cause the closing of the contacts.

iv. All circuit-breakers rated more than 16 A are to be of the trip-free type, i.e. the breaking action initiated by overcurrent or undervoltage releases is to be fulfilled independently of the position of the manual handle or other closing devices.

d. Protection devices

i. Short-circuit releases are generally to be independent of energy supplied from circuits other than that to be protected. Tripping due to short-circuit is to be reliable even in the event of a total loss of voltage in the protected circuit.

ii. Short-circuit releases for generators are to be equipped with reclosing inhibitors and are to be delayed for selective tripping.

iii. Overload releases or relays are to operate reliably at any voltage variation of the supply voltage in the protected circuit.

iv. Undervoltage relays or releases are to cause the circuit-breaker to open if the voltage drops to 70%-35% of the rated voltage.

v. Shunt releases are to ensure the disconnection of the circuit-breaker even when the supply voltage of the release drops to 85% of the rated supply voltage.

vi. The reverse power protection device is to respond to the active power regardless of the power factor, and is to operate only in the event of reverse power.

vii. Single-phase failure devices in three-phase circuits are to operate without a time lag.

viii. Insulation monitoring devices are to continuously monitor the insulation resistance to earth and trigger an alarm should the insulation resistance fall below a predetermined value.

5. Electrical slip ring assemblies

f. General requirements

i. The purpose of the electrical slip ring is to form a continuous electrical connection between a fixed part and a rotating part. The electrical slip rings may transfer power or control/automation signals.

ii. High voltage electrical slip rings are to be segregated from slip rings operating at different voltage ratings.

iii. Slip rings fitted with forced cooling system are to be capable of restricted operation in case of loss of the cooling system. The cooling system failure is to be alarmed.

iv. Where data transmission is carried out via a bus system, transmission paths are to be duplicated. Failure of each single system is to be alarmed.

g. Construction

i. It is to be considered that the mechanical and electrical characteristics of the slip rings can be degraded by contamination or by oxidation.

ii. Enclosures for slip ring assemblies is to ensure at least a degree of protection IP23.

iii. The suitability of used materials at maximum permitted temperature values is to be proven. The permitted conductor temperature values of the connected cables is not to be exceeded.

iv. The maximum temperature rise of external surface parts which can easily be touched in service is not to exceed 15°C.

v. The enclosure is to be protected against internal condensation.

vi. Power slip rings are to be capable to withstand without damage the maximum prospective value of the short-circuit current which can occur at its terminals.

vii. High voltage slip rings are to be able to withstand an internal short circuit arcing failure with the maximum duration and magnitude which can occur at this point of the installation, without harmful effect to operators. They are to be internal arc classified (IAC).

h. Testing

i. General

All slip rings are to be type approved or case-by-case approved and surveyed by QRS Class during testing and, if appropriate, during manufacturing. Tested slip rings are to be individually certified by QRS Class.

Electric slip ring assemblies are to be subjected to the tests. Where the test procedure is not specified, the requirements of IEC 61439-1 and IEC 61439-2 or IEC 62271-200 apply.

Tests procedure is to be submitted to QRS Class for approval.

Type tests are to be carried out, unless the manufacturer can produce evidence based on previous experience indicating the satisfactory performance of such equipment.

9. Description of tests
10. Visual inspection: An inspection and checks are carried out with a view to establish that the electrical slip ring assembly complies with approved technical documentation, maintains the prescribed degree of protection and is constructed in accordance with the relevant constructional

requirements, in particular as regards to creepage and clearance distances

11. Mechanical tests: The electrical slip ring is to be subjected to the following mechanical tests, free rotation test on the full 360° in both clockwise and counter-clockwise. No hard point is to be encountered, free rotation test on the full 360° in clockwise and counter-clockwise to measure and record the breakout torque and the steady running torque, free rotation test on the full 360° in clockwise and counter-clockwise when the slip ring is inclined at an angle of 22,5° (roll) to measure and record the breakout torque and the steady running torque.
12. Electric contact resistance test: The electrical slip ring is to be subjected to a resistance test to measure and record the contact resistance across all paths on the full 360° in clockwise and counter-clockwise. Test is to be carried out at the specified rotation speed. The measured values are not to exceed the values given by the Manufacturer.
13. Insulation resistance measurement: Immediately after the high voltage test, the insulation resistance between all current carrying parts and earth (and between each polarity and the other polarities) is to be measured using a direct current insulation tester.
14. Dielectric strength test

Low voltage slip ring assemblies are to be subjected to a high voltage test. High voltage slip ring assemblies are to be subjected to a high voltage test between all live parts connected together and exposed conductive parts and between each polarity and, all other polarities and exposed conductive parts connected together. The test voltage is to be applied for at least 1 minute. Temperature rise test: A temperature rise test is to be carried out to measure the temperature rise of the active parts and the slip ring enclosure when all paths are loaded at their rated current and with normal cooling capability. Test may be performed in

static condition. The measured values are not to exceed the values given by the Manufacturer.

vi. Short-circuit withstand test

A short-circuit withstand test is to be performed to demonstrate that active parts with their supports are mechanically dimensioned and fixed to withstand the stresses caused by sudden short-circuit current without damage. The test value is not to be lower than the maximum prospective value of the short-circuit current on the slip ring. A calculation note is admitted as alternative to the test.

vii. Verification of degree of protection

The degree of protection is to be as specified in IEC 60529.

viii. Environmental tests

To validate that the slip rings assemblies are designed and constructed to operate satisfactorily under the environmental conditions expected on board they are to be subjected to the following environmental tests. During testing the slip rings are to be in normal operating conditions. For large slip rings, a
case-by-case evaluation based on calculations and/or documented measures is admitted as an alternative to the vibration test.

a. Ambient temperature test in compliance with IEC 60068-2-2
b. Humidity resistance test in compliance with IEC 60068-2-30 Test Db

c. Inclination test
d. Vibration test in compliance with IEC 60068-2-6 Test Fc

9. Lighting fittings

j. Applicable requirements

xi. Lighting fittings are to comply with IEC Publications 60598 and 60092-306.

Lighting fittings complying with other standards will be specially considered by QRS Class.

l. Construction

xiii. The temperature of terminals for connection of supplying cables is not to exceed the maximum conductor temperature permitted for the cable.

Where necessary, luminaires are to be fitted with terminal boxes which are thermally insulated from the light source.

xiv. Wires used for internal connections are to be of a temperature class which corresponds to the maximum temperature within the luminaire.

xv. The temperature rise of parts of luminaires which are in contact with the support is not to exceed 50°C. The rise is not to exceed 40°C for parts in contact with flammable materials.

xvi. The temperature rise of surface parts which can easily be touched in service is not to exceed 15°C.

xvii. High-power lights with higher surface temperatures are to be adequately protected against accidental contact.

18. Accessories

s. Applicable requirements

xx. Accessories are to be constructed in accordance with the relevant IEC Publications, and in particular with Publication 60092-306.

u. Construction

xxii. Enclosures of accessories are to be of metal having characteristics suitable for the intended use on board, or of flame- retardant insulating material.

xxiii. Terminals are to be suitable for the connection of stranded conductors, except in the case of rigid conductors for mineral- insulated cables.

24. Plug-and-socket connections

y. Applicable requirements

26. Plug-and-socket connections are to comply with IEC Publication 60092-306 and with the following additional standards in relation to their use:
27. in accommodation spaces, day rooms and service rooms (up to 16 A, 250 V a.c.): IEC Publication 60083 or 60320, as applicable
28. for power circuits (up to 250 A, 690 V a.c.): IEC Publication 60309
29. for electronic switchgear: IEC Publications, 60512 and 60603
30. for refrigerated containers: ISO 1496-2.

