INTERNATIONAL REGISTER OF SHIPPING

RULES AND REGULATIONS FOR CLASSIFICATION OF STEEL VESSELS 2021

Part 6
Electrical Installation & Control Systems

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CHANGES HISTORY

Refer Changes history in Part 1

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CHAPTER 1 GENERAL

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SECTION 1 APPLICATION

Contents

1.1. General

1.1.1. The requirements of this Part shall apply to all ships except where otherwise stated. Consideration will be given to arrangements or details of equipment which comply with other National or International standards in so far as they are not less effective and reliable. Electrical equipment is to be designed and arranged such that current-carrying parts with potential to earth are protected against accidental contact and to provide accessibility to parts requiring inspection or adjustment.

1.1.2. The arrangements for ships intended for restricted services or for special services will be specially considered.

1.1.3. Whilst these requirements are considered to meet those of the "International Convention for the Safety of Life at Sea, 1974", including amendments, attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

Except as provided in Sec. 2 of this chapter the definitions of terms used are in agreement with SOLAS 1974, as amended, and IEC Publication 60092-101, paragraph 1.5.

1.1.4. The requirements of this Part apply to electrical installations on ships. Electrical & electronics systems and equipment of unrestricted sea-going ships are to be designed, constructed, installed and tested to a national, international or other recognized standard and in accordance with applicable requirements of this part.

1.1.5. All electrical & electronics components are to be so designed and manufactured that:

a. 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.
b. They are capable of operating satisfactorily under the variations of voltage, frequency and harmonic distortion of the power supply specified in Chapter 2, Sect 4, [4.2.3.] of this part;
c. It is capable to operate satisfactorily under the environmental conditions onboard (Refer Sect 2, [2.32.] of this chapter).
d. 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 in accordance with IEC Publication 60533 - "Electromagnetic Compatibility of Electrical and Electronic Installations in Ships and of Mobile and Fixed Offshore Units".

a. The electrical equipment indicated below are required to be certified by INTLREG for complying with the appropriate provisions of this part (Refer also Pt 5A, Ch 1, Sec 2, Table 1.2.3 .Generators and motors of 100 kW (135 hp) and over intended for essential services (Refer Sec 2, [2.2.] of this chapter).
b. Main, propulsion and emergency switchboards.
c. Motor controllers of 100 kW (135 hp) and over intended for essential services.
d. Motor control centers with aggregate load of 100 kW (135 hp) and over intended for essential services.
e. Battery charging and discharging boards for emergency and transitional source of power.
f. Propulsion controls, propulsion semiconductors and propulsion cables.

Other electrical equipment items are to be designed, constructed and tested in accordance with established industrial practices, manufacturer's specifications and applicable requirements in this Part. Acceptance will be based on manufacturer's documentation which is to be made available upon request and on satisfactory performance after installation. Mass produced items may, at the discretion of the manufacturers, be certified under the Type Approval Program, Pt 1, Ch 1, Sec 11, and Pt 5A, Chapter 1, Sec 2, Table 1.2.3 .

1.1.6. Electrical installations are to be such that:

a. All electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions are ensured without recourse to the emergency source of electrical power;
b. Electrical services essential for safety are ensured under various emergency conditions; and
c. The safety of passengers, crew and ship from electrical hazards is ensured.

1.1.7. It is recommended that adequate spares (e.g. One complete set of bearings for each size and type of generator and motor), together with the tools necessary for maintenance, or repair and measuring instrument (A 500 V megger) be carried. The spares are to be determined by the Owner according to the design and intended service. The maintenance of the spares is the responsibility of the Owner.

1.1.8. Before a new installation, or any alteration or addition to an existing installation, is put into service the applicable trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturer's works and are to be to the Surveyor's satisfaction.

The insulation resistance is to be measured of all circuits and electrical equipment. The minimum values of test voltage and insulation resistance are given in Ch 4, Sec 4, Table 4.4.2 of this part. Refer also Ch 4, Sec. 4, [4.1. of this part.

It is to be demonstrated that the Rules have been complied with all essential and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

1.1.9. INTLREG may refer to other regulations and standards (e.g. IEC, SOLAS) when deemed necessary. When referred to by the INTLREG, publications by IEC or other internationally recognized standards, are those currently in force at the date of agreement for ship classification.

1.1.10. INTLREG has the authority to specify additional requirements to the Construction Rules where such rules are related to installations or new systems or wherever deemed necessary due to new knowledge or operating experience.

1.1.11. Additional requirements as determined by the Society may be applicable for particular ship types based on the vessel type assigned in the Class Notation.

SECTION 2 DEFINITIONS

Contents

2.1. Power supply installations

These include all kinds of installations meant for the generation, conversion, storage and distribution of electrical energy.

2.2. Essential services

Essential equipment shall be subdivided into primary and secondary essential services.

a. Primary essential services:

These are services that are need to be operative all the time to maintain the maneuverability of the ship in terms of propulsion and steering. The primary essential service consists of:

i. Steering gear;
ii. Pumps for controllable pitch propellers;
iii. Scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for propulsion;
iv. Forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on ships where steam is used for equipment supplying primary essential services;
v. Oil burning installations for steam plants on steam turbine ships and for auxiliary boilers where steam is used for equipment supplying primary essential services;
vi. Azimuth thrusters which are the sole means for propulsion/steering and associated lubricating oil pumps, cooling water pumps;
vii. Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps;
viii. Electric generators and associated power sources supplying primary essential equipment;
ix. Hydraulic Pumps for primary essential equipment;
x. Viscosity control equipment for heavy fuel oil;
xi. Control, monitoring and safety devices/systems for primary essential equipment
xii. Low duty gas compressor and other boil-off gas treatment facilities supporting boil-off gas usage as fuel to main propulsion or electric power generation machinery

b. Secondary essential services:

Secondary Essential Services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the ship's safety. Secondary essential services comprise of:

i. Windlasses;
ii. Fuel oil transfer pumps and fuel oil treatment equipment;
iii. Lubrication oil transfer pumps and lubrication oil treatment equipment;
iv. Pre-heaters for heavy fuel oil;
v. Starting-air and control-air compressors;
vi. Bilge, ballast and heeling pumps;
vii. Sea water pumps;
viii. Fire pumps and other fire extinguishing medium pumps;
ix. Ventilation fans for engine and boiler room;
x. Navigation lights, aids and signals;
xi. Services considered necessary to maintain dangerous spaces in a safe condition;
xii. Internal safety communication equipment;
xiii. Fire detection and alarm systems;
xiv. Main lighting system;

xv. Electrical equipment for watertight closing appliances;
xvi. Electric generators and associated power sources supplying the above equipment;
xvii. Hydraulic pumps for secondary essential equipment;
xviii. Control, monitoring and safety systems for cargo containment systems;
xix. Control, monitoring and safety devices/systems for secondary essential equipment.
xx. Equipment used for cooling and maintaining lesser ambient temperature.
xxi. Re-liquefaction plant on liquefied gas carriers
xxii. Watertight Doors
xxiii. Ambient temperature control equipment

2.3. Services for minimum comfortable conditions of habitability

2.3.1. Services such as cooking, eating, domestic refrigeration, mechanical ventilation, sanitary and fresh water are considered necessary for minimum comfortable conditions of habitability.

2.3.2. Services like the following ones which are in addition to the ones mentioned in [2.2.] & [2.3.1.] of this section necessary to sustain the ship in a normal sea-going operational and habitable condition:

a. Cargo handling and cargo gear equipment.
b. Hotel services apart from those required for habitable conditions.
c. Thrusters, apart from those required for dynamic positioning.

2.4. Normal operational and habitable condition

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 designed comfortable conditions of habitability are in working order and functioning normally.

2.5. Non-essential services

Non-essential services refer to those which if temporarily disconnected do not affect the propulsion nor creates problem in steering the ship. At the same time, it does not endanger the security of the passengers, cargo, crew, ship or machinery.

2.6. Emergency condition

Condition under which, services needed for normal operational and habitable conditions are not in a working order due to the failure of the main source of electrical power.

2.7. Emergency consumers

These are mandatory consumers who require to be fed by the emergency source of supply if the main source of supply breaks down.

2.8. Main source of electrical power

Source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

2.9. Emergency source of electrical power

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

2.10. Main switchboard

Switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to ship's services.

2.11. Emergency switchboard

In the event of failure of the main electrical power supply system, switchboard which is directly supplied by the emergency source of electrical power or transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

2.12. 'Machinery spaces of Category A'

'Machinery spaces of Category A' are the spaces mentioned in Pt 5A.

2.13. Dead ship condition

Dead ship condition means that the entire machinery installation, including the power supply, is out of operation and that the auxiliary services for bringing the main propulsion systems into operation (e.g. compressed air, starting current from batteries, etc.) and for the restoration of the main power supply are not available. Means are to be available to start the emergency generator at all times, Refer Ch 2, Sec 3, [3.2.] of this part.

2.14. Blackout

Blackout situation means the loss of the main source of electrical power resulting in the main and auxiliary machinery to be out of operation. All provisions of starting by stored energy are available.

2.15. Main generating station

Main generating station is defined as space in which the main source of electrical power is situated.

2.16. Electrical services required to be operable under a fire condition

Services required to be operable under a fire condition include:

a. Fire extinguishing system including fire extinguishing medium release alarms;
b. Fire detection system;
c. Fire and general alarm system;
d. Emergency fire pump;
e. Control and power systems for all power operated watertight doors and their status indicating systems;
f. Control and power systems for all power operated fire doors and their status indicating systems;
g. Public address system;
h. Low location lighting;
i. Emergency lighting;
j. Remote emergency stop/shutdown arrangement for systems which may support the propagation of fire and/or explosion.

2.17. High fire risk areas

'High fire risk areas' are defined as follows:

a. Machinery spaces, as defined in Pt 5A .
b. Spaces containing fuel treatment equipment and other highly flammable substances;
c. Galleys and pantries containing cooking appliances;
d. Laundries containing drying equipment;
e. Hazardous zones and spaces;
f. For passenger ships carrying more than 36 passengers:

    i. Public spaces containing furniture and furnishings of other than restricted fire risk and having a deck area of 50 m^2 or more;
    ii. Barber shops and beauty parlors; and
    iii. Saunas.

Requests to exempt spaces identified in [2.17.f.] of this section may be considered when evidence is submitted that demonstrates emergency services will remain available in the event of a fire in the space (e.g. studies of fire protection measures, installation locations, system redundancy etc.).

2.18. Hazardous areas

Areas in which an explosive atmosphere is present, or may be expected to be present due to the presence of vapors, gases, flammable dusts or explosives in quantities such as to require special precautions for the construction, installation and use of electrical apparatus. Refer also Ch 3, Sec 6, [6.2] of this part.

2.19. Systems

Systems consist of all equipment required for monitoring, control and safety with the inclusion of input and output devices. Systems cover defined functions including behavior under varying operating conditions, cycles and running.

2.20. Safety voltage

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.

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.

2.21. Low voltage systems

Alternating current systems with rated voltages greater than 50 V up to 1000 V inclusive and with rated frequencies of 50 Hz or 60 Hz, or direct current systems where the maximum instantaneous value of the voltage under rated operating conditions does not exceed 1500 V are defined as low voltage system.

2.22. High voltage systems

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 are defined as high voltage system.

2.23. Variable frequency systems

Variable frequency systems are defined as 3-phase shipboard systems for intermittent or permanent operation at a frequency varying within set limits.

2.24. Section board

An assembly of a switch gear and control gear for controlling the supply of electrical power from a switchboard and dividing it among other section boards, distribution boards and final sub-circuits.

2.25. Distribution board

A combination of one or more protective devices arranged for distributing electrical power to final sub circuits.

2.26. Final sub-circuit

It is that part of the wiring system that extends beyond the final over current device of a board.

2.27. Insulation materials

Insulating materials are to be classified by their maximum continuous operating temperatures in accordance with the following table. The insulation classes given in Table 1.2.1 of this section may be used in accordance with IEC Publication 60085.

Table 1.2.1: Insulation classes

Class	Maximum continuous operating temperature (°C)
A	105
E	120
B	130
F	155
H	180

Materials or combinations of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180^{0}C will also be considered.

2.28. Protective devices

These devices have the function of detecting actual values, activating alarms in the event of limit-value infringement and preventing machinery and equipment from being endangered. Curative measures or calls for appropriate ones are automatically initiated by them.

2.29. Safety devices

The safety devices are helpful in detecting critical limit value-infringements and preventing any immediate danger to persons, machinery or ship.

2.30. Environmental categories

Electrical equipment is classified into environmental categories according to the temperature range, vibration levels, and resistance to chemically active substances and to humidity.

The designation of the environmental categories is indicated by the EC Code in Table 1.2.2 of this section.

The first characteristic numeral indicates the temperature range in which the electrical equipment operates satisfactorily, as specified in Table 1.2.3 of this section.

The second characteristic numeral indicates the vibration level in which the electrical equipment operates satisfactorily, as specified in Table 1.2.4 of this section.

The environmental categories of the electrical equipment, in relation to the place of installation, are generally to be those specified in Table 1.2.5 of this section.

Table 1.2.2: EC code

Code letter	First characteristic numeral	Second characteristic numeral	Additional letter	Supplementary letter
EC	(numerals 1 to 4)	(numerals 1 to 3)	(letter S) (Refer 1)	(letter C) (Refer 2)

(1) The additional letter S indicates the resistance to salt mist (exposed decks, masts) of the electrical equipment.

(2) The supplementary letter C indicates the relative humidity up to 80% (air-conditioned areas) in which the electrical equipment operates satisfactorily.

Note: The designation of the environmental categories is indicated by the EC Code

Table 1.2.3: First characteristic numeral

First characteristic numeral	Brief description of location	Temperature range °C	
1	Air conditioned areas	+ 5	+ 40
2	Enclosed spaces	+ 5	+ 45
3	Inside consoles or close to combustion engines and similar	+ 5	+ 55
4	Exposed decks, masts	- 25	+ 45

Note: The first characteristic numeral indicates the temperature range in which the electrical equipment operates satisfactorily.

Table 1.2.4: Second characteristic numeral				
Second characteristic numeral	**Brief description of location**	**Frequency range Hz**	**Displacement amplitude mm**	**Acceleration amplitude g**
1	Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	from 2.0 to 13.2	1.0	-
		from 13.2 to 100	-	0.7
2	Masts	from 2.0 to 13.2	3.0	-
		from 13.2 to 50	-	2.1
3	On air compressors, on diesel engines and similar	from 2.0 to 25.0	1.6	-
		from 25.0 to 100	-	4.0
Note: The second characteristic numeral indicates the vibration level in which the electrical equipment operates satisfactorily.				

Table 1.2.5: Required environmental categories of the electrical equipment, in relation to the place of installation				
	Location within main area			
Main areas on board	**General**	**Inside cubicles, desks, etc.**	**On machinery such as internal combustion engines, compressors**	**Masts**
Machinery spaces, steering gear	EC21	EC31	EC23	X (Refer 1)
Control room, accommodation	EC21 EC11C	EC31	X	X

Bridge	EC21 EC11C	EC31	X	X
Pump room, holds, rooms without heating	EC41	X	X	X
Exposed decks	EC41S	X	X	EC42S
(1) The symbol "X" denotes locations which are generally not applicable.				

2.31. Certified safe equipment

Certified safe equipment is equipment intended for installation in hazardous areas where flammable or explosive gases, vapors, or dust are normally or likely to be present. The equipment is to be type-tested and certified by a competent, independent testing laboratory for complying with IEC Publication 60079 or equivalent standard, and rated according to its enclosure and the types of flammable atmosphere in which it is safe to install.

2.31.1. Acceptable types of certified safe equipment

The following type of electrical equipment, expressed in IEC Publication 60079 nomenclature, will be acceptable for installation in hazardous areas identified in the Rules. Other types, as well as equipment complying with an equivalent standard, will also be considered.

a. Intrinsically safe equipment – 'Ex ia' and 'Ex ib'

An intrinsically safe equipment is one which is supplied by a low energy circuit which when sparking, produced normally by breaking or making the circuit or produced accidentally (i.e., by short circuit or earth-fault), is incapable under prescribed test conditions of causing ignition of a prescribed gas or vapor.

b. Flameproof (Explosion-proof) equipment – 'Ex d'

Flameproof equipment is one which possesses an enclosure capable of withstanding, without damage, an explosion of a prescribed flammable gas or vapor within the enclosure and prevent the transmission of flame or sparks which would ignite the external prescribed flammable gas or vapor for which it is designed, and which normally operates at an external temperature that will not ignite the external prescribed flammable gas or vapor. A flameproof enclosure may not necessarily or ordinarily be weatherproof or dustproof.

c. Increased safety equipment – 'Ex e'

Increased safety equipment is designed with a method of protection in which measures additional to those adopted on ordinary industrial practice are applied, so as to give increased security against the possibility of excessive temperatures and the occurrence of arcs or sparks in electrical apparatus which does not produce arcs or sparks in normal service.

d. Pressurized or purged equipment – 'Ex p'

Pressured equipment is designed with an enclosure in which the entry of flammable gases or vapors is prevented by maintaining the air (or other non-flammable gas) within the enclosure at a specified pressure above that of the external atmosphere. Purged equipment is designed with an enclosure in which a sufficient flow of fresh air or inert gas is maintained through the enclosure to prevent the entry of any flammable gas or vapor which may be present in the ambient atmosphere.

2.31.2. Flammable gas groups and temperature classes

Certified safe equipment is to be rated for the flammable atmosphere in which it is safe to install. Each flammable atmosphere is to be identified with respect to the flammable gas, vapor or dust and its self-ignition temperature; the latter is used to limit the maximum permissible external surface temperature of the equipment. The following tables show the typical flammable gas groups and the temperature classes as in IEC Publication 60079-20:

Table 1.2.6: Flammable gas groups

Gas group	Representative gas
I	Methane (Refer note below)
IIA	Propane
IIB	Ethylene
IIC	Hydrogen

Note: While methane of firedamp and mining applications, such as methane generated from coal, is classified as Group I, industrial methane, such as natural gas, is to be classified as Group IIA with temperature Class T1, if it does not contain more than 15% (V/V) of hydrogen. A mixture of industrial methane with other compounds from Group IIA, in any proportion, is also classified as Group IIA with temperature Class T1.

Table 1.2.7: Temperature class of flammable gas

Temperature class	Maximum surface temperature, °C
T1	≤ 450
T2	≤ 300
T3	≤ 200
T4	≤ 135
T5	≤ 100
T6	≤ 85

2.32. Environmental condition

For ambient temperature, inclinations etc. Refer Pt 5A, Ch 1, Sec 4 .

SECTION 3 PLANS AND DATA FOR APPROVAL

Contents

3.1. Plans & data

3.1.1. The following plans and data are to be submitted for approval:

3.1.1.1. One-line diagram

One-line diagram of main and emergency power and lighting systems which is to include:

a. Ratings of machines, transformers, batteries and semiconductor converters;
b. All feeders connected to the main and emergency switchboards;
c. Section boards and distribution boards;
d. Insulation type, size and current loadings of cables;
e. Make, type and rating of circuit-breakers and fuses.
f. Details of harmonic filters (where fitted).