31. Heating and cooking appliances

ff. Applicable requirements

xxxiii. Heating and cooking appliances are to comply with the relevant IEC Publication series 60335, with particular attention to IEC 60092-307.

hh. General

xxxv. Heating elements are to be enclosed and protected with metal or refractory material.

xxxvi. The terminals of the power supply cable are not to be subjected to a higher temperature than that permitted for the conductor of the connection cable.

37. The temperature of parts which are to be handled in service (switch knobs, operating handles and the like) is not to exceed the following values:
38. 55°C for metal parts
39. 65°C for vitreous or molded material.

nn. Space heaters

xli. The casing or enclosure of heaters is to be so designed that clothing or other flammable material cannot be placed on them.

xlii. The temperature of the external surface of space heaters is not to exceed 60°C.

xliii. Space heaters are to be provided with a temperature limiting device without automatic reconnection which automatically trips all poles or phases not connected to earth when the temperature exceeds the maximum permissible value.

rr. Cooking appliances

xlv. Live parts of cooking appliances are to be protected such that any foods or liquids which boil over or spill do not cause short-circuits or loss of insulation.

tt. Fuel oil and lube oil heaters

xlvii. In continuous-flow fuel oil and lube oil heaters, the maximum temperature of the heating elements is to be below the boiling point of the oil.

xlviii. Each oil heater is to be provided with a thermostat maintaining the oil temperature at the correct level.

xlix. Each oil heater is to be provided with a temperature limiting device without automatic reconnection, and with the sensing device installed as close as possible to the heating elements and permanently submerged in the liquid.

xx. Water heaters

li. Water heaters are to be provided with a thermostat and safety temperature limiter.

Electrical Installations

Section 11 Location

1. General

2. Location

i. The degree of protection of the enclosures and the environmental categories of the equipment are to be appropriate to the spaces or areas in which they are located.

3. Areas with a risk of explosion

i. Except where the installation of equipment for explosive gas atmosphere is provided for by the Rules, electrical equipment is not to be installed where flammable gases or vapours are liable to accumulate.

4. Main electrical system

5. Location in relation to the emergency system

i. The arrangement of the emergency electrical system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated converting equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render inoperative the main electric lighting system and the other primary essential services.

6. Main switchboard

i. The main switchboard shall be so placed relative to one main generating station that, as far as is practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space.

ii. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating switchboards from generators.

iii. The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads.

iv. Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided that there is access between the spaces.

v. The main switchboard is to be located as close as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries.

vi. Where essential services for steering and propulsion are supplied from section boards, these and any transformers, converters and similar appliances constituting an essential part of the electrical supply system are also to satisfy the above provisions.

vii. A non-required subdivision bulkhead, with sufficient access, located between the switchboard and generators, or between two or more generators, is not to be considered as separating the equipment.

7. Emergency electrical system

8. Spaces for the emergency source

i. The emergency source of electrical power, transitional source of emergency power, emergency and emergency lighting switchboard shall be located above the uppermost continuous deck and shall be readily accessible from the open deck.

ii. The spaces containing the emergency source of electrical power, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of Category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

ix. Location in relation to the main electrical system

x. The location of the emergency source of electrical power, the transitional source of emergency power, the emergency and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard shall be such as to ensure to the satisfaction of QRS Class that a fire or other casualty in these spaces will not interfere with the supply, control and distribution of emergency electrical power.

xi. The arrangement of the main electrical system is to be such that a fire or other casualty in spaces containing the main source of electrical power, the main switchboard and the main lighting switchboard will not render inoperative the emergency electric lighting system and the other emergency services other than those located where the fire occurred.

x. Emergency switchboard

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

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

xi. Distribution boards

xii. Distribution boards for cargo spaces and similar spaces

xiii. Distribution boards containing multipole switches for the control of power and lighting circuits in bunkers and cargo spaces are to be situated outside such spaces.

xiii. Distribution board for navigation lights

xiv. The distribution board for navigation lights is to be placed in an accessible position on the bridge.

xiv. Cable runs

xv. General

xvi. Cable runs are to be selected to be as far as practicably accessible, except for single cables, situated behind walls or ceilings constructed of incombustible materials, supplying lighting fittings and socket-outlets in accommodation spaces.

xvii. Cable runs are to be selected to avoid action from condensed moisture and from dripping of liquids.

xviii. Connection and draw boxes are to be accessible.

iv. Cables are generally not to be installed across expansion joints. Where this is unavoidable, however, a loop of cable of length proportional to the expansion of the joint is to be provided.

16. Location of cables in relation to the risk of fire and overheating

i. Cables and wiring serving power sources, lighting, internal communications, so far as is practicable, to be routed clear of galleys, laundries, machinery spaces of Category A and their casings and other high fire risk areas, except for supplying equipment in those spaces.

ii. When it is essential that a circuit functions for some time during a fire and it is unavoidable to carry the cable for such a circuit through a high fire risk area such as cables connecting fire pumps to the emergency switchboard, the cable is to be of a fire- resistant type.

iii. 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).

iv. Main cable runs and cables for the supply and control of essential services are, as far as is practicable, to be kept away from machinery parts having an increased fire risk unless the cables must be connected to the subject equipment, the cables are protected by a steel bulkhead and the cables in that area are of the fire-resisting type.

v. Cables and wiring serving power sources, lighting, internal communications are to be arranged, as far as practicable, in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

vi. Cables are to be arranged as remote as possible from sources of heat such as hot pipes, resistors, etc. Where installation of cables near heat sources cannot be avoided, and where there is consequently a risk of damage to the cables by heat, precautions to avoid overheating are to

be taken, for example use of ventilation, heat insulation materials or special heat-resisting cables.

17. Location of cables in relation to electromagnetic interference

i. For the installation of cables in the vicinity of radio equipment, steps are to be taken to limit the effects of unwanted electromagnetic interference.

18. Services with a duplicate feeder

i. In the case of essential services requiring a duplicate supply such as steering gear circuits, the supply and associated control cables are to follow different routes which are to be as far apart as practicable, separated both vertically and horizontally.

19. Emergency circuits

i. Cables supplying emergency circuits are not to run through spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, except for cables supplying emergency equipment located within such spaces.

20. Storage batteries

21. General

i. Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, or steam. They are to be installed in such a way that no damage may be caused to surrounding appliances by the vapors generated.

ii. Storage batteries are to be suitably housed, and compartments (rooms, lockers or boxes) used primarily for their accommodation are to be properly constructed and efficiently ventilated so as to prevent accumulation of flammable gas.

iii. Starter batteries are to be located as close as practicable to the engines

iv. Accumulator batteries shall not be located in sleeping quarters except where hermetically sealed to the satisfaction of QRS Class.

v. Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, locker, box), unless of valve-regulated sealed type.

vi. **Depending on the load of the battery set, they must be located at:**
1. Battery Room:

• Location: A dedicated battery room is required when the total load exceeds 2 kW. It should only house the necessary equipment, and all equipment must be certified as safe for battery room environments.