3.1.1.2. Schematic diagram

Schematic diagram of the electrical system (e.g. General & Navigation lights, Emergency generator starting, Interior communications, General emergency alarm, Intrinsically safe systems, Steering gear system, Fire detection & alarm system etc.) including information such as type of insulation, cable sizes, line drop of voltages, normal working currents, details of protective devices together with rating and interrupting capacity of circuit breakers & fuses and rated capacity of the connected load;

3.1.1.3. Short-circuit data

Calculations of prospective short circuit current of main bus bars and secondary side of transformers (Additionally, load schedule is to be submitted for information), Maximum calculated short-circuit current values, both symmetrical and asymmetrical values, available at the main and emergency switchboards and distribution boards, Rated breaking and making capacities of the protective devices.

Reference may be made to IEC Publication 61363-1 Electrical Installations of Ships and Mobile and Fixed Offshore Units – Pt 1: Procedures for Calculating Short-Circuit Currents in Three- Phase A.C.

3.1.1.4. Protective Device Coordination Study

This is to be an organized time-current study of all protective devices, taken in series, from the utilization equipment to the source, under various conditions of short circuit. The time-current study is to indicate settings of long-time delay tripping, short-time delay tripping, and instantaneous tripping, as applicable. Where an over current relay is provided in series and adjacent to the circuit protective devices, the operating and time-current characteristics of the relay are to be considered for coordination. Typical thermal withstanding capacity curves of the generators are to be included, as appropriate.

3.1.1.5. Load analysis

An electric-plant load analysis includes all operating conditions of the vessel, such as conditions in normal sea going, cargo handling, harbor maneuver and emergency operations.

The analyses are to include:

a. The simultaneous operation of loads on the emergency switchboard. Where the emergency generator capacity is less than the sum of the entire nameplate rated loads, which can be simultaneously connected to the emergency switchboard, than the analysis is to be supported by a justification for each reduced or non-simultaneous load used.
b. High voltage ship service transformers or converters, where applicable.
c. Identifying the loads to be tripped to ensure continuity of supply.

3.1.1.6. Equipment plans

The following plans and data, as applicable, are to be submitted for approval before proceeding with the work. Plans should generally be submitted electronically to INTLREG. However hard copies shall also be accepted.

a. Rotating machines

For rotating machines of 100 kW and over intended for essential services, plans showing the following particulars are to be submitted: assembly, seating arrangements, terminal arrangements, shafts, coupling, coupling bolts, stator and rotor details together with data of complete rating, class of insulation, designed ambient temperature and temperature rise, degree of protection for enclosures, weights and speeds of rotating parts.

b. Switchboards, distribution boards

Plans containing arrangements and details as indicated below are to be submitted for main and emergency switchboards, essential services, battery charging and discharging boards for emergency or transitional source of power:

i. Front view;
ii. Schematic diagram;
iii. Protective device rating and setting;
iv. Emergency tripping and preferential tripping features;
v. Internal power for control and instrumentation;
vi. Type and size of internal control and instrumentation wiring;
vii. Size, spacing, bracing arrangements, rated current carrying capacity and rated short-circuit current of bus bars and bus bar disconnecting device;
viii. Written description of automated functions and operations of the electrical plant.

c. Motor controllers

For motor controllers of 100 kW (135 hp) and over intended for essential services, plans showing the following particulars are to be submitted: front view, degree of protection for enclosure, schematic diagram, current rating of running protection of motor, and type and size of internal wiring.

d. Motor Control Centers

For motor control centers with aggregate loads of 100 kW (135 hp) and over intended for essential services, plans showing the following particulars are to be submitted: front view, degree of protection for enclosure, schematic diagram, current rating of running protection of motor, and type and size of internal wiring.

e. Electric slip coupling

Plans of electric slip couplings, if fitted, showing details of construction and scantlings together along with diagrams of electrical components and control gear.

3.1.1.7. Arrangements of electrical equipment

Arrangement plans showing the locations of the following equipment and systems:

a. Generators, main switchboard, motor control centers, transformers/converters;
b. Batteries and battery charging and discharging boards;
c. Emergency source of power, emergency lights;
d. Electric propulsion system;
e. Interior communication systems;
f. Emergency alarm system, public addresses system, fire detection and alarm system;
g. Locations of cable splices and cable junction boxes.

Details of hull penetrations for installations such as echo sounder, speed log and impressed current cathodic protection system.

3.1.1.8. Fire zone & hazardous area plan and equipment data

A general arrangement of the ship showing the hazardous spaces & fire zones (showing main vertical and, where applicable, horizontal fire zones) and the location of the electrical equipment in such spaces is to be submitted. When the selection of the equipment has been finalized, a list/booklet/schedule identifying all equipment in the hazardous areas & fire zones and the particulars of the equipment is to be submitted for review. Particulars of the equipment are to include manufacturers' names, model designations, rating (flammable gas group and temperature class), the method of protection (flameproof, intrinsically safe, etc.), any restrictions in their use, and document of certification. A copy of this list/booklet is to be maintained on board for future reference.

3.1.1.9. Battery installation plan

Battery installations covering arrangement plans and calculations shall be submitted. A schedule of batteries fitted for use for emergency and essential services, with details of:

a. Type and manufacturer's type designation;
b. Voltage and ampere-hour rating;

c. Location;
d. Equipment and/or system(s) served;
e. Maintenance/replacement cycle dates;
f. Date(s) of maintenance and/or replacement; and
g. For replacement batteries in storage, the date of manufacture and shelf life.

3.1.1.10. Cable selection & installation plan

Electric cable installation details shall be submitted. This include, but not limited to, cable supports and retention, typical radii of cable bends, bulkhead and deck penetrations, cable joints and sealing, cable splicing, earthing details, watertight and certified safe connections, earthing and bonding connections, cable tray and bunch configurations showing clearance and segregation of cables. For cable penetrations through watertight, gastight, and fire rated bulkheads and decks, evidence of penetration design approval is to be submitted. For watertight and gastight cable penetrations, certificates issued by a competent independent testing laboratory would be acceptable. For fire-rated cable penetrations, certificates issued by an Administration signatory to SOLAS 1974 as amended would be acceptable.

3.1.1.11. Other Information

a. A description of the power management system, including equipment fitted with preferential trips, schedule of sequential start of motors, etc., as applicable.
b. Voltage drop for the longest run of cable of each size.
c. Plans showing details and arrangements of oil mist detection/monitoring and alarm arrangements.
d. Information of alarms and safeguards for emergency diesel engines
e. Maintenance schedule of batteries for essential and emergency services.

3.1.2. INTLREG reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

3.1.3. Unless otherwise agreed with INTLREG, documents for approval shall be send in triplicate if submitted by the Shipyard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in duplicate.

In any case, INTLREG reserves the right to require additional copies when deemed necessary.

3.2. Surveys

3.2.1. Electrical propelling machinery and associated equipment together with auxiliary services for the safety of the ship are to be installed in accordance with the relevant requirements of this Part, surveyed and have tests witnessed by the Surveyors.

3.2.2. All generators, rotating machines & Converting equipment (e.g. transformer) of 100 kW and over, Switchboards & section boards, UPS units of 50 kVA and over, intended for essential & emergency services, are to be surveyed by the Surveyors during test and if appropriate also during manufacturing.

3.2.3. All electric propelling machinery including switchgear, control gear, converting equipment, cables, main and auxiliary generators, motors and exciters are to be surveyed by the Surveyors during manufacture and testing.

3.2.4. For ships having refrigerated cargo installations, motors are to be tested and certificates furnished by the manufacturers.

3.2.5. For ships having the class notation OPS, in addition to the equipment listed in [3.2.2.] of this section, the following Connection Equipment covered by Part 7A, where applicable, is to be surveyed by the Surveyors during manufacture and testing:

a. Flexible cables, with assembled plug and socket-outlets, if any;
b. Busbar trucking;
c. Filters;
d. Converters; and
e. Slip ring assemblies.

3.2.6. All other electrical equipment, not specifically referenced in [3.2.2.] to [3.2.4.] of this section, intended for use for essential or emergency services is to be supplied with a manufacturer's works test certificate showing compliance with the constructional Standard(s) as referenced by the relevant requirements of this Part.

3.3. Additions or alterations

3.3.1. Additions or alterations (temporary or permanent) to the approved load of the existing electrical installations are not to be made until it has been ascertained that the current carrying capacity and condition of the existing installation (including cables and switchgear) are adequate for the proposed modification.

3.3.2. Plans are to be submitted for consideration, and the alterations or additions are to be carried out under the survey, and to the satisfaction of the Surveyors.

CHAPTER 2 ELECTRICAL POWER SUPPLY

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1. General

1.1.1. The requirement of this Chapter is suitable to both direct current and alternating current installations unless otherwise stated.

1.1.2. The provisions of this Chapter apply to shipboard electrical power generation and distribution systems. High voltage systems are subject additionally to the provisions of Sec 5, [5.1.] of this chapter. For DC systems, unless specifically stated in this chapter, Refer IEC Publications 60092-201, 60092-202 and 60092-301.

1.1.3. The requirements of this Chapter are intended to assure the satisfactory operation of electrical systems onboard ship through:

a. The provision of sufficient number of generators to allow for at least one standby;
b. The provision of an emergency source of power and its supply to services needed in an emergency. The capacity of the emergency source of electrical power must be satisfactory to supply all those services which are crucial for safety in an emergency;
c. The continuity of supply in the event of an equipment fault or an overload by means of coordinated tripping of protective devices, automatic shedding of non-essential loads, etc.;
d. Observation of electrical safety; such as proper sizing and protection of electrical cables, fire retarding properties of insulation materials, appropriate enclosure of equipment, proper installation and tests, etc.; with a view to minimizing the risks of fire and hazard to personnel;
e. Design assessment, testing and certification of critical equipment in the systems.
f. Providing judicious attention to the hazards of the cargoes carried and their implications on electrical equipment and system design.

SECTION 2 MAIN SOURCE OF ELECTRICAL POWER

Contents

2.1. Number, capacity and arrangement of generators

2.1.1. Number and capacity of generators and converting sets

2.1.1.1. Number and capacity of generating sets and converting set (such as transformers and semi-conductor converters) shall be sufficient enough to supply all the services needed for normal and habitable conditions.

2.1.1.2. The number and capacity of generating sets and converting set (Refer Sec 4, [4.1.] of this chapter for transformers and semi-conductor converters) mentioned in [2.1.1.1.] of this section shall be such that under sea-going condition, in the event of failure of any one generating set or converting set, it will still be sufficient enough to:

a. Carry electrical loads for essential services (Refer Ch 1, Sec 2, [2.2.] of this part) and services for minimum comfortable conditions of habitability (Refer Ch 1, Sec 2, [2.3.] of this part), cargo refrigeration machinery and the container socket outlets & ventilation system of container ships.
b. In places where a central power generation system is engaged the number and rating of generator sets is to be such that with one set out of action the remaining sets are capable of providing all important and normal ship service loads while maintaining an effective level of propulsion power.
c. To allow the starting of the largest motor without causing any motor to stall or any device to fail due to extreme voltage drop (Refer Sec 4, [4.2.] of this chapter) on the system.
d. Be capable of providing the necessary electrical services to start the main propulsion machinery from a dead ship condition. The emergency source of electrical power may be used to assist if it can provide power at the same time to those services required to be supplied by Section 3. Refer also [2.2.2.] of this section. In addition, where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the vessel in conjunction with other machinery, as appropriate, from a dead ship condition, within thirty minutes after the blackout

2.1.2. Arrangement of generators

2.1.2.1. General

In places where the main source of electrical power is required for propulsion and steering of the ship, the system is to be so arranged that, in case of the loss of any one of the generators in service, the electrical supply to equipment required for propulsion and steering and for ensuring safety of the ship will be maintained or restored as per the provision in [2.1.2.2.] or [2.1.2.3.] of this section. For main distribution of electrical power Refer Sec 4, [4.2.8.] of this chapter.

Load shedding of non-essential services (Refer Ch 1, Sec 2, [2.5.] of this part) and where required secondary essential services (Refer Ch 1, Sec 2, [2.2. b.] of this part) or other arrangements, as may be essential, are to be provided to protect the generators against sustained overload. Refer also Sec 4, [4.5.14.] of this chapter.

2.1.2.2. Single generator operation

In places where normally the electrical power is supplied by a single generator, provision is to be made upon loss of power for automatic starting and connecting to the main switchboard with a standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries in sequential operation, if necessary, to permit propulsion and steering and to ensure the safety of the ship. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds after loss of the electrical power supply but in no case in more than 45 seconds.

2.1.2.3. Multiple generators operation

Where normally the electrical power is supplied by more than one generator set at the same time in parallel operation, the system is to be so arranged that in the event of the loss of any one of the generators in service, the electrical power supply to equipment necessary for propulsion, steering and safety of the ship will be maintained by the remaining generator(s) in service.

In addition, where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the ship in conjunction with other machinery, as appropriate, from a dead ship condition (Ch 1, Sec 2, [2.13.] of this part) within thirty minutes after the blackout (Ch 1, Sec 2, [2.14.] of this part). Refer also [2.2.2.] of this section.

2.1.2.4. Location of generators

At least one generating station (one or more generators sufficient to supply to essential services) is to be placed in the same space as the main switchboard (and transformers, as applicable) so that, as far as practicable, the occurrence of a fire, flooding or similar casualty in not more than one space cannot completely disrupt the normal electrical supply.

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

2.2. Starting arrangements

2.2.1. Starting arrangements of the generating sets prime movers

The starting arrangements of the generating sets prime movers are to conform to the requirements of Pt 5A, Ch 8, Sec 4 .

2.2.2. Starting from dead ship condition

2.2.2.1. In restoring the propulsion from a dead ship condition (Refer Ch 1, Sec 2, [2.13.] of this part), no stored energy is to be assumed available for starting the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available to start the emergency generator at all times.

2.2.2.2. The emergency source of electrical power may be used to restore the propulsion, provided its capacity either alone or combined with other available sources of electrical power is sufficient to provide at the same time those services required to be supplied in Sec. 3 of this chapter.

The emergency source of electrical power and other means needed to restore the propulsion are to have a capacity such that the necessary propulsion starting energy is available within 30 minutes of blackout (Refer Ch 1, Sec 2, [2.14.] of this part).

Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

For steam ships, the 30-minute time limit is to be taken as the time from blackout to light-off of the first boiler.

2.2.2.3. Where the emergency source of power is an emergency generator which complies with Sec 3, [3.2.] of this chapter and [2.2.2.2.] of this section, this emergency generator may be used for restoring operation of the main propulsion plant, boilers and auxiliary machinery.

Where there is no emergency generator installed, the arrangements for bringing main and auxiliary machinery into operation are to be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed onboard ship without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand operated compressor.

2.3. Prime movers for generators

2.3.1. Each generator required according to [2.1.] of this section is normally to be driven by a separate auxiliary prime mover. If such prime mover for a generator also is used for driving other auxiliary machinery, it is to have sufficient capacity for the total load, or the machinery arrangement is to be such that the generator and the other auxiliary machinery cannot be used simultaneously.

If the other auxiliary machinery is connected to the prime mover in such a way that it is possible to overload the prime mover, an interlocking or other effective means for preventing such overloading is to be arranged.

2.3.2. When generators driven by reciprocating steam engines or steam turbines are used, and the operation of the boiler(s) depends on electric power supply, then there is to be at least one generator driven by an auxiliary oil engine or gas turbine to enable the boiler plant to be started.

2.3.3. Generators and generator systems, having the ship's main propulsion machinery as their prime mover, may be accepted as part of the ships main source of electrical power, provided:

a. They are capable of operating under all weather conditions during sailing and during maneuvering, also when the ship is stopped, within the limits of voltage and frequency variations as specified in Sec 4, [4.2.3.] of this chapter;
b. Their rated capacity is safeguarded during all operations given above and is such that in the event of any other one of the generators failing, the services given in Ch 1, Sec 2, [2.2] and Ch 1, Sec 2, [2.3] of this part are maintained;
c. The short circuit current of the generator / generator system is sufficient to trip the generator / generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system.
d. Protection is to be arranged in order to safeguard the generator / generator system in case of a short circuit in the main bus bar. The generator / generator system is to be suitable for further use after fault clearance.
e. It is to be possible to disconnect the generator from the propulsion system by a separate clutch.
f. Starting of stand-by generating sets.

2.3.4. Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power as specified in [2.3.3. a.] of this section may be accepted whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions provided:

a. There are sufficient and adequately rated additional generators fitted, which constitute the main source of electrical power.
b. Means are provided to automatically start one or more of the generators, constituting the main source of electrical power, upon the frequency variations exceeding ± 10 of the limits as specified in Sec 4, [4.2.3] of this chapter and the voltage variations exceeding the limits as specified in Sec 4, [4.2.3] of this chapter.
c. The short circuit current of the generator and/or generator system is sufficient to trip the generator/generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system.
d. Where considered appropriate, load shedding arrangements are fitted to meet the requirements of Sec 4, [4.5.14.] of this chapter.
e. On ships having remote control of the ship's propulsion machinery from the navigating bridge means are provided, or procedures be in place, so as to ensure that supplies to essential services are maintained during maneuvering conditions in order to avoid a blackout situation.

2.3.5. Requirements for the governors of prime mover shall be comply with the following:

a. The governing accuracy of the generating sets prime movers is to meet the requirements of Part 5A.
b. The maximum electrical step load switched on or off is not to cause the frequency variation of the electrical supply to exceed the parameters given in Sec 4, [4.2.3.] of this chapter.

2.4. Power supplied by propulsion generators

For ships propelled by electric power and having two or more constant voltage propulsion generating sets, the ship’s service electric power may be derived from this source. Refer Sec 4, [4.6.4.1.] of this chapter.

2.5. Generators driven by propulsion machinery

2.5.1. Constant speed drive

A generator driven by propulsion machinery capable of operating continuously at a constant speed, e.g., those fitted with controllable-pitch propellers, may be considered one of the generators required by [2.1.1.] of this section, provided that the arrangements stated in [2.5.1. a. to 2.5.1. b.] of this section below are complied with:

a. The generator and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in Ch 4, Sec 1, [1.6.3.] of this part and Sec 4, [4.2.3.] of this chapter under all weather conditions during sailing or maneuvering and also while the ship is stopped.
b. The rated capacity of the generator and the generating systems is safeguarded during all operations given under [2.5.1. a.] of this section and is such that the services required by [2.1.1.] of this section can be maintained upon loss of any generator in service.
c. An arrangement is made for starting a standby generator and connecting it to the switchboard, in accordance with [2.1.2.] of this section.

2.5.2. Variable speed drive

A generator driven by propulsion machinery not capable of operating continuously at a constant speed may be used for normal operational and habitable conditions of the ship, provided that the arrangements stated in [2.5.2. a. to 2.5.2. e.] of this section below are complied with. This type of generator will not be counted as one of the generators required by [2.1.1.] of this section.

a. In addition to this type of generator, generators of sufficient and adequate rating are provided, which constitute the main source of electrical power required by [2.1.1.] of this section.
b. When the frequency variations at the main bus bar exceed the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to comply with [2.1.2.] of this section.

    i. Permanent frequency variation: ±5.5%;
    ii. Transient frequency variation: ±11% (5 sec).

c. The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in Ch 4, Sec 1, [1.6.3.] of this part and Sec 4, [4.2.3.] of this chapter.
d. Where load-shedding arrangements are provided, they are fitted in accordance with Sec 4, [4.5.14.] of this chapter.
e. Where the propulsion machinery is capable of being operated from the navigating bridge, means are provided or procedures are in place to ensure that the power supply to essential services is maintained during maneuvering conditions in order to avoid a blackout situation.