• Ventilation:
    • Natural Ventilation: If possible, natural ventilation is allowed, if ducts lead directly from the top of the room to the open air, with an air inlet near the floor.
    • Mechanical Ventilation: If natural ventilation is not feasible, mechanical ventilation must be used. The fan must completely change the air in two minutes and be safe for explosive environments (non-sparking).
    • Hydrogen Emission: For low hydrogen-emission batteries, natural ventilation may suffice. In this case, a visible warning must be posted.
    • Fan Interlock: Battery chargers must be interlocked with the ventilation system to prevent charging and gas release when ventilation is off.

• Corrosion Protection:
    • The interior of the battery room must be coated with paint resistant to battery electrolytes. Shelves for lead-acid batteries must have a watertight lining, while shelves for alkaline batteries must be made of corrosion-resistant steel. Alternatively, the entire room can be covered with corrosion-resistant material.
• Battery Trays and Shelves: Batteries must be placed with adequate space for heat dissipation, secured to prevent movement, and insulated to ensure proper airflow.

2. Deck Boxes, Lockers, and Racks:
• Location: Moderate battery installations (output between 0.2 kW and 2 kW) may be installed in battery boxes, lockers, or racks in well-ventilated machinery spaces, but they must be protected from mechanical damage and moisture.

Additionally, the arrangement must provide personnel protection.

- Ventilation:
  - Boxes or lockers must have ducts extending above the box with measures to prevent water from entering.At least two air inlets must be provided at the lower part of the box.
  - Adequate ventilation calculations must be submitted for approval, ensuring that the hydrogen concentration does not exceed 1% by volume.

- Corrosion Protection: Battery boxes must include watertight trays with a coaming of at least 150 mm (6 inches), as specified for battery rooms.

3. Small Battery Boxes:

- Location and Ventilation: Small battery boxes can be placed wherever desired, but not in sleeping quarters unless they are hermetically sealed. These boxes do not require mechanical ventilation but must have openings at the top to allow gas to escape.

- Corrosion Protection: The boxes must be lined to a depth of 75 mm (3 inches) with corrosion-resistant material.

22. Large vented batteries

i. Batteries connected to a charging device of power exceeding 2 kW, calculated from the maximum obtainable charging current and the nominal voltage of the battery (hereafter referred to as "large batteries") are to be installed in a room assigned to batteries only.

ii. Rooms assigned to large batteries are to be provided with mechanical exhaust ventilation. Natural ventilation may be employed for boxes located on open deck.

xxiii. Moderate vented batteries

xxiv. Batteries connected to a charging device of power between 0,2 kW and 2 kW (hereafter referred to as "moderate batteries") are to be arranged in the same manner as large batteries or placed in a box or

locker in suitable locations such as machinery spaces, storerooms or similar spaces. In machinery spaces and similar well-ventilated compartments, these batteries may be installed without a box or locker provided they are protected from falling objects, dripping water and condensation where necessary.

xxv. Rooms, lockers or boxes assigned to moderate batteries are to be provided with natural ventilation or mechanical exhaust ventilation, except for batteries installed without a box or locker (located open) in well-ventilated spaces.

xxiv. Small vented batteries

xxv. Batteries connected to a charging device of power less than 0,2 kW (hereafter referred to as "small batteries") are to be arranged in the same manner as moderate or large batteries, or without a box or locker, provided they are protected from falling objects,

xxvi. Boxes for small batteries may be ventilated only by means of openings near the top to permit escape of gas.

25. Ventilation

i. The ventilation of battery compartments is to be independent of ventilation systems for other spaces.

ii. The quantity of air expelled (by natural or forced ventilation) for compartments containing vented type batteries is to be at least equal to: Q = 110 I n where P is the quantity of air expelled in liters per hour, O is the Maximum current delivered by charging equipment in amperes, and n is the number of cells.

iii. Fans starters cabinet is to be located outside of the energy electric storage system (ESS) room.

iv. Ventilation fans are not to produce a source of vapor ignition in either the ventilated space or the ventilation system associated with the space. A non-sparking exhaust fan is to be provided.

v. Ducts are to be made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

vi. The ventilation ducting system is to be gastight and able to withstand the off-gas temperature and over-pressure. The pipes to and from the battery room are to be made of steel.

vii. Adequate air inlets (whether connected to ducts or not) are to be provided near the floor of battery rooms or the bottom of lockers or boxes (except for that of small batteries). Air inlet may be from open air or from another space, but always from non-hazardous areas.

viii. The ventilation exhaust suction is to be located as close as practicable to the ceiling such that light gases are evacuated. Exhaust ducts of natural ventilation systems are to be run directly from the top of the compartment to the open air above, are to terminate not less than 90 cm above the top of the battery compartment and are to have no part more than 45° from the vertical. Where natural ventilation is impracticable or insufficient, mechanical exhaust ventilation is to be provided. In mechanical exhaust ventilation systems electric motors for ventilation fans are not to be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served, fans are to be so constructed and of a material such as to render sparking impossible in the event of the impeller touching the fan casing, steel or aluminum impellers are not to be used, the system is to be interlocked with the charging device so that the battery cannot be charged without ventilation, and a temperature sensor is to be located in the battery compartment to monitor the correct behavior of the battery in cases where the battery element is sensitive to temperature.

ix. For natural ventilation systems for deck boxes holes for air inlet are to be provided on at least two opposite sides of the box, the exhaust duct is to

be of ample dimensions and the duct is to terminate at least 1,25 m above the box in a goose-neck or mushroom-head or the equivalent

Electrical Installations

Section 12 Installation

i. General
ii. Protection against injury or damage caused by electrical equipment
iii. All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.
iv. All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.
v. Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

3. Protection against damage to electrical equipment

i. Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, steam, oil or oil vapours.
ii. The air supply for internal ventilation of electrical equipment is to be as clean and dry as practicable; cooling air for internal ventilation is not to be drawn from below the floor plates in engine and/or boiler rooms.
iii. Equipment is to be so mounted that its enclosing arrangements and the functioning of the built-in equipment will not be affected by distortions, vibrations and movements of the ship’s structure or by other damage liable to occur.

iv. If electrical fittings, not of aluminum, are attached to aluminum, suitable provision is to be made to prevent galvanic corrosion.

iv. Accessibility

v. Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts.

5. Electrical equipment in environmentally controlled spaces

i. Where electrical equipment is installed within environmentally controlled space 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 that the equipment is not for use for emergency services, temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature, 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, and audible and visual alarms are provided, at a continually manned control station, to indicate any malfunction of the cooling units.

ii. 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.

vi. Earthing of non-current carrying parts

vii. Parts which are to be earthed

viii. Exposed metal parts of both fixed and portable electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live and similar metal parts inside non-metallic enclosures are to be earthed unless the machines or equipment are supplied at a voltage not exceeding 50 V direct current or 50 V, root mean square between conductors, achieved without the use of
auto-transformers (safety voltage); or supplied at a voltage not exceeding 250 V by safety isolating transformers supplying one consuming device only; or constructed in accordance with the principle of double insulation.

ii. To minimize shock from high frequency voltage induced by the radio transmitter, handles, handrails and other metal elements on the bridge or upper decks are to be in electrical connection with the hull or superstructures.

8. Methods of earthing

i. Metal frames or enclosures of apparatus and electrical machinery may be fixed to, and in metallic contact with, the ship’s structure, provided

that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together.

ii. For metal frames or enclosures which are not earthed, earthing connections are to be used.

9. Earthing connections

i. Every earthing connection is to be of copper or other corrosion-resistant material and is to be securely installed and protected, where necessary, against damage and electrolytic corrosion.

ii. The nominal cross-sectional area of each copper earthing connection is to be not less than that required in Table 1. Earthing connections of other metals are to have conductance at least equal to that specified for a copper earthing connection.

iii. Metal parts of portable appliances are to be earthed, where required, by means of an earth-continuity conductor in the flexible supply cable or cord, which has the cross-sectional area specified in Table 1 and which is earthed, for example, through the associated plug and socket.

iv. In no circumstances is the lead sheathing or armor of cables to be relied upon as the sole means of earthing.

Table 1 : Cross-sectional area of earth-continuity conductors and earthing connections

Type of earthing connection		Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper earthing connection
1	Earth-continuity conductor in flexible cable or flexible cord	any	Same as current carrying conductor up to and including 16 mm2 and one half above 16 mm2 but at least 16 mm2
2	Earth-continuity conductor incorporated in fixed cable	any	a. for cables having an insulated earth-continuity conductor ● a cross-section equal to the main conductors up to and including 16 mm2, but minimum 1,5 mm2 ● a cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm2, but at least 16 mm2

<table>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td colspan="2">b. for cables with a bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>Cross-section of main conductor, in mm2</td><td>Earthing connection, in mm2</td></tr>
<tr><td>1 - 2,5
4 - 6</td><td>1
1,5</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Separate fixed earthing conductor</td><td>2,5 mm2</td><td colspan="2">Same as current carrying conductor subject to minimum of 1,5 mm2 for stranded earthing connection or 2,5 mm2 for unstranded earthing connection</td></tr>
<tr><td>> 2,5 mm2 but 120 mm2</td><td colspan="2">One half the cross-sectional area of the current carrying conductor, subjected to a minimum of 4 mm2</td></tr>
<tr><td>> 120 mm2</td><td colspan="2">70 mm2</td></tr>
</table>

10. Connection to the ship’s structure

i. Every connection of an earth-continuity conductor or earthing lead to the ship’s structure is to be secured by means of a screw of brass or other corrosion-resistant material of diameter not less than 6 mm.

ii. Such earthing connection is not to be used for other purposes.

11. Earthed distribution systems

i. The system earthing of earthed distribution systems is to be effected by means independent of any earthing arrangements of non-current carrying parts and is to be connected to the hull at one point only.

ii. In a distribution system with hull return, the system earthing connection is to have at least the same cross-sectional area as the feeder lines.

iii. The earthing connection is to be in an accessible position where it may readily be inspected and disconnected for insulation testing.

xii. Aluminium superstructures

xiii. When aluminium superstructures are insulated from the steel hull to prevent electrolytic corrosion, they are to be secured to the hull by means of a separate bonding connection.

ii. The connections are to be adequately close together and are to have a resistance less than 0,1.

iii. The connections are to be located where they may readily be inspected.

xiii. Rotating machines xiv.

xv. Every rotating machine is preferably to be installed with the shaft in the fore-and-aft direction. Where a rotating machine of 100 kW (kVA) and over is installed athwartship, or vertically, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand rolling.

xv. Semiconductor converters

xvi. Semiconductor power converters

xvii. Naturally air-cooled semiconductor converters are to be installed such that the circulation of air to and from the stacks or enclosures is not impeded and that the temperature of the cooling inlet air to converter stacks does not exceed the ambient temperature for which the stacks are specified.

xvii. Vented type storage batteries

xviii. General

xix. Batteries are to be arranged so that each cell or crate of cells is accessible from the top and at least one side to permit replacement and periodical maintenance.

ii. Cells or crates are to be carried on insulating supports of material non-absorbent to the electrolyte, such as treated wood.

iii. Cells are to be securely chocked by means of insulating material non-absorbent to the electrolyte such as strips of treated wood. Special mechanical precautions are to be taken to prevent the emergency battery from being damaged by the shock due to a collision.

iv. Provision is to be made for the free circulation of air.

19. Protection against corrosion

20. The interior of battery compartments (rooms, lockers, boxes) including all metal parts subject to the electrolyte is to be protected against the deteriorating effect of the latter by electrolyte-resistant coating or other equivalent means, unless corrosion- resistant materials are used.

21. Interior surfaces of metal shelves for battery cells, whether or not grouped in crates or trays, are to be protected by a lining of electrolyte-resistant material, watertight and carried up to at least 75 mm on all sides. In particular, linings are to have a minimum thickness of 1,5 mm, if of lead sheet for lead-acid batteries, and of 0,8 mm, if of steel for alkaline batteries.

xxii. Switchgear and controlgear assemblies

xxiii. Main switchboard

xxiv. The main switchboard is to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel.

xxv. An unobstructed space is to be left in front of the switchboard wide enough to allow access for operation; such width is generally about 1 metre.

xxvi. Where necessary, an unobstructed space is to be provided at the rear of the switchboard ample to permit maintenance; in general, the width of this passage is to be not less than 0,6 m, except that this may be reduced to 0,5 m in way of stiffeners and frames, and the height sufficient for the operation foreseen.

xxvii. Where the switchboard is open at the rear, the rear space is to form a locked space provided at each end with an access door. The required IP protection for the corresponding location is to be fulfilled.

xxviii. If necessary, the clear height above the switchboard specified by the manufacturer is to be maintained for pressure relief in the event of a short-circuit.

xxix. When the voltage exceeds the safety voltage, non-conducting mats or gratings are to be provided at the front and rear of the switchboard as necessary.

xxx. Piping and conduits are not to be installed directly above or in the vicinity of switchboards.

xxiv. Emergency switchboard

xxv. For the installation of the emergency switchboard, the same requirements apply as with the main switchboard.

xxv. Section boards and distribution boards

xxvi. For the installation of section and distribution boards, the same requirements apply.

26. Cables

27. General

i. Cables having insulation with different max permissible conductor temperatures are not to be bunched together.

ii. Cables having protective covering which damages the covering of more vulnerable cables are not to be bunched together.

iii. Cables having a bare metallic sheath or braid or armor are to be installed ro prevent galvanic corrosion.

iv. All cables and wiring external to equipment are to be so installed as not to impair their original flame-retarding properties.

28. Radius of bend

i. The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the manufacturer.

ii. Where the installation of cables across expansion joints is unavoidable, the minimum internal radius of the loop at the end of the travel of the expansion joint is to be not less than 12 times the external diameter of the cable.

29. Fixing of cables

i. Cables shall be installed and supported in such a manner as to avoid chafing or other damage.

ii. The supports and the corresponding accessories are to be of robust construction and of corrosion-resistant material or suitably treated before erection to resist corrosion.

iii. Apart from cables installed in pipes, conduits, trunks or special casings, cables are to be fixed by means of clips, saddles or straps of suitable

material, in order to tighten the cables without their coverings being damaged.

iv. Cable clips or straps made from a material other than metal are to be manufactured of a flame-retardant material.

v. The distances between fastenings and between supports are to be suitably chosen according to the type and number of cables and the probability of vibration.

30. Mechanical protection

i. Cables exposed to risk of mechanical damage are to be protected by metal casing, profiles or grids or enclosed in metal pipes or conduits, unless the cable covering provides adequate mechanical protection.

ii. In situations where there would be an exceptional risk of mechanical damage, cables are to be protected by metal casing, trunks or conduits,

even when armored, if the ship's structure or attached parts do not afford sufficient protection for the cables.

iii. Metal casing used for mechanical protection of cables is to be effectively protected against corrosion.