SECTION 3 EMERGENCY SOURCE OF ELECTRICAL POWER

Contents

3.1. General

3.1.1. The requirements of this Section apply to passenger and cargo ships to be classed for unrestricted service. They do not apply to cargo ships of less than 500 tons gross tonnage. The emergency source of power for cargo ships of less than 500 tons gross tonnage will be the subject of special consideration.

3.1.2. All ships should be provided with a self-contained emergency source of electrical power.

3.1.3. In case of failure of the main source of electrical power the emergency source of electrical power must take over the supply of the emergency consumers. However, it must not be dependent on the main source of electrical power. For emergency distribution of electrical power source Refer Sec 4, [4.2.9.] of this chapter.

3.1.4. The capacity of the emergency source of electrical power must be satisfactory to supply all those services which are crucial for safety in an emergency.

3.1.5. 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. Exceptionally while the ship is at sea, is understood to mean conditions such as:

a. Blackout situation;
b. Dead ship situation;
c. Routine use for testing;
d. Short-term parallel operation with the main source of electrical power for the purpose of load transfer.

Unless otherwise instructed by the INTLREG, the emergency generator may be used during lay time in port for the supply of the ship mains, provided the requirements of [3.5.] of this section are complied with.

In a vessel engaged regularly in voyages of short duration and INTLREG satisfied that an adequate standard of safety would be attained, a lesser period than the 36-hour period & 18-hour period specified in [3.3.] and [3.4.] of this section respectively may be accepted, but not less than 12 hours.

3.1.6. The emergency source of electrical power and associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

3.1.7. The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard are to be such as to ensure to the satisfaction of INTLREG that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of category A (Refer Ch 1, Sec 2, [2.12.] of this part) will not interfere with the supply, control and distribution of emergency electrical power.

As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard is not to be continuous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

3.1.8. The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power. For emergency switchboard Refer Sec 4, [4.2.10.] of this chapter.

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

No accumulator battery fitted in accordance with this Section, unless for engine starting is to be installed in the same space as the emergency switchboard. For emergency switchboard Refer also Sec 4, [4.2.10.] of this chapter.

3.1.9. 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.

3.1.10. 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 (e.g. providing a bypass feeder or a duplication of converter).

3.1.11. The emergency generator and its prime-mover and any emergency accumulator battery is to be so designed and arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

3.1.12. Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

3.2. Starting arrangements for emergency generating sets

3.2.1. General

Emergency generating sets are to be able to readily start in their cold condition at a temperature of 0°C. If this is not practical or if lower temperatures are likely to be encountered, heating arrangements are to be fitted.

3.2.2. Number of starts

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

3.2.3. Stored energy for starting

The stored energy is to be maintained at all time, as follows:

a. Electrical and hydraulic starting systems are to be maintained from the emergency switchboard;
b. Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;
c. All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

3.2.4. Manual starting

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

When manual starting is not practicable, the requirements of [3.2.2.] and [3.2.3.] of this section are to be complied with the exception that the starting may be manually initiated.

3.3. Emergency source of electrical power in passenger ships

3.3.1. The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified herein, if they depend upon an electrical source for their operation:

3.3.1.1. For a period of 36 hours, emergency lighting:

a. In all service and accommodation alleyways, stairways and exits, personnel lift cars;
b. At every muster and embarkation station on deck and over the sides;
c. In all control stations, machinery control rooms, and at each main and emergency switchboard;
d. In alleyways, stairways and exits giving access to the muster and embarkation stations;
e. In the machinery spaces and main generating stations including their control positions;
f. At the steering gear;
g. At the fire pump, the sprinkler pump and the emergency bilge pump and at the starting position of their motors; and,
h. At all stowage positions for firemen's outfits;

3.3.1.2. For a period of 36 hours:

a. The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force; and
b. The radio-communications, as required by Amendments to SOLAS 1974, Chapter IV.

The VHF radio installation; and if applicable;

i. The ship earth station;
ii. The MF radio installation; and
iii. The MF/HF radio installations.

3.3.1.3. For a period of 36 hours; unless such services have an independent supply for the period of 36 hours from an accumulator battery suitably located for use in an emergency:

a. All internal communication equipment required in an emergency which is generally:

   i. The means of communication which is provided between the navigating bridge and the steering gear compartment.
   ii. The means of communication which is provided between the bridge and the radio telegraph or radio telephone stations.
   iii. The means of communication which is provided between the navigating bridge and the position in the machinery space or control room from which the engines are usually controlled.
   iv. The public address system or other effective means of communication which is provided throughout the accommodation, public and service spaces.
   v. The means of communication which is provided between the officer of the watch and the person responsible for closing any watertight door which is not capable of being closed from a central control station.
   vi. The means of communication which is provided between the navigating bridge and the main fire control station.

b. The navigational aids as required by Amendments to SOLAS 1974 Reg. V/19, where such provision is unreasonable or impracticable INTLREG may waive this requirement for ships of less than 5,000 tons gross tonnage;
c. The fire detection and fire alarm system, and the fire door holding and release system; and
d. For intermittent operation of the daylight signaling lamp, the ship's whistle, the manual fire alarms and all internal signals those are required in an emergency.

3.3.1.4. For a period of 36 hours:

a. Emergency fire pump;
b. The automatic sprinkler pump, if any; and
c. The emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves.

3.3.1.5. The steering gear for the period of time required by Ch 5, Sec 3, [3.9.] of this part.

3.3.1.6. For a period of half an hour:

a. Any watertight doors which are required to be power operated together with their indicators and warning signals. Sequential operation of the doors may be permitted provided all doors can be closed in 60 seconds;
b. The emergency arrangements to bring the lift cars to deck level for the escape of persons. The passenger lift cars may be brought to deck level sequentially in an emergency.

3.3.1.7. In a ship engaged regularly on voyages of short duration, INTLREG if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 36-hour period specified in [3.3.1.1.] to [3.3.1.5.] of this section but not less than 12 hours.

3.3.2. The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a. Where the emergency source of electrical power is a generator, it is to be:

i. Driven by a suitable prime-mover with an independent supply of fuel having a flashpoint (closed cup test) of not less than 43°C;
ii. Started automatically upon failure of the electrical supply from the main source of electrical power and is to be automatically connected to the emergency switchboard; those services referred to in [3.3.3.] of this section are then to be transferred automatically to the emergency generating set. The automatic starting system and the characteristic of the prime-mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; unless a second independent means of starting the emergency generating set is provided, the single source of stored energy is to be protected to preclude its complete depletion by the automatic starting system; and
iii. Provided with a transitional source of emergency electrical power according to [3.3.3.] of this section.

b. Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

i. carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 percent above or below its nominal voltage;
ii. Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
iii. Immediately supplying at least those services specified in [3.3.3.] of this section.

3.3.3. The transitional source of emergency electrical power required by [3.3.2.a.iii.] of this section is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

a. For half an hour:

i. The lighting required by [3.3.1.1.] and [3.3.1.2. a.] of this section;
ii. Services required by [3.3.1.3. (a., c. and d.) of this section] unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

b. Power to close the watertight doors but not essentially all of them simultaneously, unless an independent temporary source of stored energy is provided. Power to the control, indication and alarm circuits as required for half an hour.

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

The above-mentioned voltage variants are not to exceed the following limits, as applicable:

a. Where the system on the load side of the converter or inverter is D.C.: limits as given in [3.3.3.] of this section.
b. Where the system on the load side of the converter or inverter is A.C.: limits as given in Sec 4, [4.2.3.] of this chapter.

3.4. Emergency source of electrical power in cargo ships

3.4.1. The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

a. For a period of three hours, emergency lighting at every survival craft preparation station, muster and embarkation station and over the sides. Remotely located stations for a life raft installed in accordance with SOLAS 1974 as amended, CHAPTER III/B, Regulation 31.1.4 that is provided with portable means of illumination acceptable to the National Administration with which the Ship is registered may be considered to satisfy this requirement;
b. For a period of 18 hours, emergency lighting:

    i. In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks;
    ii. In the machinery spaces and main generating stations including their control positions;
    iii. In all control stations, machinery control rooms, and at each main and emergency switchboard;
    iv. At all stowage positions for fireman’s outfits;
    v. At the steering gear; and
    vi. At the emergency fire pump, at the sprinkler pump, if any, and at the emergency bilge pump, if any, and at the starting positions of their motors;
    vii. In all cargo pump rooms of tankers.

c. For a period of 18 hours:

    i. the navigation lights and other lights, as required by the International Regulations for Preventing Collisions at Sea in force; and
    ii. The radio communications, as required by Amendments to SOLAS 1974, Chapter IV.

d. For a period of 18 hours:

    i. All internal communication equipment as required in an emergency;
    ii. The navigational aids as required by Amendments to SOLAS 1974 Reg. V/19; where such provision is unreasonable or impracticable this requirement may be waived for ships of less than 5000 tons gross;
    iii. The fire detection and fire-alarm system; and

iv. Intermittent operation of the daylight signaling lamp, the ship's whistle, the manually operated call points and all internal signals that are required in an emergency;

Unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency.

e. For a period of 18 hours the emergency fire pumps if dependent upon the emergency generator for its source of power.
f. The steering gear for the period of time required by Ch 5, Sec 3, [3.9.] of this part.
g. Where applicable, the services required by Sec 2, [2.2.2.] of this chapter.

3.4.2. The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a. Where the emergency source of electrical power is a generator it is to be:

i. Driven by a suitable prime mover with an independent supply of fuel, having a flashpoint (closed-cup test) of not less than 43°C;
ii. Started automatically upon failure of the main source of electrical power supply unless a transitional source of emergency electrical power in accordance with [3.4.2. a. iii.] of this section is provided; where the emergency generator is automatically started, it is to be automatically connected to the emergency switchboard; those services referred to in [3.4.3.] of this section are to be connected automatically to the emergency generator; and unless a second independent means of starting the emergency generator is provided the single source of stored energy is to be protected to preclude its complete depletion by the automatic starting system; and
iii. Provided with a transitional source of emergency electrical power as specified in unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds.

b. Where the emergency source of electrical power is an accumulator battery it is to be capable of:

i. Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 percent above or below its nominal voltage.
ii. Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and;
iii. Immediately supplying at least those services specified in [3.4.3.] of this section.

3.4.3. The transitional source of emergency electrical power where required by [3.4.2.a.] of this section is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and is to be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

a. The lighting required by [3.4.1.a.] to [3.4.1.c.] of this section. For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

b. All services required by [3.4.1.d. (i., iii. and iv.) of this section] unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

3.5. Use of emergency generator in port

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

3.5.2. 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.

3.5.3. 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 the emergency services for the period of time as required in [3.3.] & [3.4.] of this section.

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

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

3.5.6. Means are to be provided to readily change over to emergency mode from harbor mode.

3.5.7. 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.

3.5.8. When necessary for safe operation, the emergency switchboard is to be fitted with switches to isolate the circuits.

3.5.9. Operational instructions (such as fuel oil tank level, harbor/seagoing mode changeover arrangements, etc.) are to be provided on board. Before the ship is under way, all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard. Such instructions are to be distinctly posted at the emergency generator room.

3.6. Alarms and safeguards for emergency diesel engines

3.6.1. Information to be submitted

Information demonstrating compliance with these requirements is to be submitted for review. The information is to include instructions to test the alarm and safety systems.

3.6.2. Alarms and safeguards

3.6.2.1. Alarms and safeguards are to be fitted in accordance with Table 2.3.1 of this section.

3.6.2.2. The safety and alarm systems are to be designed to ‘fail safe’. The characteristics of the ‘fail safe’ operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship.

3.6.2.3. Regardless of the engine output, if shutdowns additional to those specified in Table 2.3.1 of this section are provided, except for the over speed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

3.6.2.4. The alarm system is to function in accordance with Ch 8, Sec 2, [2.1.1.] and [2.7.] of this part, with additional requirements that grouped alarms are to be arranged on the bridge.

3.6.2.5. In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

3.6.2.6. Local indications of at least those parameters listed in Table 2.3.1 of this section are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

Table 2.3.1: Alarms and safeguards for emergency diesel engines

Parameter	**≥ 220 kW**	**< 220 kW**
Fuel oil leakage from fuel injection pipes	Alarm activated	Alarm activated
Lubricating oil temperature	Alarm for high value	
Lubricating oil pressure	Alarm for low value	Alarm for low value
Oil mist concentration in crankcase (Refer Note 1)	Alarm for high value	
Pressure or flow of cooling water	Alarm for low value	
Temperature of cooling water (or cooling air)	Alarm for high value	Alarm for high value
Over-speed activated	Alarm activated + Shutdown	

Note 1: For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.

SECTION 4 SYSTEM DESIGN

Contents

4.1. Transformers, semiconductor converters

4.1.1. Transformers

4.1.1.1. General

Transformers shall comply with the requirements of IEC 60076. Power transformers, or an acceptable and relevant National Standard amended where necessary for ambient temperature.

4.1.1.2. Continuity of supply

Where transformers and/or converters form a part of the ship's electrical system supplying essential services and services necessary for minimum comfortable conditions of habitability, as defined in Ch.1, sec 2, [2.2.] and [2.3.] of this part, the number and capacity of the transformers and/or converters are to be such that, with any one transformer or converter, or any one single phase of a transformer out of service, the remaining transformers and/or converters or remaining phases of the transformer are capable of supplying power to these loads under normal seagoing conditions.

4.1.1.3. Arrangements

Each required transformer is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. Each primary circuit is to be provided with switchgear protective devices in each phase. Each of the secondary circuits is to be provided with a multi pole isolating switch. This multi pole isolating switch is not to be installed on the transformer casing or its vicinity, to preclude its damage by fire or other incident at the transformer.

4.1.1.4. Construction

a. Generally, transformers are to be of the dry, air-cooled type, and encapsulated or liquid- filled type.
b. Transformers, apart from those for motor starting, are to be double wound (two or more separate windings.).
c. When forced cooling is used, whether air or liquid, there is to be monitoring of the cooling medium and transformer winding temperatures with an alarm should these exceed preset limits. There are to be arrangements so that the load may be reduced to a level commensurate with the cooling available. Water cooled heat exchangers are used in transformer cooling circuits, there is to be provision for the detection of water leakage and the system is to be arranged so as to prevent the entry of water into the transformer.
d. Liquid-cooled transformers may be used provided that:

    i. The liquid is non-toxic and of a type which does not readily support combustion.
    ii. The construction is such that the liquid is not spilled in inclined position.
    iii. Temperature and pressure relief devices with an alarm are installed
    iv. Drip trays or other appropriate arrangements for collecting the liquid from leakages are provided.
    v. Liquid gauge signifying the normal liquid level range is fitted.

e. Suitable fixed terminal connections are to be provided in an accessible position with sufficient space for convenient connection of the external cables.
f. Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the following information:

i. The manufacturer's name;
ii. The number of phases;
iii. The manufacturer's serial number (or identification mark);
iv. The ambient temperature;
v. The year of manufacture;
vi. The rated frequency;
vii. The rated power;
viii. The rated current in primary and secondary sides;
ix. The rated voltage in primary and secondary sides;
x. The class of insulation or permissible temperature rise.

4.1.1.5. Transformers and converters for battery charger

Where batteries connected to a single battery charger are the sole means of supplying DC power to equipment for essential services, as defined in Ch 1, Sec 2, [2.2] of this part, failure of the single battery charger under normal operating conditions should not result in total loss of these services once the batteries are depleted. In order to ensure continuity of the power supply to such equipment, one of the following arrangements is to be provided:

a. Duplicate battery chargers; or
b. A single battery charger and a transformer/rectifier (or switching converter) which is independent of the battery charger, provided with a change-over switch; or
c. Duplicate transformer/rectifier (or switching converter) units within a single battery charger, provided with a changeover switch.

The above requirements are not applicable for the following:

i. The equipment for the essential services, which contains a single transformer/ rectifier with a single AC power supply feeder to such equipment.
ii. The services which are not used continuously, such as battery chargers for engine starting batteries, etc.

4.1.1.6. Enclosures

Transformers are to have enclosures with a degree of protection in accordance with [4.5.22.] of this section.

4.1.1.7. Transformers for essential services

Transformers for essential services and for emergency source of power are to be constructed in accordance with the following requirements. Other transformers, including auto-transformers for starting motors and isolation transformers may be constructed in accordance with good commercial practice.

a. Rating:

Transformers are to be continuously rated based on the maximum expected ambient temperature to which they are subjected, but not less than 45ºC (113°F) for boiler and engine rooms and 40 ºC (104°F) for other locations.

b. Temperature rise:

The design temperature rise of insulated windings based on an ambient temperature of 40°C is not to exceed that in the Table 2.4.1 of this section. If the ambient temperature exceeds 40°C (104°F), the transformer is to be derated so that the total temperatures based on the table are not exceeded.

Table: 2.4.1: Temperature rise limits for transformers

Insulation Class	Copper Temperature Rise by Resistance, °C (°F)	Hottest Spot Temperature Rise, °C (°F)
A	55 (99)	65 (117)
B	80 (144)	110 (198)
F	115 (207)	145 (261)
H	150 (270)	180 (324)
Note: Metallic parts in contact with or adjacent to insulation are not to attain a temperature in excess of the hottest spot temperature rise.		

c. Prevention of the accumulation of moisture:

Transformers of 10 kVA/ phase and over are to be provided with effective means to prevent accumulation of moisture and condensation within the transformer enclosure where the transformer is disconnected from the switchboard during standby (cold standby). Where it is arranged that the transformer is retained in an energized condition throughout a period of standby (hot standby), the exciting current to the primary winding may be considered as a means to meet the above purpose. In case of hot standby, a warning plate is to be posted at or near the disconnecting device for the primary side feeder to the transformer.

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

a. Under resistive load (cos θ = 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%. An exception is made for special transformers, such as starting and instrument transformers, for which a different voltage variation may be considered.
b. 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 switchboards bus bars to the consumers i.e. When the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard bus bars to any point in the installation is not to exceed 6% of the nominal voltage. For battery circuits with supply voltage less than 55 V, this value may be increased to 10%. For the circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.
c. 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.
d. When transformers are so arranged that their secondary windings may be connected in parallel, the winding connections are to be compatible, the rated voltage ratios are to be equal (with tolerances allowed) and the short-circuit impedance values, expressed as a percentage, are to have a ratio within 0.9 to 1.1. When transformers are intended for operation in parallel, the rated power of the smallest transformer in the group is to be not less than half of the rated power of the largest transformer in the group.

4.1.1.9. Testing of transformer

a. Single-phase transformers rated 1 kVA and above and three-phase transformers rated 5 kVA and above, intended for essential or emergency services, are to be tested by the manufacturer whose certificate of tests will be acceptable and are to be submitted upon request by INTLREG. The tests are to include at least the following:

   i. Measurement of winding resistance, voltage ratio, impedance voltage, short-circuit impedance, insulation resistance, load loss, no load loss and excitation current, phase relation and polarity.
   ii. Dielectric strength.
   iii. Temperature rise (required for transformer of each size and type).

b. On new transformers intended for essential services the tests specified in Table 2.4.2 of this section are to be carried out.