31. Penetrations of bulkheads and decks

i. If cables have to pass without adequate support through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes are to be fitted with glands or bushings of suitable material.
ii. If cables have to pass through a watertight bulkhead or deck, the penetration is to be effected in a watertight manner.
iii. Cables passing through decks and continuing vertically are to be protected against mechanical damage to a suitable height above the deck, considering a minimum height of 100 mm.
iv. Where cables pass through bulkheads or decks separating areas with a risk of explosion, arrangements are to be such that hazardous gas or dust cannot penetrate through openings for the passage of cables into other areas.
v. Where cables pass through a bulkhead or deck which is required to have some degree of fire integrity, penetration is to be so effected as to ensure that the required degree of fire integrity is not impaired.

xxxii. Expansion joints

xxxiii. If there is reason to fear that a tray plate, pipe or conduit may break because of the motion of the ship, different load conditions and temperature variations, appropriate expansion joints are to be provided.

33. Cables in closed pipes or conduits

34. Closed pipes or conduits are to have such internal dimensions and radius of bend as will permit the easy drawing in and out of the cables which they are to contain; the internal radius of bend is to be not less than that permitted for cables and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe where this value is greater.

35. Closed pipes and conduits are to be suitably smooth on the interior and are to have their ends shaped or bushed in such a way as not to damage the cable covering.

36. The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional areas of the pipe or conduit) is to be not greater than 0,4.

37. If necessary, openings are to be provided at the highest and lowest points so as to permit air circulation and ensure that the heat from the cables can be dissipated, and to obviate the possibility of water accumulating at any part of the pipe or conduit.

38. Vertical trunks for electrical cables is to be so constructed as not to jeopardize the required passive fire protection between the spaces.

39. Metal pipes or conduits are to be protected against corrosion.

40. Non-metallic pipes or conduits are to be flame-retardant.

xxxvi. Cables in casings or trunks and conduits with removable covers

xxxvii. Covers are to be removable and when they are open, cables are to be accessible.

xxxviii. If the fixing of covers is by means of screws, the latter are to be of non-rusting material and arranged so as not to damage the cables.

xxxix. Means are to be provided to ensure that the heat from the cables can be dissipated and water accumulation is avoided.

xxxvii. Cable ends

xxxviii. Terminations in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding properties of the cable.

xxxix. Where mechanical clamps are not used, the ends of all conductors having a cross-sectional area greater than 4 mm2 are to be fitted with soldering sockets or compression-type sockets of sufficient size to contain all the strands of the conductor.

xl. Cables not having a moisture-resistant insulation, such as mineral-insulated, are to have their ends effectively sealed against ingress of moisture.

xxxviii. Joints and tappings (branch circuit)

xxxix. Cable runs are normally not to include joints. Where absolutely necessary, cable joints are to be carried out by a junction method with rebuilding of the insulation and protective coverings.

ii. Joints in all conductors are to be so made as to retain the original electrical (continuity and isolation), mechanical (strength and protection), flame-retarding and, where necessary, fire-resisting properties of the cable.

iii. Tappings (branch circuits) are to be made via suitable connections or in suitable boxes of such design that the conductors remain adequately insulated and protected from atmospheric action and are fitted with terminals or busbars of dimensions appropriate to the current rating.

iv. Cables for safety voltages are not to terminate in the same connection boxes as cable for higher voltages unless separated by suitable means.

xxxix. Earthing and continuity of metal coverings of cables

xl. All metal coverings of cables are to be electrically connected to the metal hull of the ship.

ii. Metal coverings are generally to be earthed at both ends of the cable.

iii. Single-point earthing is admitted for final sub-circuits (at the supply end), except for those circuits located in areas with a risk of explosion.

iv. Earthing is to be at one end only in those installations (mineral-insulated cables, intrinsically safe circuits, control circuits where it is required for technical or safety reasons.

v. Metal coverings of single-core a.c. cables and special d.c. cables with high "ripple" content such as those for thyristor equipment are to be earthed at one point only, usually at the midpoint.

vi. The electrical continuity of all metal coverings of cables throughout the length of the latter, particularly at joints and tappings, is to be ensured.

vii. The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

viii. The metal covering of cables may also be earthed by means of clamps or clips of corrosion-resistant material making effective contact with the covering and earthed metal.

40. Earthing and continuity of metal pipes, conduits and trunks or casings

i. Metal casings, pipes, conduits and trunks are to be effectively earthed.

ii. Pipes or conduits may be earthed by being screwed into a metal enclosure, or by nuts on both sides of the wall of a metallic enclosure, provided the surfaces in contact are clean and free from rust, scale or paint and that the enclosure is in accordance with these requirements on earthing.

iii. Pipes and conduits may be earthed by means of clamps or clips of corrosion-resistant metal making effective contact with the earthed metal.

iv. Pipes, conduits or trunks together with connection boxes of metallic material are to be electrically continuous.

v. All joints in metal pipes and conduits used for earth continuity are to be soundly made and protected, where necessary, against corrosion.

vi. Individual short lengths of pipes or conduits need not be earthed.

vii. The connections to earth are to have a resistance less than 0,1.

41. Precautions for single-core cables for a.c.

i. Conductors belonging to the same circuit are to be contained within the same pipe, conduit or trunks, unless this is of non-magnetic material.

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

iii. In the installation of two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits, or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any event, the distance between the external covering of two adjacent cables is to be not greater than one diameter.

iv. When single-core cables having a current rating greater than 250 A are installed near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

v. Magnetic material is not to be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit are to pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material is to be no less than 75 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

42. Cables in refrigerated spaces

i. Power cables installed in refrigerated spaces are not to be covered by thermal insulation. Moreover, such cables are not to be placed directly on the face of the refrigerated space unless they have a thermoplastic or elastomeric extruded sheath.

ii. Power cables entering a refrigerated space are to pass through the walls and thermal insulation at right angles, in tubes sealed at each end and protected against oxidation.

43. Cables in areas with a risk of explosion

i. Terminals of intrinsically safe circuits are to be separated from terminals of non-intrinsically safe circuits by a physical distance of at least 50 mm, or by an earthed metallic partition.

ii. In enclosures, unscreened wirings of intrinsically safe circuits are to be separated from non-intrinsically safe circuits by a physical distance of at least 50mm, or by an earthed metallic partition.

44. Cables and apparatus for services required to be operable under fire conditions

i. Cables and apparatus for services required to be operable under fire conditions including their power supplies are to be so arranged that the loss of these services is minimized due to a localized fire at any one area or zone.

45. Cables in the vicinity of radio equipment

i. All cables between antennas and transmitters are to be routed separately of any other cable.

ii. Where it is necessary to use single-core cables, the arrangement of conductors is to be such as to avoid complete or partial loops.

46. Cable trays/protective casings made of plastics materials

ii. Cable trays or protective casings made of plastics materials (thermoplastic or thermosetting plastic materials) are to be case-by-case approved or type-approved in accordance with IACS recommendation No. 73.

iii. Cable trays/protective casings are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing injury to personnel and/or an obstruction to any escape route.

iv. The load on the cable trays/ protective casings is to be within the Safe Working Load (SWL). The support spacing is not to be greater than the manufacturer recommendations nor in excess of spacing at SWL test. In general, the spacing is not to exceed 2 meters.

v. The selection and spacing of cable tray/protective casing supports are to take into account. cable trays/protective casings' dimensions, mechanical and physical properties of their material, mass of cable trays/protective casings, loads due weight of cables, external forces, thrust forces and vibrations, maximum accelerations to which the system may be subjected and combination of loads.

vi. The sum of the cables total cross-sectional area, based on the cables external diameter is not to exceed 40% of the protective casing internal cross-sectional area. This does not apply to a single cable in a protective casing.

xlvii. Various appliances

xlviii. Lighting fittings

xlix. Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

l. Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

li. Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

lii. Emergency lights are to be marked for easy identification.

xlix. Heating appliances

l. Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

li. Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

lii. Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

l. Heating cables and tapes or other heating elements

li. Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials. Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

Electrical Installations

Section 13 High Voltage Installations

1. General

2. Field of application

i. The following requirements apply to a.c. three-phase systems with nominal voltage exceeding 1kV, the nominal voltage being the voltage between phases.

3. Nominal system voltage

i. The nominal system voltage is not to exceed 15 kV.

4. High-voltage, low-voltage segregation

i. Equipment with voltage above about 1 kV 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.

5. System design

6. Distribution

i. It is to be possible to split the main switchboard into at least two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable.

ii. In the event of an earth fault, the current is not to be greater than full load current of the largest generator on the switch- board or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energized mode. 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.

iii. 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.

iv. All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, communication and control equipment circuits.

v. In systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

vi. Alternators running in parallel may have a common neutral connection to earth provided they are suitably designed to avoid excessive circulating currents.

vii. In systems with earthed neutral, resistors or other current-limiting devices for the connection of the neutrals to the hull are to be provided for each section in which the systems are split.

7. Degrees of protection

i. Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC 60092-201.

ii. The degree of protection of enclosures of rotating electrical machines is to be at least IP 23. The degree of protection of terminals is to be at least IP 44.

iii. The degree of protection of enclosures of transformers is to be at least IP 23. For transformers installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

iv. The degree of protection of metal enclosed switchgear, controlgear assemblies and static converters is to be at least IP 32. For switchgear, control gear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

viii. Insulation

ix. In general, for non type tested equipment phase-to-phase air clearances and phase-to-earth air clearances between non- insulated parts are to be not less than those specified in Table 1.

Table 1 : Minimum clearances

Nominal voltage (kV)	Highest voltage for equipment (kV)	Minimum air clearance (mm)
3 - 3,3	3.6	55
6 - 6,6	7.2	90
10 - 11	12	120
15	17.5	160

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

ix. Protection

x. Protective devices 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.

ii. Any earth fault in the system is to be indicated by means of a visual and audible alarm. In low impedance or direct earthed systems provision is to be made to automatically disconnect the faulty circuits. In high impedance earthed systems, where outgoing feeders will not be isolated

in case of an earth fault, the insulation of the equipment is to be designed for the phase-to-phase voltage.

iii. Power transformers are to be provided with overload and short circuit protection. When transformers are connected in parallel, tripping of the protective devices on the primary side is to automatically trip the switch connected on the secondary side.

iv. Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

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

vi. Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages.

10. Rotating machinery

11. Stator windings of generators

i. Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

12. Temperature detectors

i. Rotating machinery is to be provided with temperature detectors in its stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit.

If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

13. Tests

i. A high voltage test in accordance with IEC 60034-15 is to be carried out on the individual coils to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

14. Power transformers

15. General

i. Dry type transformers are to comply with IEC 60076-11. Liquid cooled transformers are to comply with the applicable parts of the IEC 60076 series. Oil immersed transformers are to be provided with low liquid level alarm, high liquid level alarm, low liquid level trip or load reduction, high level trip or load reduction and high gas pressure relay trip.

16. Cables

17. General

i. Cables are to be constructed in accordance with IEC 60092-353 and 60092-354

18. Switchgear and controlgear assemblies

19. General

i. Switchgear and controlgear assemblies are to be constructed in accordance with IEC 62271-200 and the following additional requirements.

20. Construction

ii. Switchgear is to be of metal-enclosed type in accordance with IEC 62271-200 or of the insulation-enclosed type in accordance with IEC 62271-201.

iii. Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

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

v. For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked on in safety.

vi. Switchgear and controlgear assemblies are to be internal arc classified (IAC). Where swichgear and controlgear are accessible by authorized personnel only, Accessibility Type A is sufficient (IEC 62271-200 Annex AA 2.2). Accessibility Type B is required if accessible by non-authorised personnel. Installation and location of the switchgear and controlgear is to correspond with its internal arc classification and classified sides.

21. Auxiliary systems

i. If electrical energy and/or physical energy is required for the operation of circuit-breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components.

ii. 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 a main switchboard section.

22. High voltage test

i. A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to IEC 62271-200, Section 7, Routine tests.

23. Installation

24. Electrical equipment

i. 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. At the entrance to spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed indicating danger of high voltage. As regards high-voltage electrical equipment installed outside the aforementioned spaces, similar marking is to be provided. An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. 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.

25. Cables

i. In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

ii. High voltage cables are to be segregated from cables operating at different voltage ratings; in particular, they are not to be run in the same cable bunch, in the same ducts or pipes, or in the same box.

iii. High voltage cables are generally to be installed on cable trays when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise, they are to be installed for their entire length in metallic castings effectively bonded to earth.

iv. Terminations in all conductors of high voltage cables are, as far as practicable, to be effectively covered with suitable insulating material. 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. High voltage cables of the radial field type are to have terminations which provide electric stress control.

v. High voltage cables are to be readily identifiable by suitable marking.

vi. Before a new high voltage cable installation, or an addition to an existing installation, is put into service, a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories. The test is to be carried out after an insulation resistance test. For cables with rated voltage (Uo/U) above 1,8/3 kV (Um = 3,6 kV) an a.c. voltage withstand test may be carried out upon advice from high voltage cable manufacturer. A test for 5 minutes with the phase to phase voltage of the system applied between the conductor and the metallic screan/sheath and test for 24 hours with the normal operating voltage of the system. Alternatively, a d.c. test voltage equal to 4 Uo may be applied for 15 minutes shall be carried out. For cables with rated voltage (Uo/U) up to 1,8/3 kV (Um = 3,6 kV) an d.c. voltage equal to 4 Uo is to be applied for 15 minutes.

vii. After completion of the test, the conductors are to be connected to earth for a sufficient period to remove any trapped electric charge.

Electrical Installations

Section 14 Electric Propulsion Plant

i. General
ii. Applicable requirements
iii. The following requirements apply to ships for which the main propulsion plants are provided by at least one electric propulsion motor and its electrical supply. All electrical components of the propulsion plants are to comply with these requirements.

iii. Operating conditions
iv. The normal torque available on the electric propulsion motors for maneuvering is to be such as to enable the vessel to be stopped or reversed when sailing at its maximum service speed.
v. Adequate torque margin is to be provided for three-phase synchronous motors to avoid the motor pulling out of synchronism during rough weather and when turning.
vi. Means are to be provided to limit the continuous input to the electric propulsion motor. This value is not to exceed the continuous full load torque for which motor and shafts are designed.
vii. The plant as a whole is to have sufficient overload capacity to provide the torque, power and reactive power needed during starting and maneuvering conditions.

viii. The electric motors and shaft line are to be constructed and installed so that, at any speed reached in service, all the moving components are suitably balanced.

iv. Design of the propulsion plant

v. General

vi. The electrical power for the propulsion system may be supplied from generating sets, dedicated to the propulsion system, or from a central power generation plant, which supplies the ship's services and electric propulsion. The minimum configuration of an electric propulsion plant consists of one prime mover, one generator and one electric motor.

vii. For plants having only one propulsion motor controlled via a static converter, a standby converter which it is easy to switch over to is to be provided. Double stator windings with one converter for each winding are considered as an alternative solution.