Table: 2.4.2: Tests to be carried out on transformers

No	Tests	Type test (Refer 1)	Routine test (Refer 2)
1	Examination of the technical documentation, as appropriate, and visual inspection (Refer 3)	X	X
2	Insulation resistance measurement	X	X
3	Voltage drop	X	X
4	High voltage test	X	X
5	Temperature rise measurement	X	
6	Induced voltage test	X	X
7	Voltage ratio	X	X
(1) Type test on prototype transformer or test on at least the first batch of transformers.			
(2) The certificates of transformers routine tested are to contain the manufacturer's serial number of the transformer which has been type tested and the test result.			
(3) A visual examination is to be made of the transformer to ensure, as far as practicable, that it complies with technical documentation.			

c. 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. Such test reports are to be made available to the INTLREG.
d. 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. The results of this test and the serial number of the tested transformer are to be inserted in the test reports for the other transformers.
e. Where the test procedure is not specified, the requirements of IEC 60076 and 60726 apply.

f. 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 the INTLREG.

g. Procedure of insulation tests shall be carried out as follows:

   i. Transformers are to be subjected to a high voltage test in accordance with the procedure.
   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 together. Single-phase transformers for use in a poly phase group are to be tested in accordance with the requirements applicable to that group.
   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 percent 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 MΩ.

4.1.2. Semiconductor converters

4.1.2.1. General

a. Services using semiconductor rectifying elements such as diodes, reverse blocking triodes, thyristors, etc. The manufacturer may carry out the tests by whose certificate of tests will be acceptable and is to be submitted. All semiconductor converters will be accepted, subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.
b. Semiconductor equipment is to comply with the requirements of IEC 60146: Semiconductor converters, or an acceptable and relevant National Standard amended where necessary for ambient temperature.
c. Semiconductor static power converter equipment is to be rated for the required duty having regard to peak loads, system transients and over voltage.

4.1.2.2. Technical integration

Unless otherwise stated, it is the responsibility of the Yard to make sure technical integration of converters, with respect to:

a. Rating and cooling (with respect to increased losses);
b. Operating philosophies;
c. Torque/speed characteristics;
d. Harmonic filters;
e. Bearing currents;
f. Acceleration/breaking;
g. Installation instructions.

4.1.2.3. Functionality

A converter shall be described in a functional description. This description shall at least cover the following items:

a. Control system;
b. Manual operation;
c. Alarms;

d. Intended use and operational modes;
e. Integration versus higher level control system;
f. Protection functions, trips and shut downs;
g. Redundancy;
h. Redundancy for cooling.

4.1.2.4. Constructional and operational requirements

a. Semiconductor converters are generally to comply with the requirements for switchgear assemblies.
b. The monitoring and control circuits are generally to comply with the requirements of Ch. 8 of this part.
c. Accessibility of semiconductor converter are to comply with requirement of following:

    i. Converter equipment is to be so arranged that the semiconductor devices, fuses, control and firing circuit boards may be readily removed from the equipment for repair or replacement.
    ii. Converter equipment, including any associated transformers, reactors, capacitors and filters, if provided, is to be so arranged that the harmonic distortion, and voltage spikes, introduced in to the ship's electrical system are within the limits of Harmonics or restricted to a lower level necessary to ensure that it causes no malfunction of equipment connected to the electrical installation.

d. The converters high voltage sections shall have enclosures as required for high voltage switchgear. Doors shall be automatically locked unless the main circuit breaker is open and the circuit is earthed.
e. Over voltage spikes or oscillations caused by commutation or other phenomena, are not to result in the supply voltage waveform deviating from a superimposed equivalent sine wave by more than 10 per cent of the maximum value of the equivalent sine wave.
f. Transformers, reactors, capacitors and other circuit devices associated with converter equipment, or associated filters are to be suitable for the distorted voltage and current waveforms to which they may be subjected and filter circuits are to be provided with facilities to ensure that their capacitors are discharged before the circuits are energized.
g. A nameplate or identification is to be provided on the semiconductor converter and is to indicate at least the manufacturer's name and the identification number of the equipment.
h. Where control systems form an integral part of semiconductor equipment, they are to be designed and manufactured with regard to the environmental conditions to which they will be exposed in service and their performance is to be demonstrated during the test and trials programmed.
i. Electrical rating and duty of converter are to be established according to following:

    i. The specified capacity shall at least include a 100 percent continuous load, and a specified overload capacity given by a current of maximum duration of time.
    ii. Converters for motor drives (including soft starters), shall as a minimum withstand two consecutive start attempts immediately followed after stopping, or starting up from cold without being overheated.

j. Unless an impulse voltage test has been carried out as a type test with impulse voltages as given in relevant product standard, the creep age and clearance distances shall be in accordance with relevant product standard, suitable for pollution degree 3 and over voltage category III. The clearance and creep age distances given in the relevant IEC standards are reproduced in Table 2.4.3, Table 2.4.4 and Table 2.4.5 of this section. The impulse voltage test voltages are reproduced in Table 2.4.6 of this section.

Table 2.4.3: Minimum clearance distances for low voltage semi-conductor converters (Refer 1)

Nominal voltage of the system, (line voltage); (V) (Refer2)	Minimum clearance distance, (mm)
120	0.80
220, 230, 240	1.5
380, 400, 415, 440, 480	3.0
600, 630, 660, 690	5.5

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2. Applicable for three phase systems. If single phase supply, the distance shall be increased one step.

2) Interpolation is not permitted.

Table 2.4.4: Minimum clearance distances for high voltage semi-conductor converters [1)]

Nominal voltage of the system (maximum line voltage); (V) [2)]	Minimum clearance distance, (mm)
1732	8.0
6235	25
12470	60
20785	90

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2.

2) Interpolation is permitted.

Table 2.4.5: Minimum creep age distances, semi-conductor converters [1)]

Working voltage (V) [2) 3)] (rms)	Minimum creep age distance [4)], (mm)
100	2.2
160	2.5
200	3.2
250	4.0
320	5.0
400	6.3
500	8.0
630	10.0
800	12.5
1000	16
1250	20
1600	25
2000	32
2500	40
3200	50
4000	63
5000	80

6300	100
8000	125
10000	160

1) Extract from IEC 61800-5-1, Table 10, and IEC 60950-1, Table 2N.
2) The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use.
3) Interpolation is permitted.
4) Based on insulating material group III a/b. If the material group is not known, group III a/b shall be assumed.

k. Capacitors within a converter shall be discharged to less than 60 Volt in less than 5 s (or a residual charge of less than 50 µC) after removal of the power. If this requirement not is achievable, warning signboards shall be fitted.
l. The output voltage and frequency of the power supply units shall comply with the requirements for power supply systems.
m. Converters serving as power supplies shall be able to supply a short circuit current sufficient for selective tripping of downstream protective devices without suffering internal damage. Such selective tripping may be achieved by the utilization of an automatic bypass. Current limiting power supplies or power supplies limited by internal temperature may be used for single consumers.
n. For converters serving as power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.
o. Cooling arrangements of semiconductor are to comply with following:

  i. Converter equipment may be air or liquid cooled and is to be so arranged that it cannot remain loaded unless effective cooling is maintained. Alternatively, the load may be automatically reduced to a level commensurate with the cooling available.
  ii. Liquid cooled converter equipment is to be provided with leakage alarms and there is to be a suitable means provided to contain any liquid which may leak from the system in order to ensure that it does not cause an electrical failure of the equipment. Where the semiconductors and other current carrying parts are in direct contact with the cooling liquid, the liquid is to be monitored for satisfactory resistivity and an alarm initiated at the relevant control station should the resistivity be outside the agreed limits.
  iii. Where forced cooling is used, the temperature of the heated cooling medium is to be monitored. If the temperature exceeds a preset value an alarm is to be given and the shutdown of the convertor is to be activated.
  iv. Cooling fluids are to be non-toxic and of low flammability.

4.1.2.5. Parallel operation with other power sources

For convertors 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.

4.1.2.6. Temperature rise

a. 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.

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

4.1.2.7. Protection and monitoring

a. Alarm shall be given for power supply failure and trip of unit.
b. For liquid cooled converters where the cooling liquid is in direct contact with live parts, the conductivity shall be monitored, and high conductivity shall give alarm.
c. When harmonic filters are integrated in a converter, protection and monitoring as required in [4.5.12.5.] of this section is required.
d. For power supply units with batteries included, the following additional alarms shall be provided:

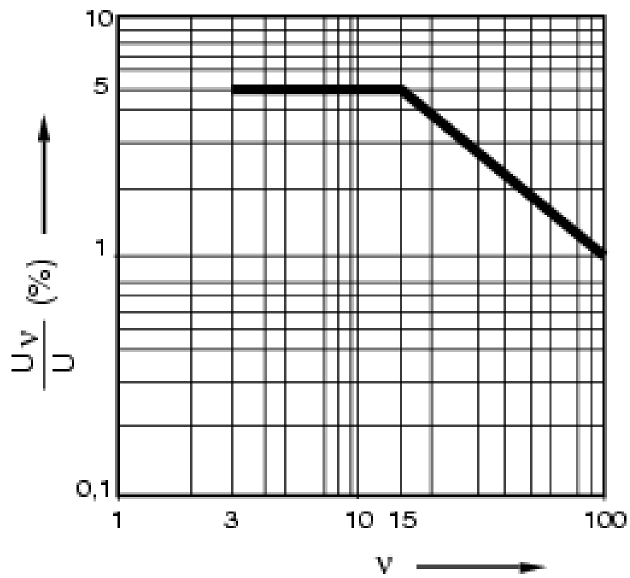
    i. When the charging of a battery fails, alternatively if the battery is being discharged.
    ii. When the automatic bypass is in operation for on-line units.
    iii. Operation of battery protective device.

e. Alarms shall be given to a manned control station.
f. For IT distribution, alarm shall be given for secondary side earth fault (except in dedicated supply system for single consumers).
g. Protection devices fitted for converter equipment protection are to ensure that, under fault conditions, the protective action of circuit-breakers, fuses or control systems is such that there is no further damage to the converter or the installation. (Refer [4.5.12.] of this section).

4.1.2.8. Harmonic distortion

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 percent, and the single harmonic does not exceed 3 percent of the nominal voltage. For components intended for systems fed by static converters, and/or systems in which the static converter load predominates, it is assumed that

a. The single harmonics do not exceed 5 percent of the nominal voltage up to the 15th harmonic of the nominal frequency, decreasing to 1 percent at the 100th harmonic (Refer following figure), and that
b. The total harmonic distortion does not exceed 10 percent.



c. Higher values for the harmonic content (e.g. in electric propulsion plant systems) may be accepted on the basis of correct operation of all electrical devices.
d. An alarm is to be provided for tripping of protective devices against over voltages and over currents in electric propulsion converters and for converters for the emergency source of power.

4.1.2.9. Emergency stop, shutdown

In drives used for applications where emergency stop is required, the emergency stops circuit i.e. the emergency stop signal shall be directly connected to trip the main power supply to the drive unit, either directly or through the control power circuit for the circuit breaker. Alternative arrangements independent of the software based control system may be accepted (e.g. pulse blocking, disconnection of control voltage to pulse amplifiers.).

4.1.2.10. Testing of converters

a. Insulation test procedure is that specified in IEC Publication 60146.The effective value of the test voltage for the insulation test is to be as shown in following table.

Table 2.4.6: Test voltages for high voltage test on static converters

Nominal voltage of the system	Test voltages		
	Power frequency withstand voltage		Impulse voltage level
	AC r.m.s (V)	DC (V)	Uimp (kV)
<50	1250	1770	0.8
100	1300	1840	1.5
150	1350	1910	2.5
300	1500	2120	4
600	1800	2550	6

1000	2200	3110	8
>1000	3000	4250	8
3600	10000	14150	20
7200	20000	28300	40
12000	28000	39600	60
17500	38000	53700	75
Interpolation is permitted			

b. Test and monitoring facilities are to be provided to permit identification of control circuit faults and faulty components.

c. Tests at the manufacturer's works of converter equipment and any associated reactors or filters are to include the high voltage test, a temperature rise test on one of each size and type of converter equipment and such other tests as may be necessary to demonstrate the suitability of the equipment for its intended duty.

d. Converters intended for essential services are to be subjected to the tests stated in [4.1.2.10. f.] of this section.

e. 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.

f. Tests on converters are to be subjected to tests in accordance with following table. Type tests are the tests to be carried out on a prototype convertor or the first of a batch of convertors, and routine tests are the tests to be carried out on subsequent convertors of a particular type.

g. 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.

h. High-voltage testing shall be carried out with test voltages as given in relevant product standard. These voltages given in IEC 60146-1-1 are reproduced in Table 2.4.6 of this section.
The test voltage shall be applied for 1 minute at 50/ 60 Hz for Type Tests and minimum 1 s for Routine Tests. If the circuit contains capacitors the test may be performed with a DC voltage

Table 2.4.7: Tests to be carried out on static converters

No.	Tests	Type test (1)	Routine test (2)
1	Examination of the technical documentation, as appropriate, and visual inspection (3) including check of earth continuity	x	
2	Light load function test to verify all basic and auxiliary functions	x	x
3	Rated current test	x	x
4	Temperature rise measurement	x	x
5	Insulation test (dielectric strength test and insulation resistance measurement)	x	x
6	Protection of the convertors in case of failure of forced cooling system	x	x
(1) Type test on prototype converter or test on at least the first batch of converters.			
(2) The certificates of converters routine tested are to contain the manufacturer's serial number of the converter which has been type tested and the test result.			
(3) A visual examination is to be made of the converter to ensure, as far as practicable, that it complies with technical documentation.			

Table 2.4.8: Systems of generation and distribution		
Description	**Tankers intended for the carriage in bulk of oil, liquefied gases and other hazardous liquids having a flashpoint not exceeding 60°C (closed cup test)**	**Other ships**
D.C. two wire insulated system (Refer Note 1)	Acceptable	Acceptable
A.C., single-phase, two wire Insulated system (Refer Note 1)	Acceptable	Acceptable
A.C., three-phase, three wire insulated system (Refer Note 2)	Acceptable	Acceptable
A.C. or D.C. earthed systems	Normally not acceptable (Refer Note 3)	Acceptable
A.C. three-phase, four wire system with neutral earthed but without hull return	Not acceptable	Acceptable up to 1000V
Hull return system of distribution (A.C. or D.C.)	Normally not acceptable (Refer Notes 4 and 5)	Normally not acceptable (Refer Notes 4 and 5)

Note 1: None of the poles/phases is earthed.
Note 2: Neutral is not earthed.
Note 3: This may be acceptable for –

a. Power supplied control circuits and instrumentation circuits, where technical or safety reasons require connection to earth, provided the current in the hull is limited to not more than 5 Amps in both normal and fault conditions.
b. Earthed intrinsically safe circuits.
c. Limited to areas outside any hazardous space or zone, and arranged so that no current arising from an earth-fault in any part of the system could pass through a hazardous space or zone.
d. Alternating current power networks of 1000 Volts root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any of the dangerous spaces.
e. The electrical systems shall be specially considered for existing ships built before 1st October, 1994.

Note 4: This may be acceptable for -

a. Impressed current cathodic protection systems.
b. Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any of the dangerous spaces.
c. Insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavorable conditions.

Note 5: All final sub-circuits, i.e. all circuits fitted after the last protective device are to be of two insulated wires the hull return being achieved by connecting to the hull, one of the busbars of the distribution board from which wires originate.

i. High-voltage testing shall be carried out with test voltages as given in relevant product standard.

4.1.2.11. Restart

It shall be possible to restart the converter in a normal manner after a blackout. Local resetting/restarting of the unit shall not be necessary.

4.2. Supply & distribution

4.2.1. Supply system

4.2.1.1. The following systems of generation and distribution as detailed in Table 2.4.8 of this section are acceptable.

4.2.1.2. Systems of generation and distribution, other than those specified above, will, upon application, be given special consideration.

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

4.2.1.4. 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.

4.2.2. Maximum voltages

4.2.2.1. The maximum voltages for both alternating current and direct current low-voltage systems of supply for the ship's services are given in Table 2.4.9 of this section.

4.2.2.2. Voltages exceeding those shown in Table 2.4.9 of this section will be specially considered in the case of specific systems.

Table 2.4.9: Maximum voltages for various ship services

Use		Maximum Voltage, in 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 (Refer 1), communication (including signal lamps) and instrumentation equipment	250
For permanently installed and connected by flexible cable	Power and heating equipment, where such connection is necessary because of the application (e.g. for moveable cranes or other hoisting gear)	1000
For socket-outlets supplying	Portable appliances which are not hand-held during operation (e.g. refrigerated containers) by flexible cables	1000
	Portable appliances and other consumers by flexible cables	250
	Equipment requiring extra precaution against electric shock where an isolating transformer is used to supply one appliance (Refer 2)	250
	Equipment requiring extra precaution against electric shock with or without a safety transformer (Refer 2).	50

(1) For control equipment which is part of a power and heating installation (e.g. pressure or temperature switches for starting/stopping motors), the same maximum voltage as allowed for the power and heating equipment may be used provided that all components are constructed for such voltage. However, the control voltage to external equipment is not to exceed 500 V.

(2) Both conductors in such systems are to be insulated from earth.

4.2.3. Voltage and frequency variations

4.2.3.1. General

The electrical equipment supplied from the main or emergency systems are to be capable of being operated satisfactorily under normally occurring variations in voltage and frequency. Unless otherwise specified in national or international standards, the following variations from the rated value are to be assumed:

Table 2.4.10: Voltage and frequency variations for ac distribution systems

Quantity in operation	**Permanent variation**	**Transient variation** **(Recovery time)**
Frequency	±5 percent	±10 percent (5 s)
Voltage	+6 percent, −10 percent	±20 percent (1.5 s)

Table 2.4.11: Voltage variations for DC distribution systems (such as systems supplied by DC generators or rectifiers)

Parameters	**Variations**
Voltage tolerance (continuous)	±10 percent
Voltage cyclic variation deviation	5 percent
Voltage ripple (AC r.m.s over steady DC voltage)	10 percent

Table 2.4.12: Voltage variations for battery systems

Type of system	**Variations**
Components connected to the battery during charging (Refer Note)	+30 percent, –25 percent
Components not connected to the battery during charging	+20 percent, –25 percent
Note: Different voltage variations as determined by the charging/discharging characteristics, including the ripple voltage from the charging device, may be considered.	

For installations supplied by generators, the voltage on the main switchboard's bus-bars is to be kept between 97.5 and 102.5 percent of the installation's nominal voltage under all steady load conditions.

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

4.2.3.2. Diversity (demand) factors

a. The cables and protective devices of final sub-circuits (Refer Ch 1, Sec 2, [2.26.] of this part) are to be rated in accordance with their connected load.
b. 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.
c. 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.

4.2.3.3. Harmonics

The total harmonic distortion (THD) (Refer [4.1.2.8.] of this section) in the voltage waveform in the distribution systems is not to exceed 5 percent and any single order harmonics not to exceed 3 percent. Other higher values may be accepted provided the distribution equipment and consumers are designed to operate at the higher limits. Where higher values of harmonic distortion are expected, any other possible effects, such as additional heat losses in machines, network resonances, errors in control and monitoring systems are to be considered.

4.2.4. General requirements for distribution systems

4.2.4.1. 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.

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

4.2.4.3. 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.

4.2.4.4. Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of non-essential services (Refer Ch 1, Sec 2, [2.5.] of this part) and if necessary secondary essential services (Refer Ch 1, Sec 2, [2.2. b.] of this part) and those provided for habitability (Refer Ch 1, Sec 2, [2.3.] of this part), are to 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.

4.2.4.5. The load shedding is to be automatic. Load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

4.2.4.6. Separate feeders are to be provided for normal vessels service loads and emergency service loads.

4.2.5. Earthed distribution systems

4.2.5.1. System earthing is to be affected by independent of any earthing arrangements of the non-current carrying parts.