viii. In electric propulsion plants having two or more constant voltage propulsion generating sets, the electrical power for the ship's auxiliary services may be derived from this source. Additional ship's generators for auxiliary services need not be fitted provided that effective propulsion is maintained with any one generating set out of service.

ix. Plants having two or more propulsion generators, two or more static converters or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically, without affecting the operation of the others.

vi. Power supply

vii. Where the plant is intended exclusively for electric propulsion, voltage variations and maximum voltage are to be maintained within the limits required.

viii. In special conditions (crash-stop maneuvers), frequency variations may exceed its limits provided that other equipment operating on the same network is not unduly affected.

ix. The electric plant is to be so designed as to prevent the harmful effects of electromagnetic interference generated by semiconductor converters.

vii. Auxiliary machinery

viii. Propeller/thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution board or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

ix. When the installation has one or more lubrication systems, devices are to be provided to ensure the monitoring of the lubricating oil return temperature.

x. Propelling machinery installations with a forced lubrication system are to be provided with alarm devices which will operate in the event of oil pressure loss.

viii. Electrical Protection

ix. Automatic disconnections of electric propulsion plants which adversely affect the maneuverability of the ship are to be restricted to faults liable to cause severe damage to the equipment.

x. Converters are to be provided with protection against overvoltage in the supply systems to which converters are connected, protection against

overcurrents in semiconductor elements during normal operation and short-circuit protection.

xi. Overcurrent protective devices in the main circuits are to be set sufficiently high so that there is no possibility of activation due to the overcurrents caused during normal operation, such as during maneuvering or in heavy seas.

xii. Overcurrent protection may be replaced by automatic control systems ensuring that overcurrents do not reach values which may endanger the plant, such as. by selective tripping or rapid reduction of the magnetic fluxes of the generators and motors.

xiii. In the case of propulsion plants supplied by generators in parallel, suitable controls are to ensure that, if one or more generators are disconnected, those remaining are not overloaded by the propulsion motors.

xiv. In three-phase systems, phase-balance protective devices are to be provided for the motor circuit which de-excite the generators and motors or disconnect the circuit concerned.

ix. Excitation of synchronous electric propulsion motor

x. Each propulsion motor is to have its own exciter.

xi. For plants where only one generator or only one motor is foreseen, each machine is to be provided with a standby exciter, which it is easy to switch over to.

xii. In case of multi-propeller propulsion ships, standby exciter may be omitted, provided failure of one exciter on one electric motor doesn’t impair the functionality of the remaining motor.

xiii. In excitation circuits, there is to be no overload protection causing the opening of the circuit, except for excitation circuits with semiconductor converters.

xiv. Each exciter is to be supplied by a separate feeder.

x. Construction of rotating machines, semiconductor converters and braking resistors

xi. Ventilation

xii. Where electrical machines are fitted with an integrated fan and are to be operated at speeds below the rated speed with full load torque, full load current, full load excitation or the like, the design temperature rise is not to be exceeded.

xiii. Where electrical machines or converters are force-ventilated, at least two fans, or other suitable arrangements, are to be provided so that limited operation is possible in the event of one fan failing.

xii. Protection against moisture and condensate

xiii. Machines and equipment which may be subject to the accumulation of moisture and condensate are to be provided with effective means of heating. The latter is to be provided for motors above 500 kW, to maintain the temperature inside the machine at about 3°C above the ambient temperature.

xiv. Provision is to be made to prevent the accumulation of bilge water, which is likely to enter inside the machine.

xiii. Rotating machines

xiv. Electrical machines are to be able to withstand the excess speed which may occur during operation of the ship.

xv. The design of rotating machines supplied by static converters is to consider the effects of harmonics.

xvi. The winding insulation of electrical machines is to be capable of withstanding the overvoltage which may occur in manoeuvring conditions.

xvii. The design of a.c. machines is to be such that they can withstand without damage a sudden short-circuit at their terminals under rated operating conditions.

xviii. The obtainable current and voltage of exciters and their supply are to be suitable for the output required during manoeuvring and overcurrent conditions, including short-circuit in the transient period.

xiv. Semiconductor converters

xv. The following limiting repetitive peak voltages U_{RM} are to be used as a base for each semiconductor valve:

- when connected to a supply specifically for propeller drives: $U_{RM} = 1,5\ U_P$
- when connected to a common main supply:

$U_{RM} = 1,8\ U_P$

where

U_P : Peak value of the rated voltage at the input of the semiconductor converter.

ii. For parallel-connected converter elements, an equal current distribution is to be ensured.

iii. Means are to be provided, where necessary, to limit the effects of the rate of harmonics to the system and to other semiconductor converters. Suitable filters are to be installed to keep the current and voltage within the required limits.

xv. Braking resistors

xvi. Braking resistors may be provided to absorb excess amounts of regenerated energy and to reduce the speed of the propulsion motor.

xvi. Control and monitoring

xvii. General

xviii. The control and monitoring systems, including computer based systems, are to be type approved.

xviii. Power plant control systems

xix. The power plant control systems are to ensure that adequate propulsion power is available, by means of automatic control systems and/or manual remote control systems.

xx. The automatic control systems are to be such that, in the event of a fault, the propeller speed and direction of thrust do not undergo substantial variations.

xxi. Failure of the power plant control system is not to cause complete loss of generated power (i.e. blackout) or loss of propulsion.

iv. The loss of power plant control systems is not to cause variations in the available power; i.e. starting or stopping of generating sets is not to occur as a result.

v. Where power-aided control (for example with electrical, pneumatic or hydraulic aid) is used for manual operation, failure of such aid is not to result in interruption of power to the propeller. Any such device is to be capable of purely manual local operation.

vi. The control system is to include alarm monitoring of critical systems, a speed controller for the propeller, and shutdown capability.

vii. Where the electric propulsion system is supplied by the main switchboard together with the ship's services, load shedding of the non-essential services and /or power limitation of the electric propulsion is to be provided. An alarm is to be triggered in the event of power limitation or load shedding.

viii. The risk of blackout due to electric propulsion operation is to be eliminated. At the request of QRS Class, a failure mode and effects analysis is to be carried out to demonstrate the reliability of the system.

19. Indicating instruments

i. Instruments indicating consumed power and power available for propulsion are to be provided at each propulsion remote control position.

ii. Each alternator must have an ammeter on each phase, a voltmeter, a wattmeter, a tachometer, a power factor meter and a temperature indicator for stator windings.

iii. Each A.C. propulsion motor must have an ammeter, a temperature sensor for the windings, and a voltage meter between phase of each motor.

iv. Where a speed measuring system is used for control and indication, the system is to be duplicated with separate sensor circuits and separate power supply.

v. An ammeter is to be provided on the supply circuit for each propulsion semiconductor bridge.

20. Alarm system

i. Where an alarm system is provided for other essential equipment or installations, alarms may be connected to such system.

ii. Critical alarms for propulsion are to be indicated to the bridge separately.

iii. Alarms are to be provided for high temperature of machine air cooling and ventilation, reduced flow of coolant, coolant leakage, low lube oil pressure, high winding temperatures, tripping of protective devices against overvoltage and over currents, voltage unbalance, and earth fault for main and excitation circuits.

xxi. Reduction of power

xxii. Power is to be automatically reduced with low lube oil pressure, high winding temperature, fan failures, lack of coolant and load limitation of generators.

xxiii. When power is reduced automatically, this is to be indicated at the propulsion control position (critical alarm).

xxiv. Switching-off of the semiconductors in the event of abnormal service operation is to be provided.

xxii. Installation

xxiii. Ventilation of spaces

xxiv. Loss of ventilation to spaces with forced air cooling is not to cause loss of propulsion. To this end, two sets of ventilation fans are to be provided, one acting as a standby unit for the other. Equivalent arrangements using several independently supplied fans may be considered.

xxiv. Cable runs

xxv. Where there is more than one propulsion motor, all cables for any one machine are to be run as far as is practicable away from the cables of other machines.

ii. Cables which are connected to the sliprings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during maneuvering.

xxv. Tests

xxvi. Test of rotating machines

xxvii. For rotating machines, such as synchronous generators and synchronous electric motors, of a power of more than 1 MW, a quality plan detailing the different controls during the machine assembly is to be submitted to QRS Class for approval.

ii. In relation to the evaluation of the temperature rise, it is necessary to consider the supplementary thermal losses induced by harmonic currents in the stator winding. To this end, two methods may be used: Direct test method, when the electric propulsion motor is being supplied by its own frequency converter, and/or back-to-back arrangement according to the supplier's facility. Indirect test method, a validation of the estimation of the temperature excess due to harmonics is to be documented. A justification based on a computer program calculation may be taken into consideration if validation of such program is demonstrated by previous experience.

iii. Rotating machines used for propulsion or maneuvering are to be subjected to testing.

27. Test of braking resistors

i. Each braking resistor is to undergo testing of visual and mechanical inspection, ohmic value measurement, insulation resistance measurement, dielectric testing, earth continuity check, cabling verification and test of leakage detector.

28. Specific requirements for PODs

29. General

i. When used as steering maneuvering system, the POD is to comply with QRS Class requirements.

30. Electric motor

i. The thermal losses are dissipated by the liquid cooling of the bulb and by the internal ventilation of the POD. The justification for the evaluation of the heating balance between the sea water and air cooling is to be submitted to QRS Class.

ii. Means to adjust the air cooler characteristics are to be provided on board, in order to obtain an acceptable temperature rise of the windings. Such means are to be set following the dock and sea trials.

iii. Vibrations of the electric motor are to be monitored. The alarm set point is to be defined in accordance with the manufacturer recommendation.

31. Instrumentation and associated devices

i. Means are to be provided to transmit the low level signals connected to the sensors located in the POD.

32. Additional tests and tests on board

i. Tests of electric propulsion motors are to be carried out.

ii. Tests are to be performed to check the validation of the temperature rise calculation.

Electrical Installations

Section 15 Testing

i. General
ii. Rule application
iii. Before a new installation, or any alteration or addition to an existing installation, is put into service, the electrical equipment is to be tested to the satisfaction of the Surveyor in charge.

iii. Insulation-testing instruments
iv. Insulation resistance may be measured with an instrument applying a voltage of at least 500 V. The measurement will be taken when the deviation of the measuring device is stabilized.

ii. For high voltage installation, the measurement is to be taken with an instrument applying a voltage adapted to the rated value and agreed with QRS Class.

iv. Type approved components v.
vi. The following components are to be type approved:
- electrical cables

- transformers
- rotating machines
- electrical converters for primary essential services
- switching devices (circuit-breakers, contactors, disconnectors, etc.) and overcurrent protective devices
- sensors, alarm panels, electronic protective devices, automatic and remote control equipment, actuators, safety devices for installations intended for essential services (steering, CPP, propulsion machinery, etc.), electronic speed regulators for main or auxiliary engines
- computers used for tasks essential to safety
- cable trays or protective casings made of plastics materials (thermoplastic or thermosetting plastic materials).

ii. Case by case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of QRS Class.

6. Insulation resistance
7. Lighting and power circuits

i. The insulation resistance between all insulated poles (or phases) and earth and, where practicable, between poles (or phases), is to be at least 1 M in ordinary conditions. The installation may be subdivided to any desired extent and appliances may be disconnected if initial tests give results less than that indicated above.

8. Internal communication circuits

i. Circuits operating at a voltage of 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 M.
ii. Circuits operating at voltages below 50 V are to have an insulation resistance between conductors and between each conductor and earth of at least 0,33 M.
iii. If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

9. Switchboards

i. The insulation resistance between each busbar and earth and between each insulated busbar and the busbar connected to the other poles (or phases) of each main switchboard, emergency switchboard, section board, etc. is to be not less than 1 M.
ii. The test is to be performed before the switchboard is put into service with all circuit-breakers and switches open, all fuse- links for pilot lamps, earth fault-indicating lamps, voltmeters, etc. removed and voltage coils temporarily disconnected where otherwise damage may result.

10. Generators and motors

i. The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded.
ii. The test is to be carried out with the machine hot immediately after running with normal load.
iii. The insulation resistance of generator and motor connection cables, field windings and starters is to be at least 1 M.

11. Earth
12. Electrical constructions

i. Tests are to be carried out, by visual inspection or by means of a tester, to verify that all earth-continuity conductors and earthing leads are connected to the frames of apparatus and to the hull, and that in socket-outlets having earthing contacts, these are connected to earth.

13. Metal-sheathed cables, metal pipes or conduits

i. Tests are to be performed, by visual inspection or by means of a tester, to verify that the metal coverings of cables and associated metal pipes,

conduits, trunks and casings are electrically continuous and effectively earthed.

14. Operational tests
15. Generating sets and their protective devices

i. Generating sets are to be run at full rated load to verify electrical characteristics, commutation, lubrication, ventilation, noise and vibration level.
ii. Suitable load variations are to be applied to verify the satisfactory operation under steady state and transient conditions for voltage regulators and speed governors.
iii. Generating sets intended to operate in parallel are to be tested over a range of loading up to full load to verify parallel operation, sharing of the active load , synchronization and sharing of the reactive load.

iv. The satisfactory operation of the overspeed protection, overcurrent protection, and load-shedding devices is to be verified: For sets intended to operate in parallel reverse power protection, and minimum voltage protection is to be verified.
v. The satisfactory operation of the emergency source of power and of the transitional source of power, when required, is to be tested. In particular, the automatic starting and the automatic connection to the emergency switchboard, in case of failure of the main source of electrical power, are to be tested.

xvi. Switchgear

xvii. All switchgear is to be loaded and, when found necessary by the attending Surveyor, the operation of overcurrent protective devices is to be verified.

xviii. Short-circuit tests may also be required at the discretion of QRS Class to verify the selectivity characteristics of the installation.

17. Consuming devices

i. Electrical equipment is to be operated under normal service conditions (though not necessarily at full load or simultaneously) to verify that it is suitable and satisfactory for its purpose.

ii. Motors and their starters are to be tested under normal operating conditions to verify power, operating characteristics, commutation, speed, direction of rotation and alignment.

iii. The remote stops foreseen are to be tested.

iv. Lighting fittings, heating appliances etc. are to be tested under operating conditions to verify that they are suitable and satisfactory for their purposes (with regard to the operation of emergency lighting).

18. Communication systems

i. Communication systems, order transmitters and mechanical engine-order telegraphs are to be tested.

19. Installations in areas with a risk of explosion

i. Installations and the relevant safety certification are to be examined to ensure that they are of a type permitted in the various areas and that the integrity of the protection concept has not been impaired.

20. Voltage drop

i. If deemed necessary by attending Surveyor, voltage drop is to be measured to verify that permissible limits are not exceeded.

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