4.2.5.2. 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.

4.2.5.3. Generator neutrals may be connected in common, provided that the third harmonic content of the voltage wave form of each generator does not exceed 5 percent.

4.2.5.4. 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.

4.2.5.5. 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 (e.g. in automation systems or to avoid electromagnetic disturbances), provision (e.g. transformers) is to be made such that current unbalances do not occur in the individual poles or phases.

4.2.5.6. No fuse, non-linked switch or non-linked circuit breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors. These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

4.2.5.7. For high voltage systems, where the earthed neutral system of generation and primary distribution is used, earthing is to be through impedance in order to limit the total earth fault current to a magnitude which does not exceed that of the three phase short-circuit current for which the generators are designed.

4.2.5.8. Earthing conductor is to be independent of conductors used for earthing of non-current carrying parts of electrical equipment. Refer Table 2.4.13 of this section for earth conductor size. Four-wire three-phase AC systems having an earthed neutral are not to have protective devices fitted in the neutral conductors. Multi-pole switches or circuit breakers which simultaneously open all conductors, including neutral, are allowed. In multiple-generator installations, each generator’s neutral connection to earth is to be provided with a disconnecting link for maintenance purpose.

<table>
<tr><th colspan="5">Table 2.4.13: Size of earthing conductors (equipment and system earthing)</th></tr>
<tr><th colspan="2">Type of earthing connection</th><th>Cross-sectional area of associated current carrying conductor</th><th colspan="2">Minimum cross-sectional area of copper earthing connection</th></tr>
<tr><td>1</td><td>Earth-continuity conductor in flexible cable or flexible cord</td><td>any</td><td colspan="2">Same as current carrying conductor up to and including 16 mm^2 and one half above 16 mm^2 but at least 16 mm^2</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Earth-continuity conductor incorporated in fixed cable</td><td rowspan="3">any</td><td colspan="2">• For cables having an insulated earth-continuity conductor
○ A cross-section equal to the main conductors up to and including 16 mm^2. But minimum 1.5 mm^2
○ A cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm^2. But at least 16 mm^2
• For cables with a bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>Cross-section of main conductor (mm^2)</td><td>Earthing connection (mm^2)</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 mm^2</td><td colspan="2">Same as current carrying conductor subject to minimum of 1.5 mm^2 for stranded earthlings connection or 2.5 mm^2 for unstranded earthing connection</td></tr>
<tr><td>> 2.5 mm^2 but <= 120 mm^2</td><td colspan="2">One half the cross-sectional area of the current carrying conductor. subjected to a minimum of 4 mm^2</td></tr>
<tr><td>> 120 mm^2</td><td colspan="2">70 mm^2</td></tr>
</table>

4.2.6. Insulated distribution systems

4.2.6.1. 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.

4.2.6.2. Where any insulated lower voltage system is supplied through transformers from a high voltage system, adequate precautions are to be taken to prevent the low voltage system being charged by capacitive leakage from the high voltage system.

4.2.6.3. Where filters are fitted, these are not to cause distribution systems to be unintentionally connected to earth.

4.2.7. Distribution systems with hull return

Where the hull return system is used, all final sub-circuits, i.e., all circuits fitted after the last protective device, are to consist of two insulated wires, the hull return being achieved by connecting to the hull one of the busbars of the distribution board from which they originate. The earth wires are to be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation. Refer also Table 2.4.8 of this section.

4.2.8. Main distribution of electrical power

4.2.8.1. 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. The connection of generating sets and associated auxiliaries and other duplicated equipment is to be equally divided between the parts as far as practicable, so that in the event of damage to one section of the switchboard the remaining parts are still supplied. For main source of electrical power Refer also Sec 2 of this chapter.

4.2.8.2. Two or more units serving the same consumer (e.g. 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. This requirement is satisfied when such units are supplied by separate cables from the main switchboard or from two independent section boards. For main switchboard Refer also [4.2.10.] of this section.

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

4.2.9. Emergency distribution of electrical power

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

Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short-circuit.

For emergency switchboard Refer also [4.2.10.] of this section.

4.2.9.2. 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.

For emergency source of electrical power Refer also Sec 3 of this chapter.

4.2.9.3. The emergency source of electrical power shall be capable of supplying simultaneously the services specified in Sec 3, [3.3.] & [3.4.] of this chapter.

4.2.9.4. Internal communication equipment required in an emergency generally includes:

a. The means of communication between the navigating bridge and the steering gear compartment.
b. The means of communication between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled.
c. The public address system.

4.2.9.5. Internal signals required in an emergency generally include:

a. General alarm.
b. Watertight door indication.

4.2.9.6. In a ship engaged regularly in voyages of short duration, i.e. voyages where the route is no greater than 20 nautical miles offshore, the INTLREG may, if satisfied that an adequate standard of safety would be attained, accept a lesser period than the 18-hour period specified in [4.2.9.3.] of this section but not less than 12 hours.

4.2.10. Main and emergency switchboards

In addition to the applicable requirements in Ch 3, Sec 7, [7.2.] of this part, main and emergency switchboards are to comply with the following requirements.

4.2.10.1. Location and installation

a. Switchboards are to be installed in accessible and well-ventilated dry spaces free from flammable gases and acid fumes.
b. Switchboards are to be secured to a solid foundation and protected against shocks and damage due to leaks and falling objects. They are to be self-supported, or be braced to the bulkhead or the deck above. In case the later method is used, the means of bracing is to allow normal deflections of the deck without buckling the control cell or assembly structure.
c. Pipes should not be installed directly above or in front of or behind switchboards. If such piping is unavoidable, suitable protection is to be provided in these positions.
d. An adequate, unobstructed working space is to be left in front of switchboards. At the rear, a clearance of at least 0.6 m is to be maintained except that this may be reduced to 0.5 m in way of stiffeners or frames. If switchboards are enclosed at the rear and are fully serviceable from the front, clearance at the rear will not be required unless necessary for cooling.
e. The main switchboard is to be so placed relative to one main generating station that, as far as practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space. 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 A-60 fire boundaries. An environmental enclosure for 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 the switchboards from the generators.
f. 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 electrical supply system are also to satisfy [4.2.10.1. e.] of this section.

4.2.10.2. Construction of switchboards

a. Construction is to be in accordance with IEC Publication 60092-302.
b. 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.
c. Insulating material for panels and other elements of the switchboard is at least to be moisture-resistant and flame-retardant.
d. Switchboards are to be of dead front type with enclosure protection according to Table 2.4.16 of this section.
e. 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.
f. Where the aggregate capacity of generators connected to the main bus bars 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.
g. 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 earthing is reduced as far as practicable.
h. Where it is necessary to make provision for the opening of the doors of the switchboard, this is to be in accordance with one of the following requirements:

    i. Opening is to necessitate the use of a key or tool (e.g. when it is necessary to replace a lamp or a fuse-link).
    ii. All live parts which can be accidentally touched after the door has been opened are to be disconnected before the door can be opened.
    iii. The switchboard is to include an internal barrier or shutter with a degree of protection not less than IP2X shielding all live parts such that they cannot accidentally be touched when the door is open. It is not to be possible to remove this barrier or shutter except by the use of a key or tool.

i. 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.
j. 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.
k. The incoming and outgoing circuits from every switchboard or section board are to be provided with a means of isolation and switching to permit each circuit to be switched off:

    i. On load;
    ii. For mechanical maintenance;
    iii. In an emergency to prevent or remove danger.

    Isolation and switching is to be by means of a circuit-breaker or switch arranged to open and close simultaneously all insulated poles. Where a switch is used as the means of isolation and switching, it is to be capable of:

    i. Switching off the circuit on load;
    ii. Withstanding, without damage, the over-currents which may arise during overloads and short-circuit.

In addition, these requirements do not preclude the provision of single pole control switches in final sub-circuits, for example light switches. For circuit-breaker Refer [4.5.16.] of this section.

l. Provision is to be made, in accordance with one of the following, to prevent any circuit being inadvertently energized:

   i. The circuit-breaker or switch can be withdrawn, or locked in the open position;
   ii. The operating handle of the circuit-breaker or switch can be removed;
   iii. The circuit fuses, where fitted, can be readily removed and retained by authorized personnel.

m. 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.
n. 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.
o. All measuring instruments and all monitoring and control devices are to be clearly identified with indelible labels of durable, flame-retardant material.
p. The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device (circuit-breaker, thermal relay etc.) for each circuit is to be permanently indicated at the location of the fuse or protective device.

4.2.10.3. Marking and labels

All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly marked for identification purposes. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit breaker, and marked with particulars of the full load current of the generator or cable which the fuse or circuit-breaker protects. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. The distribution voltage is to be indicated. Labels are to be of flame-retardant material and markings are to correspond with the designations used in the wiring diagrams.

4.2.10.4. Internal wiring

a. Insulated conductors for internal wiring of auxiliary circuits of switchboards are to be constructed in accordance with Ch 6, Sec 3, [3.4.] of this part.
b. All insulated conductors are to be of flexible construction and of the stranded type.
c. Connections from bus bars 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 short-circuit.
d. All conductors are to be secured to prevent vibration and are to be kept away from sharp edges.
e. 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.
f. Non-metallic trays for internal wiring of switchboards are to be of flame-retardant material.

g. Control circuits are to be installed and protected such that they cannot be damaged by arcs from the protective devices.
h. Where foreseen, fixed terminal connectors for connection of the external cables are to be arranged in readily accessible positions.

4.2.10.5. Instruments

a. In general, main switchboard instruments are to be of accuracy class 1.5 and other switchboard instruments are to be of accuracy class 2.5.
b. The upper limit of the scale of every voltmeter is to be approximately 120 percent of the normal voltage of the circuit, and the normal voltage is to be clearly indicated.
c. The upper limit of the scale of every ammeter is to be approximately 130 percent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.
d. Ammeters for use with direct current generators, and watt-meters for use with alternating current generators, which may be operated in parallel, are to be capable of indicating 15 percent reverse-current or reverse-power respectively.
e. For watt-meters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.
f. The upper limit of the scale of every wattmeter is to be approximately 130 percent of the rated full load of the circuit in which it is installed.
g. The rated value of the measure read, at full load, is to be clearly indicated on the scales of instruments.
h. Frequency meters are to be capable of indicating a variation in the frequency from minus 8 percent to plus 8 percent of the nominal frequency of the installation.
i. Instruments are to have effective screening, for example, by metal enclosures, in order to diminish faulty readings caused by induction from adjacent current-carrying parts.
j. The secondary windings of instrument transformers are to be earthed.
k. Each a.c. generator not operated in parallel is to be provided with:

   i. 1 voltmeter
   ii. 1 frequency meter
   iii. 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read
   iv. 1 three-phase wattmeter in the case of generators rated more than 50 kVA.

l. Each a.c. generator operated in parallel is to be provided with:

   i. 1 three-phase wattmeter
   ii. 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read.

m. For paralleling purposes, the following are to be provided:

   i. 2 voltmeters
   ii. 2 frequency meters
   iii. 1 synchro scope and synchronizing indicating lamps or equivalent means.

   A switch is to be provided to enable one voltmeter and one frequency meter to be connected to each generator before the latter is connected to the busbars.

The other voltmeter and frequency meter are to be permanently connected to the busbars.

n. Each secondary distribution system is to be provided with one voltmeter.
o. Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems as stipulated in [4.2.6.1.] of this section.
p. 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 (Refer [4.3.7.] of this section).
q. For each d.c. power source (e.g. convertors, rectifiers and batteries), one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices (e.g. starting motor for emergency generator).

4.2.10.6. Requirements for section boards and distribution boards

a. Section boards and distribution boards are to be constructed, insofar as applicable, as specified for main and emergency switchboards.
b. All parts which require operation in normal use are to be placed on the front.
c. 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.
d. Where a section board, distribution board or item of equipment can be supplied by more than one circuit, a switching device is to be provided to permit each incoming circuit to be isolated and the supply transferred to the alternative circuit.

   The switching device is to be situated within or adjacent to the section board, distribution board or item of equipment. Where necessary, interlocking arrangements are to be provided to prevent circuits being inadvertently energized.

e. A notice is to be fixed to any section board, distribution board or item of equipment to which [4.2.10.6. d.] applies warning personnel before gaining access to live parts of the need to open the appropriate circuit-breakers or switches, unless an interlocking arrangement is provided so that all circuits concerned are isolated before access is gained.
f. Distribution boards are to be suitably enclosed unless they are installed in a cupboard or compartment to which only authorized persons have access in which case the cupboard may serve as an enclosure.
g. Distribution boards are to be installed in accessible locations, but not in such spaces as bunkers, storerooms, cargo holds or passengers' spaces.

   Distribution boards may be located behind panels/linings within accommodation spaces, including stairway enclosures, without the need to categorize the space for fire integrity standard, provided no provision is made for storage.

4.2.10.7. Testing

Switchboards and distribution boards are to be inspected by, tested in the presence of and certified by the Surveyor, preferably at the plant of the manufacturer. Test certificates are to be submitted upon request by INTLREG.

a. Insulation Resistance Measurement

The insulation resistance between current-carrying parts and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 V before and after the dielectric strength tests. The insulation resistance is not to be less than 1 MΩ.

b. Dielectric Strength Test

The dielectric strength of the insulation is to be tested for 60 seconds by an AC voltage applied, in accordance with the voltage values given in the following, between:

i. Each electric circuit, and
ii. All other electric circuits and metal parts earthed.

Rated Voltage Un (V)	AC Test Voltage r.m.s. (V)
Un ≤12	250
12 < Un ≤60	500
60 < Un ≤300	2000
300 < Un ≤690	2500
690 < Un ≤800	3000
800 < Un ≤1000	3500
1000 < Un ≤1500 (DC only)	3500

Equipment and apparatus produced in large quantities for which the standard test voltage is 2500 V or less may be tested for one second with a test voltage 20% higher than the 60 second test voltage.

c. Operational Tests

Operational tests are to be carried out including but not limited to the testing of protective devices (over current, under voltage, and preferential tripping etc.), electrical interlocks and synchronization of generators, earth detection, alarms and measurement of bus bar temperature rise.

With the UPS unit initially switched off and with no external power supply to the UPS itself, it is to be demonstrated that the UPS can be switched on to supply the load

d. Shipboard test

Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor.

It is to be demonstrated that the Rules have been complied with in respect of:

i. Temperature of joint, connections, circuit-breakers and fuses;
ii. The operation of engine governors, synchronizing devices, over speed trips, reverse-current, reverse-power and over-current trips and other safety devices.

4.2.11. Shore supply

For external supply/shore supply, Refer [4.3.] of this section

4.2.12. Specific requirements for special power services

4.2.12.1. For the supply and characteristics of the distribution of the following services Refer the requirements listed:

a. Steering gear. For power supply to steering gear Refer Ch 5, Sec 3, [3.2.] of this part.
b. Fire-extinguishing and detecting systems.
c. Permanently installed submergible bilge pump.
d. Ventilation fans. Ventilation fans for cargo spaces are to have feeders separate from those for accommodations and machinery spaces. In general, power ventilation is to be capable of being stopped from a location outside the space ventilated.
e. Fuel pumps;
f. Pumps discharging overboard above the lightest water line and in way of the area of lifeboat and life raft launching.

4.2.12.2. 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.

4.2.12.3. 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.

4.2.13. Power supply to motors

4.2.13.1. A separate final sub-circuit is to be provided for every motor required for essential services (Ch. 1, Sec. 2, [2.2.] of this part) and for every motor rated at 1 kW or more.

4.2.13.2. Every electric motor is to be provided with efficient means for starting and stopping so placed as to be easily operated by the person controlling the motor.

4.2.13.3. Each motor is to be provided with control gear ensuring its satisfactory starting. Depending on the capacity of the generating plant or the cable network, it may be necessary to limit the starting current to an acceptable value. Direct on-line starters are accepted if the voltage drop does not exceed 15 percent of the network voltage.

4.2.13.4. Efficient means are to be provided for the isolation of the motor and its associated control gear from all live poles of the supply. Where the control gear is mounted on or adjacent to a switchboard, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the control gear enclosure or a separate enclosed disconnecting switch is to be provided.

4.2.13.5. Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided. For protection of motor circuit Refer [4.5.7.] of this section.

4.2.13.6. Where the starter or any other apparatus for disconnecting the motor is remote from the motor itself, one of the following is to be arranged:

a. Provision for locking the circuit disconnecting switch in the 'OFF' position.
b. An additional disconnecting switch fitted near the motor.
c. Provision such that the fuses in each live pole or phase can be readily removed and retained by persons authorized to have access to the motor.

4.2.14. Power supply to heaters

Each heater is to be connected to a separate final branch circuit. However, a group of up to 10 heaters with aggregate current not exceeding 16 A may be connected to a single final branch circuit.

4.2.15. Power supply to lighting installations

4.2.15.1. Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power. 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.

4.2.15.2. In spaces such as:

a. Machinery spaces, workshops, large galleys, laundries, etc.
b. Large galleys;
c. Passageways;
d. Stairways leading to boat-decks;
e. Public spaces;
f. Control stations.

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.

4.2.15.3. Where the emergency installation is required, one of the circuits in [4.2.15.2.] of this section may be supplied from the emergency source of power.

4.2.15.4. Lighting for enclosed hazardous spaces is to be supplied from at least two final sub-circuits. One of these circuits may be an emergency circuit, provided it is normally energized.

4.2.15.5. 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. Provision is to be made for the complete isolation of these circuits and locking the means of control in the off position.

4.2.15.6. Where lighting circuits in the cargo pump rooms of tankers are also used for emergency lighting, and have been interlocked with the ventilation, the interlocking arrangements are:

a. Not to cause the lighting to go out following a failure of the ventilation system;
b. Not to prevent operation of the emergency lighting following the loss of the main source of electrical power.

4.2.15.7. For power supply to navigation light Refer Chapter 5, Sec. 1 of this part.

4.2.16. Power supply to general emergency alarm system

For power supply to general emergency alarm system, Refer Ch 7, Sec 2 of this part.

4.2.17. Power supply to public address system

For power supply to public address system, Refer Ch 7, Sec 3, [3.1.] of this part.

4.2.18. Power supply to combined general emergency alarm

For power supply to combined general emergency alarm, Refer Ch7, sec 3, [3.1.10.] of this part.

4.2.19. Power supply to control and indication circuits

4.2.19.1. Control and indicating circuits relative to primary essential services (Ch 1, Sec 2, [2.2. a.] of this part) are to be branched off from the main circuit in which the relevant equipment is installed. Equivalent arrangements may be accepted by INTLREG.

4.2.19.2. Control and indicating circuits relative to secondary essential services (Ch 1, Sec 2, [2.2. b.] of this part) and to non-essential services (Ch 1, Sec 2, [2.5.] of this part) may be supplied by distribution systems reserved for the purpose to the satisfaction of INTLREG.

4.2.19.3. For the power supply of automation system, comprising control, alarm & safety system, Refer Ch 8, Sec 2, [2.4.] of this part.

4.2.20. Power supply to the speed control systems of main propulsion engines

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

4.2.20.2. 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 (Ch 1, Sec 2, [2.24.] of this part). Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied equally from the two sections.

4.2.20.3. 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. Such battery may also be used for other services such as automation systems, where foreseen.

4.2.21. Power supply to the speed control systems of generator sets

4.2.21.1. 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.

4.2.21.2. The wiring supplying the main source of electrical power is to be from the main switchboard or from independent section boards. Where the main bus bars are divided into two sections, the governors are, as far as practicable, to be supplied from the sections to which the relevant generators are connected.

4.2.22. Cable sizing

This Paragraph applies to cables conforming to IEC Publication 60092-353 or IEC Publication 60092-3. Cables conforming to other standards are to be sized in accordance with corresponding provisions of that standard.

4.2.22.1. Cable’s current carrying capacity

For current rating, correction factors for current rating, voltage drop & conductor size Refer Chapter 6, sec. 2 of this part.

4.2.22.2. Generator cable

Generator cable is to have a current carrying capacity of not less than the rated current or the rated continuous overload current of the generator.

4.2.22.3. Transformer cable

Cables provided for primary and secondary circuits of transformers are to have current carrying capacities not less than the rated primary and secondary currents, respectively.

4.2.22.4. Motor control center feeder

Feeder cables supplying to motor control centers are to have a continuous current-carrying capacity not less than 100 percent of the sum of the rated current of all motors connected to the motor control center. Feeder cables of lesser current capacity are permitted, where the design is such that connected consumers are not operated simultaneously, under any operating mode.

4.2.22.5. Distribution panel feeder

Feeder cables supplying to distribution panels or to any sub-distribution panels are to have current-carrying capacity of not less than 100 percent of the sum of the rated currents of all connected consumers, where connected consumers are not operated simultaneously.

4.2.22.6. Motor branch circuit

A separate circuit is to be provided for each motor having a full-load current of 6 A or more. The cables are to have a carrying capacity of not less than 100 percent of the motor full-load current rating. Branch circuit conductor for each motor is not to be less than 1.5 mm^2.

4.2.22.7. Lighting circuits

Cable for a branch lighting circuit is to have the current carrying capacity of not less than the sum of the full load currents of the connected lighting fixtures. Refer also Ch 3, Sec 1 of this part.

4.2.22.8. Protection of feeder size reduction

The size of feeder conductors is normally to be uniform for the total length, but may be reduced beyond any intermediate distribution board, provided that the reduced size section of the feeder is protected by the overload device at the board at which the feeder size is reduced.

4.3. External supply/shore connection

4.3.1. 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 to receive the flexible cable from the external source.

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

4.3.3. 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.

4.3.4. The connection box is to contain a circuit-breaker or a switch-disconnector and fuses. The shore connection is to be protected against short-circuit and overload; however, the overload protection may be omitted in the connection box if provided on the main switchboard.

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

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

4.3.7. The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

4.3.8. At the connection box a notice is to be provided giving full information on the nominal voltage and frequency of the installation.

4.3.9. An interlocking arrangement shall be provided between all generators, including the emergency generator, and the shore power supply to prevent the shore power from being inadvertently paralleled with the shipboard power

4.3.10. 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.

4.3.11. For circuits rated maximum 63 A, connection by socket outlet can be used instead of shore-connection box. The circuit may then have short circuit and over current protection in the receiving switchboard only.

4.4. Switchgear & control-gear

4.4.1. Applicable standards

Switchgear and control gear assemblies and their components are to conform to one of the following standards modified where necessary for ambient temperature and other environmental conditions:

a. IEC 61439-1 and IEC 60092-302: Low voltage switchgear and control gear assemblies.
b. IEC 62271-200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV;
c. IEC 60466: AC insulated-enclosed switchgear for rated voltages above 1 kV and up to and including 38 kV;
d. IEC 60255: Electrical relays;
e. Acceptable and relevant National Standard.

4.4.2. Materials

Generally, framework, panels and doors are to be of steel or aluminum alloy, and shall be of rigid construction.

4.4.3. General design and construction of switchgear and control gear

4.4.3.1. For switchgear constructed and type tested in accordance with IEC 61439-1 sections can be designed to withstand the short-circuit stress occurring on the load side of the respective short-circuit protective device as stated in IEC 61439-1 item 7.5.5.1.2. However, this reduced short-circuit level shall not be less than 60% of the short circuit rating of the main busbars.

4.4.3.2. Control gear is to comply with IEC Publication 158, "Low Voltage Control Gear", or an equivalent national standard, amended where necessary for ambient temperature.

4.4.3.3. Control gear, including isolating and reversing switches, is to be so arranged that shunt field circuits are not disconnected without adequate discharging path being provided.

4.4.3.4. Control gear for essential and important motors is to be separated from each other and from other current carrying parts by screens. The arrangement is to be such that maintenance work can be carried out on each unit without danger when isolated.

4.4.3.5. When installed in main switchboards, motor control gear is to be placed in separate cubicles separated from all other parts of the switchboard by partitions of flame-retardant material. The arrangements are to be such that arcs occurring by short-circuit in one cubicle cannot spread to bus-bars.

4.4.3.6. Control gear for duplicated essential or important equipment shall be mutually independent and shall be divided between two motor control centers or distribution boards having separate supplies from different sides of the main switchboard and/or the emergency switchboard.

4.4.3.7. Instruments, including current transformers, in switchgear and control gear shall have a nominal accuracy of 2.5 percent or better.

4.4.3.8. For high voltage switchgear and control gear assemblies Refer sec. 5, [5.1.4.4.] of this chapter.

4.4.3.9. The fixed contacts of withdrawal circuit breakers and switches are to be so arranged that in the withdrawn position, the live contacts of the bus bars are automatically covered. Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colors or labels.

4.4.3.10. Internal Arc Classification (IAC). Switchgear and control gear assemblies are to be Internal Arc Classified (IAC). Where switchgear and control gear are accessible by authorized personnel only accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2). Accessibility Type B is required if accessible by non-authorized personnel. Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).

4.4.4. Nameplates and marking

The switchgear and fuse gear for each circuit shall be marked with circuit designation, cable cross-section and rating of fuses or necessary data for easy recognition of components and circuits according to relevant drawings.

4.4.5. Circuit separation

4.4.5.1. There shall be arranged a separate cubicle for each generator, with flame retardant partitions between the different generator cubicles and between these and other cubicles. The partitions shall withstand the effect of an internal arc, and prohibit this from spreading to other cubicles.

4.4.5.2. Control gear for essential or important consumers shall be separated from each other, and from other current carrying parts, by flame retardant partitions providing protection of the cubicle in case of an arcing fault occurring in the neighboring cubicle. Alternatively, an arrangement without flame retardant partitions may be accepted, provided the bus bar is divided with a circuit breaker with short circuit protection, located in a separate cubicle. The arrangement shall be so that maintenance work can be carried out in each unit without danger when isolated.

4.4.5.3. Control gear for non-important consumers may be installed in a common cubicle provided this cubicle could be effectively isolated.

4.4.5.4. Consumer control gear installed in main switchboards shall be placed in cubicles separated from all other parts of the switchboard by partitions of flame retardant material.

4.4.5.5. Equipment for different distribution systems shall be placed in separate switchboards (panels), or shall be separated from each other by partitions clearly marked with the actual voltages and system identifications.

4.4.5.6. Switchgear and control gear assemblies supplied by different supply circuits shall not be placed in the same enclosure.

4.4.5.7. Equipment with voltage above 1 kV shall not 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.

4.4.5.8. Each outgoing circuit from a switchboard shall be provided with switchgear for isolating purposes. If remote from the consumer, the switchgear shall be lockable in the “off” position. For isolating purposes, a group of non-important consumers may be feed from common switchgear.

4.4.6. Power components in assemblies - busbars and bare conductors

4.4.6.1. Busbars and other conductors shall normally be made of copper or copper covered aluminum. Copper coated aluminum or pure aluminum bus bar shall be adequately protected against corrosion by placing in an air-conditioned environment, by special coating sealing of the aluminum or by the aluminum itself being seawater resistant.

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

4.4.6.3. 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 the INTLREG.

4.4.6.4. The cross-section of busbars for neutral connection on an AC three-phase, four-wire system, and for equalizer connection on a DC system, shall be at least 50 percent of the cross-section for the corresponding phases (poles).

4.4.6.5. Bare main busbars, excluding the conductors between the main busbars and the supply side of outgoing units, are to have the minimum clearances and creep age distances given in Table 2.4.14 of this section. The values shown apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.

Table 2.4.14: Clearance and creepage distances

Rated insulation voltage A.C. R.M.S. or D.C. (V)	Minimum clearance (mm)	Minimum creepage distance (mm)
≤ 250	15	20
> 250 to ≤ 690	20	25
> 690	25	35

Note 1: Clearance is the distance between two conductive parts along a string stretched the shortest way between such parts. Creepage distance is the shortest distance along the surface of an insulating material between two conductive parts.

4.4.6.6. Reduced values as specified in IEC Publication 60092-302 may be accepted for type tested and partially type tested assemblies. The reference values for the evaluation of the minimum clearances and creepage distances for these assemblies are based on the following:

a. Pollution degree 3 (conductive pollution occurs, or dry non-conductive pollution occurs which becomes conductive due to condensation which is expected);
b. Over voltage category III (distribution circuit level);
c. Inhomogeneous field conditions (case A);
d. Rated operational voltage 1000 V A.C., 1500 V D.C;
e. Group of insulating material III a.

Special consideration is to be given to equipment located in spaces where a pollution degree higher than 3 is applicable, e.g. in diesel engine rooms.

4.4.6.7. Busbars and other conductors with their supports shall be so mechanically or thermally dimensioned and fixed that they can withstand for 1 sec. the forces occurring by the maximum short circuit current which can occur without detrimental effect (maximum symmetrical short-circuit currents are expected to exceed 50 kA). Further, provision is to be made to allow the busbars to expand without causing any abnormal stress on their supports.

4.4.6.8. Connections from bus-bars and from generator circuit terminals to all circuit breakers and fuses are to be installed "short-circuit proof", i.e. either bare conductors, or insulated conductors or single-core cable without metallic sheath/armor /braid are used and these are mounted on supports of insulating material and with adequate distance between the different poles (phases) and to earthed parts.

4.4.6.9. Horizontally installed busbars and bare conductors or connections shall be protected by screens, if they are placed such that there could be a risk of anything falling down on them (e.g. tools, fuses or other objects).

4.4.7. Testing

4.4.7.1. Insulation resistance test at power frequency for low voltage assemblies

a. Switchgear and assemblies with rated voltage above 60 V shall be subject to a voltage test between the circuits and between live parts and the enclosure. The test voltage shall be minimum equal to twice the rated voltage plus 1000 V with a minimum of 1500 V. The test voltage shall be applied for 1 minute at any frequency between 25 and 100 Hz.
b. For switchgear and assemblies with rated voltage below 60 V, the test voltage given in [4.4.7.1. a.] of this section shall be minimum 500 V.
c. As an alternative to the voltage test in [4.4.7.1. a.] of this section, impulse voltage test in accordance with IEC 61439-1 Section 8.3.2 can be carried out for type tested (TT) and partly type tested (PTT) low voltage assemblies.
d. Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Ch 4, Sec 4, Table 4.4.2 of this part. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level. The insulation level shall be at least 1 MΩ.

4.4.7.2. Operational tests

a. All switchgear is to be loaded and, when found necessary by the attending Surveyor, the operation of over current protective devices is to be verified.

The workshop test is generally considered sufficient to ensure that such apparatus will perform as required while in operation.

b. Short-circuit tests may also be required at the discretion of INTLREG in order to verify the selectivity characteristics of the installation.

4.4.7.3. "Type tested assemblies" and "Partly type tested assemblies"

a. Electrical low voltage assemblies constructed and tested in accordance with IEC 60092-302, item 7.1.2.101 (referring to IEC 61439-1) are accepted as long as the following conditions are met:

   i. Minimum clearance distance shall be 8 mm; minimum creepage distance shall be 16 mm.
   ii. The assembly has been type tested with impulse voltage test in accordance with IEC 61439-1.
   iii. Maximum operating temperature of busbars shall be documented to be acceptable with respect to fixing materials and internal temperature by a full current type test.
   iv. Maximum temperature rise at termination points for external cables shall be 60ºC.
   v. Such assemblies shall not be installed in machinery space category "A" (Refer Ch 1, Sec 2, [2.12.] of this part).

b. For bus bar trunking systems where the conductors are fixed for the whole length with an insulating rail or similar, distances in accordance with IEC 61439-1, pollution degree 3, inhomogeneous field, may be accepted.

4.5. Protection system

4.5.1. General

All installations are to be protected against accidental over-currents including short circuits and other electrical faults. The choice, location and characteristics of the protective device are to provide complete and coordinated protection to ensure:

a. Elimination of the fault to reduce damage to the system and hazard of fire.
b. Continuity of service so as to maintain, through the discriminative action of the protective devices, the supply to essential and all other services not directly affected by the fault.

These automatic protective devices are to protect each non-earthed phase conductors (e.g., multi pole circuit breakers or fuses in each phase). In addition, where the possibility exists for generators to be over loaded, load-shedding arrangements are to be provided to safeguard continuity of supply to essential services. The following are exceptions:

a. Where it is impracticable to do so, such as engine starting battery circuits.
b. Where, by design, the installation is incapable of developing overload, in which case, it may be protected against short circuit only.
c. Steering circuits; Refer [4.5.7.5.] of this section.

4.5.2. Protection against short circuit

Protection against short circuit is to be provided for each non-earthed conductor (multi pole protection) by means of circuit breakers, fuses or other protective devices.

In order to establish that protective devices throughout the electrical system (e.g., on the main and emergency switchboards and sub-distribution panels) have sufficient short-circuit breaking and making capacities, short-circuit data as Ch 1, sec 3, [3.1.1.3.] of this part are to be submitted.

4.5.2.1. Rated breaking capacity

The rated breaking capacity of every protective device is not to be less than the maximum prospective short-circuit current value at the point of installation. For alternating current (AC), the rated breaking capacity is not to be less than the root mean square (rms) value of the prospective short-circuits current at the point of installation. The circuit breaker is to be capable of breaking any current having an AC component not exceeding its rated breaking capacity, whatever the inherent direct current (DC) component may be at the beginning of the interruption.

4.5.2.2. Rated making capacity

The rated making capacity of every circuit breaker which may be closed on short circuit is to be adequate for the maximum peak value of the prospective short-circuit current at the point of installation. The circuit breaker is to be capable of closing onto a current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.

4.5.2.3. Backup fuse arrangements

Circuit breakers having breaking and/or making capacities less than the prospective short-circuit current at the point of application will be permitted; provided that such circuit breakers are backed up by fuses which have sufficient short-circuit capacity for that application. Refer [4.5.3.] of this section.

4.5.2.4. Cascade protection

Cascade protection may be permitted, subject to special consideration. Such special consideration is not intended for new construction ships, however may be granted when modifications are performed to existing ships. The cascade protection is to be arranged such that the combination of circuit protective devices has sufficient short-circuit breaking capacity at the point of application Refer [4.5.2.1.] of this section. All circuit protective devices are to comply with the requirements for making capacity Refer [4.5.2.2.] of this section. Cascade protection is not to be used for circuits of primary essential services. Where cascade protection is used for circuits of secondary essential services, such services are to be duplicated, provided with means of automatic transfer and the automatic transfer is to alarm at a manned location. Cascade protection may be used for circuits of non-essential services.

4.5.3. Protection against overload

Circuit breakers and fuses for overload protection are to have tripping characteristics (over current trip time) which adequately protect all elements in the system during normal and overload conditions having regard to overload capacity of each of these elements. Fuses of greater than 320 A are not to be used for overload protection. However, current-limiting fuses may be used for short-circuit protection without current rating limitation. The rating or setting of the overload protective device for each circuit is to be permanently indicated on or at the location of the protective device. For earthed AC distribution system, Refer [4.2.5.] of this section.

4.5.4. Protection against earth faults

4.5.4.1. Every distribution system that has an intentional connection to earth, by way of impedance, is to be provided with a means to continuously monitor and indicate the current flowing in the earth connection.

4.5.4.2. If the current in the earth connection exceeds 5 A there is to be an alarm and the fault current is to be automatically interrupted or limited to a safe value.

4.5.4.3. The rated short-circuit capacity of any device used for interrupting earth fault currents is to be not less than the prospective earth fault current at its point of installation.

4.5.4.4. Insulated neutral systems with harmonic distortion of the voltage waveform, which may result in earth fault currents exceeding the level given in [4.5.4.2.] of this section because of capacitive effects, are to be provided with arrangements to isolate the faulty circuit(s).

4.5.5. Protection of generators

4.5.5.1. Overload protection

Generators are to be protected by circuit breakers providing long-time delay over current protection not exceeding 15 percent above either the full-load rating of continuous-rated machines or the overload rating of special-rated machines. Alternatively, generators of less than 25 kW not arranged for parallel operation may be protected by fuses.

4.5.5.2. Short-circuit protection

Generators are to be protected for short circuit by circuit breakers provided with short-time delay trips. For coordination with feeder circuit breakers, the short-time delay trips are to be set at the lowest values of current and time which will coordinate with the trip settings of feeder circuit breakers. The current setting of the short time delay trip is to be less than the steady state short circuit current of the generator. Where two or more AC generators are arranged for parallel operation, each generator's circuit breaker is, in addition, to be provided with instantaneous trip set in excess of the maximum short circuit contribution of the individual generator.

For generators of less than 200 kW driven by diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of the short-time delay trips if instantaneous trips and long-time over current protection (Refer [4.5.5.1.] of this section) are provided. When the short time delay trips are omitted, the thermal withstand capacity of the generator is to be greater than the steady state short-circuit current of the generator, until activation of the tripping system. Alternative suitable protection, such as generator differential protection, which will trip the generator circuit breaker in the event of a fault in the generator or in the supply cable between the generator and its circuit breaker, would also be acceptable

4.5.5.3. Thermal damage protection

Generator circuit breakers at the main and emergency switchboard are to have tripping characteristics and to be set such that they will open before the generator sustains thermal damages due to the fault current. Refer [4.5.15.] of this section.

4.5.5.4. Reverse power protection

A reverse power protection device is to be provided for each generator arranged for parallel operation. The setting of the protective devices is to be in the range 2 percent to 6 percent of the rated power for turbines and in the range 8 percent to 15 percent of the rated power for diesel engines. A setting of less than 8 percent of the rated power of diesel engines may be allowed with a suitable time delay recommended by the diesel engine manufacturer.

4.5.5.5. Prime mover shutdown

The shutting down of the prime mover is to cause the tripping of the generator circuit breaker.

4.5.5.6. Under voltage protection

Generators arranged for parallel operation are to be provided with means to prevent the generator circuit breaker from closing if the generator is not generating, and to open the same when the generator voltage collapses. In the case of an under-voltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

4.5.6. Protection of transformer

4.5.6.1. Protection at primary side only

Each power and lighting transformer along with its feeder is to be provided with short-circuit and overload protection. The protective device is to be installed on the primary side of the transformer and is to be set at 100 percent of the rated primary current of the transformer. If this setting is not practicable, it may be increased to, but in no case exceeding 125 percent of the rated primary current. The instantaneous trip setting of the protective device is not to be activated by the in-rush current of the transformer when switching into service.

4.5.6.2. Protection at both primary and secondary sides

Where the secondary side of the transformer is fitted with a protective device set at not more than125 percent of the rated secondary current, the transformer primary side protective device may be set at a value less than 250 percent of the rated primary current.

4.5.6.3. Parallel operation

When the transformers are arranged for parallel operation, means are to be provided to disconnect the transformer from the secondary circuit. Where power can be fed into secondary windings, short-circuit protection (i.e., short-time delay trips) is to be provided in the secondary connections.

In addition, when the disconnecting device in primary side of the transformer is opened due to any reason (e.g., the short-circuit protection, overload protection, or manual operation for opening), the disconnecting device in the secondary side of the transformer is to be arranged to open the circuit automatically.

4.5.7. Protection of motor circuits

Overload and short-circuit protection is to be provided for each motor circuit in accordance with the following requirements.

4.5.7.1. Motor branch circuit protection

a. General:

Motor branch circuits are to be protected with circuit breakers or fuses having both instantaneous and long-time delay trips or with fuses. The setting is to be such that it will permit the passage of starting currents without tripping. Normally, the protective device is to be set in excess of the motor's full load current but not more than the limitations given in the table below. If that rating or setting is not available, the next higher available rating or setting may be used. In cases where the motor branch circuit cable has allowable current capacity in excess of the motor full load current, the protective device setting may exceed the applicable limitation, but not that given in [4.5.8.] of this section.

Table 2.4.15: Protective device current setting

Type of motor	Rating or setting, percent motor full-load current
Squirrel-cage and synchronous full voltage, reactor- or resistor-starting	250
Autotransformer starting	200
Wound rotor	150

b. Short-circuit protection only:

Where the motor branch circuit is protected with a circuit breaker fitted with instantaneous trip only, the motor controller is to have a short-circuit rating matching at least that of the circuit breaker instantaneous trip setting, and the motor overload protection (Refer [4.5.7.2.] of this section) is to be arranged to open all conductors.

4.5.7.2. Motor overload protection

The overload protective devices of motors are to be compatible with the motor overload thermal characteristics, and are to be set at 100 percent of the motor rated current for continuous rated motor. If this is not practicable, the setting may be increased to, but in no case exceeding, 125 percent of the motor rated current. This overload protective device may also be considered the overload protection of the motor branch circuit cable.

For athwart ship thrusters, a motor overload alarm in the wheelhouse is acceptable in lieu of the overload protection.

4.5.7.3. Under voltage protection

Under voltage protection is to be provided for motors having power rating exceeding 0.5 kW (0.7 hp) to prevent undesired restarting upon restoration of the normal voltage, after a stoppage due to a low voltage condition or voltage failure condition.

4.5.7.4. Under voltage release protection

Under voltage release is to be provided for the following motors unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions:

a. Primary essential services (Refer Ch 1, Sec 2, [2.2.a.] of this part);
b. Only those secondary essential services (Refer Ch 1, Sec 2, [2.2. b.] of this part) necessary for safety, such as:

    i. Fire pumps and other fire extinguishing medium pumps.
    ii. Ventilating fans for engine and boiler rooms where their failure to restart may prevent the normal operation of the propulsion machinery (Refer Note 1. below).

Special attention is to be paid to the starting currents due to a group of motors with under voltage release controllers being restarted automatically upon restoration of the normal voltage. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

Note 1: Under voltage protection is to be provided for ventilation fans for engine and boiler room, which are supplied by an emergency source of power for the purpose of removing smoke from the space after a fire has been extinguished.

4.5.7.5. Protection of steering gear circuits

a. AC motors:

    The steering gear feeder is to be provided with short-circuit protection only, which is to be located at the main or emergency switchboard. However, overload protection may be permitted if it is set at a value not less than 200 percent of the full load current of the motor (or of all the loads on the feeder), and is to be arranged to permit the passage of the starting current.

b. DC motors:

    The feeder circuit breaker on the main switchboard is to be set to trip instantaneously between 300 percent and 375 percent of the rated full-load current of the steering-gear motor. The feeder circuit breaker on the emergency switchboard may be set to trip instantaneously between 200 percent and 375 percent.

c. Fuses:

    The use of fuses for steering gear motor circuits is not permitted.

4.5.8. Protection of feeder circuit

Each feeder conductor is to be protected by a circuit breaker, or fuse with disconnecting switchgear, from short circuit and overload at the supply end.

Fuse ratings and rating of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the feeder cables, except as otherwise permitted for motor and transformer circuits where starting in-rush current need be taken into account.

If the standard rating or setting of the overload protective device does not correspond to the current rating of the feeder cable, the next higher standard rating or setting may be used, provided it does not exceed 150 percent of the allowable current carrying capacity of the feeder cable, where permitted by the Standard to which the feeder cables have been constructed.

4.5.9. Protection for accumulator batteries

4.5.9.1. Circuits connected to batteries above 12 V or above 1 Ah capacity shall have short circuit and over current protection. Protection may also be required for smaller batteries capable of creating a fire risk. Short circuit protection shall be located as close as is practical to the batteries, but not inside battery rooms, lockers, boxes or close to ventilation holes. The connection between the battery and the charger is also to have short circuit protection.

4.5.9.2. Connections between cells and from poles to first short circuit protection shall be short circuit proof.

4.5.9.3. The main circuit from a battery to a starter motor may be carried out without protection. In such cases, the circuit shall be installed short circuit proof, and with a switch for isolating purposes. Auxiliary circuits, which are branched off from the starter motor circuit, shall be protected as required in [4.5.9.1.] of this section.

4.5.9.4. Fuses may be used for the protection of batteries for emergency lighting instead of circuit breakers up to and including 320 A rating. The charging equipment, except rectifiers, for all batteries is to be provided with reverse current protection

4.5.10. Protection for branch lighting circuits

Branch lighting circuits are to be protected against overload and short circuit. In general, overload protective devices are to be rated or set at not more than 30 A. The connected load is not to exceed the lesser of the rated current carrying capacity of the conductor or 80 percent of the overload protective device rating or setting.

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

4.5.11.1. 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 multi pole circuit-breakers or fuses. The protective devices are to be placed as near as possible to the tapping from the supply. The secondary side of current transformers is not to be protected.

4.5.11.2. Control circuits and control transformers are to be protected against overload and short-circuit by means of multi pole 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.

4.5.11.3. 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.

Pilot lamps connected via short-circuit-proof transformers may be protected in common with control circuits.

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

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

4.5.12. Protection of semi-conductor element

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

4.5.12.2. Over current and over voltage 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.

4.5.12.3. Semiconductor converters are not to cause distortion in the voltage wave form of the power supply at levels exceeding the voltage wave form tolerances at the other user input terminals (Refer [4.1.2.8.] of this section).

4.5.12.4. An alarm is to be provided for tripping of protective devices against over voltages and over currents in electric propulsion converters and for converters for the emergency source of power.

4.5.12.5. Each harmonic filter shall be protected against over-current and short circuit. Circuit protection in filter circuits shall be monitored and provided with alarm in a manned control station.

4.5.13. Protection of essential services

4.5.13.1. Where generators are operated in parallel and essential services are electrically operated, arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

4.5.13.2. If required, this load shedding may be carried out in one or more stages according to the overload ability of the generating sets, taking into consideration the relative importance of the loads being thus disconnected.

4.5.13.3. In cargo ships, circuits for cargo refrigeration machinery are to be included in the last group of services to be disconnected.

4.5.14. Load shedding arrangements

4.5.14.1. Provision for load shedding arrangements

In order to safeguard continuity of the electrical power supply, automatic load-shedding arrangements or other equivalent arrangements are to be provided:

a. Where only one generating set is normally used to supply power for propulsion and steering of the ship, and a possibility exists that due to the switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated capacity of the running generator, or
b. Where electrical power is normally supplied by more than one generator set simultaneously in parallel operation for propulsion and steering of the ship, upon the failure of one of the parallel running generators, the total connected load exceeds the total capacity of the remaining generator(s).

4.5.14.2. Services not allowed for shedding

Automatic load-shedding arrangements or other equivalent arrangements are not to automatically disconnect the essential services. Refer Ch 1, Sec 2, [2.2.] of this part for the definition of essential services.

a. Primary essential services that, when disconnected, will cause immediate disruption to propulsion and maneuvering of the vessel,
b. Emergency services as listed in sec 3, [3.3.], [3.4.] of this chapter,
c. Secondary essential services that, when disconnected, will:

    i. Cause immediate disruption of systems required for safety and navigation of the vessel, such as: Lighting systems, Navigation lights, aids and signals, internal communication systems etc.
    ii. Prevent services necessary for safety from being immediately reconnected when the power supply is restored to its normal operating conditions, such as: Fire pumps, and other fire extinguishing medium pumps, Bilge pumps, Ventilation fans for engine and boiler rooms.

4.5.15. Coordination of protective devices

Protective devices are to be selected such that, where considered in series, their tripping characteristics will allow, in the event of a fault (overload or short circuit), the protective device nearest to the fault to open first, thus eliminating the faulted portion from the system.

Protective devices upstream of the fault are to be capable of carrying for the necessary duration the short-circuit current and the overload current, without opening, to allow the device nearest to the fault to open.

Coordination is to be provided for the following:

a. Between generator protective device, bus tie, bus feeder protective device, and feeder protective devices;
b. Between feeder and branch circuit protective devices for essential services except for cascade protection in [4.5.2.4.] of this section.
c. Between protective devices of emergency generator, emergency feeders and branch circuits.

For main and emergency generators, the circuit breakers are to open to prevent the generators from being damaged by thermal stress due to the fault current.

For verification of compliance with the above, a protective device coordination study in accordance with Ch 1, Sec 3, [3.1.1.4.] of this part is to be submitted for review.

4.5.16. Circuit breaker

4.5.16.1 Circuit-breakers for alternating current systems are to satisfy the following conditions:

a. The r.m.s. symmetrical breaking current for which the device is rated is to be not less than the r.m.s. value of the A.C. component of the prospective fault current, at the instant of contact separation (i.e. first half cycle, or time of interruption where an intentional time delay is provided to ensure suitability).
b. The peak asymmetrical making current for which the device is rated is not to be less than the peak value of the prospective fault current at the first half cycle, allowing for maximum asymmetry.
c. The power factor at which the device short-circuit ratings are assigned is to be no greater than that of the prospective fault current; alternatively, for high voltage, the rated percentage D.C. component of the short-circuit breaking current of the device is to be not less than that of the prospective fault current.

4.5.16.2 Circuit-breakers for D.C. systems are to have a breaking current not less than the initial prospective fault current. The time constant of the fault current is not to be greater than that for which the circuit-breaker was tested.

4.5.16.3 The fault ratings considered in [4.5.16.1.] and [4.5.16.2.] of this section, are to be assigned on the basis that the device is suitable for further use after fault clearance.

4.5.16.4 Circuit-breaker selection is, and ratings are, to be in accordance with the relevant requirements of IEC 60092- 202: Electrical installations in ships – System design – Protection. Alternative methods acceptable to INTLREG of selecting suitable circuit-breakers may be considered.

4.5.16.5 Circuit breakers are to be designed, constructed and tested to IEC Publication 60947-2 or other recognized standard.

4.5.17. Fuses

All fuses are to comply with IEC Publication 60269 or any equivalent there to, amended in cases where necessary for ambient temperature.

4.5.17.1. Fuses for a.c. systems are to have a breaking current rating not less than the initial r.m.s. value of the a.c. component of the prospective fault current.

4.5.17.2. Fuses for d.c. systems are to have a d.c. breaking current rating not less than the initial value of the prospective fault current.

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

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

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

4.5.17.6. The performance of fuses and fuse-holders are to comply with following:

a. Temperature rises in connecting terminals of cables are not to exceed 45K at ambient temperature of 45^0c in cases where fuses are fitted to fuse-holders; furthermore 100 percent of rated currents are carried there through.
b. Fuses are to have those fusing characteristics corresponding to their kind; further more under those circuit conditions specified in IEC Publication 60269 such fuses are to be capable of securely breaking all currents whichever is below their rated breaking capacity and above their fusing current.

4.5.18. Circuit-breakers requiring back-up by fuse or other device

4.5.18.1. The use of a circuit-breaker having a short-circuit current capacity less than the prospective short circuit current at the point of installation is permitted, provided that it is preceded by a device having at least the necessary short-circuit capacity. The generator circuit-breakers are not to be used for this purpose.

4.5.18.2. The same device may back-up more than one circuit-breaker provided that no essential or emergency service is supplied from there, or that any such service is duplicated by arrangements unaffected by tripping of the device.

4.5.18.3. The combination of back-up device and circuit breaker is to have a short-circuit performance at least equal to that of a single circuit-breaker satisfying the requirements of circuit breaker.

4.5.18.4. Evidence of testing of the combination is to be submitted for consideration; alternatively, consideration may be given to arrangements where it can be shown that:

a. The takeover current, above which the back-up device would clear a fault, is not greater than the rated short-circuit breaking capacity of the circuit-breaker.
b. The characteristics of the back-up device, and the prospective fault level, are such that the peak fault current rating of the circuit-breaker cannot be exceeded and;
c. The Joule integral of the let-through current of the backup device does not exceed that corresponding to the rated breaking current and opening time of the circuit breaker.

4.5.19. Electromagnetic contactors

Electromagnetic contactors are to comply with IEC publications 60947-1 and 60947-4-1, or any equivalent thereto, amended in cases where necessary for ambient temperature.

4.5.19.1. Electromagnetic contactors are to be such that no accidental opening and closing occurs due to ship vibration; furthermore, no malfunction is to be caused by any list of an angle of 30^0 in any direction.

4.5.19.2. Contact pieces and magnetic coils are to be easily replaceable.

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

4.5.19.4. Temperature rises in connecting terminals of cables are not exceeding 45K at ambient temperatures of 45^0c in cases where full-load currents corresponding to rated capacities are carried there though.

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

4.5.19.6. Electromagnetic contactors are not to accidentally open circuits at voltages exceeding 85 percent of rated voltages.

4.5.20. Earthing

4.5.20.1. Except where exempted by [4.5.20.2.] of this section, all non-current carrying exposed metal parts of electrical equipment and cables are to be earthed for personal protection against electric shock.

4.5.20.2. The following parts may be exempted from the requirements of [4.5.20.1.] of this section:

a. Lamp-caps, where suitably shrouded;
b. Shades, reflectors and guards supported on lamp holders or light fittings constructed of, or shrouded in, non-conducting material.
c. Metal parts on, or screws in or through, non-conducting materials, which are separated by such material from current-carrying parts and from earthed non-current carrying parts in such a way that in normal use they cannot become live or come into contact with earthed parts.
d. Bearing housings which are insulated in order to prevent circulation of current in the bearings.
e. Clips for fluorescent lamps;
f. Cable clips and short lengths of pipes for cable protection.
g. Apparatus supplied at a voltage not exceeding 50 V direct current or 50 V, root mean square, between conductors, or between any conductor and earth in a circuit isolated from the supply. Auto transformers are not to be used for the purpose of achieving the alternating current voltage;
h. Apparatus or parts of apparatus which although not shrouded in insulating material is nevertheless otherwise so guarded that it cannot be touched and cannot come in contact with exposed metal.

i. The machine or equipment is supplied at a voltage not exceeding 250 V (AC) by safety isolating transformers supplying only one consuming device.

4.5.20.3. Metal coverings of cables are to be effectively earthed at both ends of the cable. In final sub-circuits, other than those installed in hazardous zones or spaces, earthing at the supply end only will be considered adequate. Single point earthing may be accepted for instrumentation cables, or cables for intrinsically safe circuits, if desirable for technical reasons.

4.5.20.4. The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and trappings, is to be ensured.

4.5.20.5. Metal parts of portable appliances, other than current-carrying parts and parts exempted by [4.5.20.2.] of this section are to be earthed by means of an earth continuity conductor in the flexible cable or cord through the associated plug and socket outlet.

4.5.20.6. Earthing conductors are to be of copper or other corrosion-resistant material and be securely installed and protected where necessary against damage and also, where necessary, against electrolytic corrosion. Connections are to be so secured that they cannot work loose under vibration.

4.5.20.7. The nominal cross-section areas of copper earthing conductors are, in general to be equal to the cross-section of the current-carrying conductor up to 16 [mm^2]. Above this figure they are to be equal to at least half the cross-section of the current-carrying conductor with a minimum of 16 [mm^2]. Every other earthing conductor is to have a conductance not less than that specified for an equivalent copper earthing conductor.

4.5.20.8. The connection of the earthing conductors to the hull of the ship is to be made in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation. They are to be secured by a screw or stud of diameter not less than 6 [mm] which is to be used for this purpose only. Bright metallic surfaces at the contact areas are to be ensured immediately before the nut or screw is tightened and where necessary, the joint is to be protected against electrolytic corrosion. The connection is to remain unpainted.

4.5.20.9. For Size of Earthing Conductors Refer Table 2.4.13

4.5.20.10. Bonding for the control of static electricity are required as following:

a. For cargo tanks, process plant and piping systems, for flammable products and solids liable to release flammable gas and/or combustible dust, which are not permanently connected to the hull of the ship either directly or via their bolted or welded supports and where the resistance between them and the hull exceeds 1MΩ.
b. They are to be robust, that having a cross-sectional area of about 10 [mm^2] and are to comply with [4.5.20.6.] and [4.5.20.8.] of this section.

4.5.21. Protection of communication circuits

Communication circuits other than those supplied from primary batteries are to be protected against overload and short-circuit.

4.5.22. Degree of protection of enclosure

4.5.22.1. Equipment supplied at nominal voltages in excess of 500 V and accessible to non-authorized personnel (e.g. 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 IP4X.

4.5.22.2. Electrical equipment is to have a degree of enclosure for protection against the intrusion of foreign objects and liquids, appropriate for the location in which it is installed. The minimum degree of protection is to be in accordance with Table 2.4.16 of this section.

4.5.22.3. The degree of protection by an enclosure with respect to the intrusion of foreign particles and water is defined by the designation 'IP' followed by two digits: the first digit signifies the protection degree against particles, and the second digit signifies the protection degree against water. For complete details, Refer Table 2.4.17 and Table 2.4.18 of this section. These designations are identical to that specified in IEC Publication 60529.

Table 2.4.16: Minimum required degrees of protection

Condition in location	Example of location	Switchboard, control gear, motor starters	Generators	Motors	Transformers	Luminaries	Heating Appliances	Cooking Appliances	Socket outlets	Accessories (e.g. switches, connection boxes)
Danger of touching live parts only	Dry accommodation spaces, dry control rooms	IP 20	X (1)	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
	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 mechanical damage	Ballast pump rooms	IP 44	X	IP 44 (2)	IP 44 (2)	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
	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

(1) The symbol "X" denotes equipment which it is not advised to install.
(2) Electric motors and starting transformers for lateral thrust propellers located in spaces similar to ballast pump rooms may have degree of protection IP 22.

Table 2.4.17: Degree of protection of electrical equipment (First IP numeral)		
First IP numeral	**Short description**	**Definition**
0	Non-protected	No special protection
1	Protected against solid objects greater than 50 mm (2 in.)	A large surface of the body, such as a hand (but no protection against deliberate access). Solid object exceeding 50 mm (2 in.) in diameter.
2	Protected against solid objects greater than 12 mm (0.5 in.)	Fingers or similar objects not exceeding 80 mm (3.15 in.) in length. Solid objects exceeding 12 mm (0.5 in.) in diameter.
3	Protected against solid objects greater than 2.5 mm (0.1 in.)	Tools, wires, etc. of diameter or thickness greater than 2.5 mm (0.1 in.). Solid objects exceeding 2.5 mm (0.1 in.) in diameter
4	Protected against solid objects greater than 1 mm (0.04 in.)	Wires or strips of thickness greater than 1 mm (0.04 in.). Solid objects exceeding 1 mm (0.04 in.) in diameter.
5	Dust protected	Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment
6	Dust-tight	No ingress of dust

Table 2.4.18: Degree of protection of electrical equipment (Second IP numeral)		
Second IP numeral	**Short description**	**Definition**
0	Non-protected	No special protection.
1	Protected against dripping water	Dripping water (vertically falling drops) is to have no harmful effect.
2	Protected against dripping water when tilted up to 15°.	Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position.
3	Protected against spraying water	Water falling as spray at an angle up to 60° from the vertical is to have no harmful effect.
4	Protected against splashing water	Water splashed against the enclosure from any direction is to have no harmful effect.
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction is to have no harmful effect.
6	Protected against heavy seas	Water from heavy seas or water projected in powerful jets is not to enter the enclosure in harmful quantities.
7	Protected against the effects of immersion	Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water under defined conditions of pressure and time.
8	Protected against submersion	The equipment is suitable for continuous submersion in water under conditions which are to be specified by the manufacturer. **Note:** Normally this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.

4.5.23. Explosion protection

4.5.23.1. Protection against explosive gas or vapor atmosphere hazard

a. Electrical equipment intended for use in areas where explosive gas or vapor atmospheres may occur (e.g. oil tankers, liquefied gas carriers, chemical tankers, etc.), is to be of a "safe type" suitable for the relevant flammable atmosphere and for shipboard use.
b. Other equipment complying with types of protection other than those in Ch 1, Sec 2, [2.31.] of this part may be considered by the INTLREG, such as:

   i. Simple electrical apparatus and components (e.g. 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.
   ii. Electrical apparatus specifically designed and certified by the appropriate authority for use in Zone 0 or specially tested for Zone 2 (e.g. type "n" protection).
   iii. Equipment the type of which ensures the absence of sparks and arcs and of "hot spots" during its normal operation.
   iv. Pressurized equipment;
   v. Equipment having an enclosure filled with a liquid dielectric, or encapsulated.

4.5.23.2. Protection against combustible dust hazard

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.

Note: Where the characteristics of the dust are unknown, the appliances are to have a degree of protection IP6X. For most dusts a maximum surface temperature of 200°C is considered adequate.

4.5.24. Protection against lightning

Precautions are to be taken to protect essential electronic equipment that may be susceptible to damage from voltage pulses attributable to the secondary effects of lightning. This may be achieved by suitable design and/or the use of additional protective devices, such as surge arrestors. Resultant induced voltages may be further reduced by the use of earthed metallic screened cables. Refer also Ch 3, sec 5 of this part.

4.6. Electric propulsion

4.6.1. General

4.6.1.1. Application

a. The Rules in this Subsection are applicable to electric propulsion systems. In this section the technical requirements are in addition to those described in other relevant sections in this chapter. Electric propulsion systems complying with other recognized standard also to be applicable & considered acceptable.

b. Prime movers for generators providing electric power for propulsion shall be considered as propulsion prime movers. Prime movers and associated instrumentation and monitoring shall conform to the rule requirements for propulsion prime movers. Associated speed governing and control shall be arranged as for auxiliary prime movers.
c. Prime movers that drive generators for the supply of power for ship service only, are defined as auxiliary prime movers, even if they may be connected to the propulsion power system and thus contribute to propulsion power.
d. Local and remote control systems for electric propulsion machinery shall comply with Ch 8 of this part.
e. For instrumentation and automation, that includes computer based control and monitoring, the requirements in this chapter are additional to those given in Ch 8, Sec 5 of this part.

4.6.1.2. Plans and data to be submitted

The following plans and data are to be submitted for review:

a. One-line diagrams of propulsion control system for power supply, circuit protection, alarm, monitoring, safety and emergency shutdown systems including list of alarm and monitoring points.
b. Plans displaying the location of propulsion controls and its monitoring stations.
c. Arrangements and details of the propulsion control console or panel including schematic diagram of the system therein.
d. Arrangements and details of electric coupling.
e. Arrangements and details of the semiconductor converter enclosure for propulsion system, including data for semiconductor converter, cooling system with its interlocking arrangement.

4.6.2. Operating conditions

4.6.2.1. The normal torque available on the electric propulsion motors for maneuvering is to be such as to facilitate the ship to be stopped or reversed when sailing at its maximum service speed.

4.6.2.2. As a whole the plant is to have adequate overload capacity to provide the torque, power and reactive power required during starting and maneuvering conditions.

4.6.2.3. Locked rotor torque which may be required in relation to the operation of the ship (e.g. for navigation in ice) is to be considered.

4.6.2.4. 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.

4.6.3. System design

4.6.3.1. The minimum configuration of an electric propulsion plant consists of one prime mover, one generator and one electric motor. When the electrical production used for propulsion is independent of the shipboard production, the diesel engines driving the electric generators are to be considered as main engines. For the purposes of the electric propulsion system requirements, an electric propulsion system is one in which the main propulsion of the vessel is provided by at least one electric motor. A vessel may have more than one electrical propulsion system

4.6.3.2. For ships with an integrated electric propulsion system, under normal sea-going conditions, when one generator is out of service, the remaining generator capacity is to be sufficient to carry all of the loads for ship services (essential services, normal services and for minimum comfortable conditions of habitability) and the propulsion loads to provide for a speed of not less than 7 knots or one half of the design speed, whichever is the lesser.

4.6.3.3. Electrical equipment in propulsion lines, which have been built with redundancy in technical design and physical arrangement, shall not have common mode failures endangering the maneuverability of the ship, except for fire and flooding, which are accepted as common mode failures.

4.6.3.4. Ships having two or more propulsion motors and converters, or two electric motors on one propeller shaft, shall be arranged so that any unit may be taken out of service and electrically disconnected without affecting the operation of the others.

4.6.3.5. Ships having only one propulsion motor will be accepted as being built with redundancy in technical design and physical arrangement, with respect to single failures, as long as the motor is equipped with two independent sets of armature windings. These sets shall not be laid in the same slots in the iron core.

4.6.3.6. Ships having only one propulsion motor of non-self-exciting type having armature windings but only one common field winding will be accepted without further redundancy when equipped with more than one external exciter. Where electric motors are to provide the sole means of propulsion for a vessel, a single propulsion motor with dual windings does not meet this requirement

4.6.3.7. 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 and the services are maintained with any one generating set out of service.

4.6.3.8. Where the arrangements permit a propulsion motor to be connected to a generating plant having a continuous rating greater than the motor rating, means are to be provided to limit the continuous input to the motor to a value not exceeding the continuous full load torque for which the motor and shafts are approved.

4.6.3.9. A harmonic distortion (Refer [4.1.2.8.] of this section) calculation is to be submitted for review for all ships with electric propulsion. The calculation is to indicate that the harmonic distortion levels at all locations throughout the power distribution system (main generation switchboard, downstream power distribution switchboards, etc.) are within the limits. The harmonic distortion levels at dedicated propulsion buses are also to be within the limits, otherwise documentation from the manufacturer is to be submitted indicating that the equipment is designed for operation at a higher level of distortion.

4.6.3.10. For systems where regenerative power may be developed through the semiconductor converters, the regenerative power is not to cause disturbances in the system voltage and frequency which exceeds the limits of system voltage & frequency as mentioned in [4.2.3.] of this section.

In the case of an integrated electrical propulsion system, the electrical drive train is considered to consist of the equipment connected to the electrical network such as a drive (frequency converter) and the propulsion motor(s).

4.6.3.11. Ventilation and cooling for propulsion shall be comply with the following requirements:

a. The general requirements will normally imply that loss of ventilation or cooling to spaces or equipment with forced air-cooling shall not cause loss of propulsion. Sufficient power necessary for maneuvering shall be available after any single failure. Where the propulsion system is arranged in different lines with the associated equipment for power distribution to these lines arranged in different rooms, failure of ventilation or cooling shall only render one propulsion line out of operation. However, redundancy requirements for main class and relevant additional class notations shall be adhered to.

b. The ventilation and cooling systems for electrical propulsion equipment are to be provided with monitoring devices arranged to operate an alarm if the temperature of the heated cooling medium exceeds a predetermined safe value.

4.6.4. Power supply systems

4.6.4.1. Propulsion generators

a. Power supply:

i. The electric distribution system shall conform to the requirements in [4.2.] of this section.
ii. The power for the propulsion equipment may be derived from a single generator. If a ship service generator is also used for propulsion purposes other than for boosting the propulsion power, such generator and power supply circuits to propulsion systems are also to comply with the applicable requirements in this Subsection.
iii. If a propulsion system contains only one generator and one motor and cannot be connected to another propulsion system, more than one exciter set is to be provided for each machine. However, this is not necessary for self-exited generators or for multi-propeller propulsion ships where any additional exciter set may be common for the ship.
iv. Systems having two or more propulsion generators, two or more semiconductor 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 preventing the operation of the remaining units.
v. For supply to the speed control systems of main propulsion engines Refer [4.2.20.] of this section.

b. Features for other services:

If the propulsion generator is used for other purposes than for propulsion, such as dredging, cargo oil pumps and other special services, overload protection in the auxiliary circuit and means for making voltage adjustments are to be provided at the control board. When propulsion alternating-current generators are used for other services for operation in port, the port excitation control is to be provided with a device that is to operate just below normal idling speed of the generator to remove excitation automatically.

c. Excitation systems:

Arrangements for electric propulsion generators are to be such that propulsion can be maintained in case of failure of an excitation system or failure of a power supply for an excitation system. Propulsion may be at reduced power under such conditions where two or more propulsion generators are installed, provided such reduced power is sufficient to provide for a speed of not less than 7 knots or 1/2 of the design speed, whichever is the lesser.

4.6.4.2. Propulsion excitation

a. Excitation circuits:

Every exciter set is to be supplied by a separate feeder. Excitations circuits are not to be fitted with overload circuit-interrupting devices, except those intended to function in connection with the protection for the propulsion generator. In such cases, the field circuit breaker is to be provided with a discharge resistor unless a permanent discharge resistor is provided.

b. Field circuits:

Field circuits are to be provided with means for suppressing voltage rise when a field switch is opened. Where fuses are used for excitation circuit protection, it is essential that they do not interrupt the field discharge resistor circuit upon rupturing.

c. Ship service generator connection:

Where the excitation supply is obtained from the ship service generators, the connection is to be made to the generator side of the generator circuit breaker with the excitation supply passing through the overload current device of the breaker.

4.6.4.3. Semiconductor converters

Semiconductor converter circuits are to be able to withstand the transient over current to which the system is subject during maneuvering. Where semiconductor converters are connected in parallel, the current for each semiconductor converter is to be equally distributed, as far as practicable. If several elements are connected in parallel and a separate fan is fitted for each parallel branch, arrangements are to be made for disconnecting the circuit for which ventilation is not available. Where semiconductor converters are connected in series, the voltage between the semiconductors devices are to be equally distributed, as far as practicable. In case of failure of the cooling system, an alarm is to be given or the current is to be reduced automatically.

4.6.5. Propulsion power requirements

4.6.5.1. The propulsion system is to have sufficient power for maneuvering the ship and for going astern. With the ship travelling at maximum service speed the propulsion equipment is to be capable of stopping and reversing the ship in an agreed time.

4.6.5.2. The propulsion system is to have adequate torque and power margins for all operating conditions including maneuvering and rough weather with due regard to propeller and ship characteristics.

4.6.5.3. The electric power for the propulsion system may be derived from generating sets dedicated to propulsion duty or from a central power generation plant which serves both propulsion and ship service loads.

4.6.5.4. Where propulsion power is derived from a central, common, power plant the control system is to ensure a safe distribution of power between propulsion and ship services, with tripping of non-essential loads and/or reduction in propulsion power if necessary.

4.6.5.5. Where a central power generation system is employed the number and rating of generator sets is to be such that with one set out of action the remaining sets are capable of providing all essential and normal ship service loads whilst maintaining an effective level of propulsion power.

4.6.5.6. The electrical power requirements are normally supplied by two or more generating sets operating in parallel, on sudden loss of power from one set, the rating of the remaining set(s) in service is to be sufficient to ensure uninterrupted operation of essential services and an effective level of propulsion power.

4.6.6. Power management system

For ships with an integrated electric propulsion system, a power management system is to be provided. The power management system is to be designed to control load sharing between generators, prevent blackouts, maintain power to the essential service loads and maintain power to the propulsion loads.

The system is to account for the following operating scenarios:

a. All generators in operation, then the loss of one generator.
b. When at least one generator is not in operation and there is an increase in the propulsion loads or a loss of one of the generators that would result in the need to start a generator that was not in operation.

Further, the system is to prevent overloading the generators, by reducing the propulsion load or load shedding of non-essential loads. In general, the system is to limit power to the propulsion loads to maintain power to the ship's essential service loads. However, the system is to shed non-essential loads to maintain power to the propulsion loads. An audible and visible alarm is to be installed at each propulsion control location and is to be activated when the system is limiting the propulsion power in order to maintain power to the other essential service loads

4.6.7. Monitoring and alarms

4.6.7.1. Safety functions installed in equipment and systems for electric propulsion shall not result in automatic shutdown unless the situation implies that the equipment is not capable of further functioning, even for a limited time. Automatic reduction of propulsion power is accepted.

4.6.7.2. Priming control shall not prevent blackout start, if arranged.

4.6.7.3. Shutdowns caused by a safety function shall, as far as possible, be arranged with a pre-warning alarm.

4.6.7.4. For installations with one propulsion motor having two separate armature windings, the converters shall be arranged for automatic restart if an excitation failure in the motor may cause shutdown of both propulsion converters.

4.6.7.5. Critical alarms for propulsion shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.

4.6.7.6. Monitoring with alarm shall be arranged for:

a. High temperature of cooling medium of machines and semi-conductor converters having forced cooling.
b. High winding temperature of all propulsion generators and motors

c. Loss of flow of primary and secondary coolants of machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself. Auxiliary contacts from motor starters may be used for this purpose.
d. Lubricating oil pressure for machines with forced oil lubrication
e. Leakage of water-air heat exchanger for cooling of machines and semi-conductor converters
f. Earth fault for main propulsion circuits
g. Earth fault for excitation circuits. (This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
h. Fuses for filter units or for other components where fuse failure is not evident.

4.6.7.7. A request for manual load reduction shall be issued, visually and acoustically on the bridge, or an automatic load reduction shall be arranged in case of:

a. Low lubricating oil pressure to propulsion generators and motors.
b. High winding temperature in propulsion generators and motors.
c. Failure of cooling in machines and converters.

4.6.7.8. An audible and visible alarm is to be installed at each propulsion control location and is to be activated when the system is limiting the propulsion power in order to maintain power to the other essential service loads.

4.6.7.9. Where machines have enclosed ventilation systems, an aural alarm device is to be provided and arranged to operate if the temperature of the heated air exceeds the predetermined safe value.

4.6.8. Propulsion control

4.6.8.1. General

Failure of a control signal is not to cause an excessive increase in propeller speed. The reference value transmitters in the control stations and the control equipment are to be so designed that any defect in the desired value transmitters or in the cables between the control station and the propulsion system will not cause a substantial increase in the propeller speed.

4.6.8.2. Automatic and remote control systems

Where two or more control stations are provided outside the engine room, or where the propulsion machinery space is intended for centralized control or unattended operation, the provisions of Ch 8, Sec 2, Sec 3 & Sec 4 of this part are to be complied with.

4.6.8.3. Testing and inspection

Controls for electric propulsion equipment are to be inspected when finished and dielectric strength tests and insulation resistance measurements made on the various circuits in the presence of the Surveyor, preferably at the plant of manufacture. The satisfactory tripping and operation of all relays, contactors and the various safety devices are also to be demonstrated.

4.6.8.4. Initiation of control

The control of the propulsion system can be activated only when the delegated control lever is in zero position and the system is ready for operation.

4.6.8.5. Emergency stop

Each control station shall have an emergency stop device which is independent of the control lever.

4.6.8.6. Prime mover control

Where required by the system of control, means are to be provided at the control assembly for controlling the prime mover speed and for mechanically tripping the throttle valve.

4.6.8.7. Control power failure

If failure of the power supply occurs in systems with power-aided control (e.g., with electric, pneumatic or hydraulic aid), it is to be possible to restore control in a short time.

4.6.8.8. Protection

Arrangements are to be made so that opening of the control system assemblies or compartments will not cause inadvertent or automatic loss of propulsion. Where steam and oil gauges are mounted on the main-control assembly, provision is to be made so that the steam or oil will not come in contact with the energized parts in case of leakage.

4.6.8.9. Interlock arrangements

All levers for operating contactors, line switches, field switches and similar devices are to be interlocked to prevent their improper operation. Interlocks are to be provided with the field lever to prevent the opening of any main circuits without first reducing the field excitation to zero, except that when the generators simultaneously supply power to an auxiliary load apart from the propulsion, the field excitation need only be reduced to a low value.

4.6.9. Instrumentation at the Control Station

4.6.9.1. Indication & display

a. Instruments and other devices mounted on the switchboard are to be labeled and the instruments provided with a distinguishing mark to indicate full-load conditions. Metallic cases of all permanently installed instruments are to be permanently earthed. The following instruments, where applicable, are to be provided:

   i. For A.C. systems:

- An ammeter for each generator and propulsion motor; voltmeter, wattmeter and frequency meter for each generator and ammeter for each excitation circuit.
- A temperature indicator for each generator and propulsion motor, the indicator is to read stator Winding and cooling system temperature.

ii. For D.C. systems:

- A voltmeter and ammeter for each generator and propulsion motor; an ammeter for each excitation circuit.

iii. For electric slip couplings:

- An ammeter for the coupling excitation circuit.

b. Each control station is to be provided with instruments to indicate:

i. Propeller speed;
ii. Direction of rotation for a fixed pitch propeller or pitch position for a controllable pitch propeller; and
iii. Visual indication of power limitation.

4.6.9.2. Indication of propulsion system status:

The control stations of the propulsion systems are to have at least the following indications for each propeller:

a. “Ready for operation”: power circuits and necessary auxiliaries are in operation.
b. “Faulty”: propeller is not controllable.
c. “Power limitation”: in case of disturbance, for example, in the ventilators for propulsion motors, in the converters cooling water supply or load limitation of the generators.

4.6.10. Electrical protection

4.6.10.1. Automatic disconnections of electric propulsion plants which adversely affect the maneuverability of the ship are to be restricted to faults likely to cause severe damage to the equipment.

4.6.10.2. The following protection of converters is to be provided:

a. Protection against overvoltage in the supply systems to which converters are connected and to prevent the application of voltages in excess of the rating of semiconductor devices
b. Protection against over currents in semiconductor elements during normal operation.

Short-circuit protection. Semiconductor converters and the associated semiconductor devices are to be protected against short circuit.
Filter Circuits. Filter circuits are to be protected against overvoltage, overcurrent and short circuit.

c. *Alarms.* Visual and audible alarms are to be provided at the control station in the event of operation of the protection system

4.6.10.3. Over current protective devices in the main circuits are to be set sufficiently high so that there is no possibility of activation due to the over currents caused in the course of normal operation, e.g. during maneuvering or in heavy seas.

4.6.10.4. Over-current protection may be replaced by automatic control systems ensuring that over currents do not reach values which may endanger the plant, e.g. by selective tripping or rapid reduction of the magnetic fluxes of the generators and motors.

4.6.10.5. 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.

4.6.10.6. 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.

4.6.10.7. Where a single failure in the generators' excitation systems may endanger the maneuverability of the ship, provisions shall be made to monitor the proper operation of the excitation system. Upon detection of abnormal conditions, an alarm shall be given on the navigating bridge and in the engine control room and actions to bring the system into a safe operational mode shall be automatically executed.

4.6.10.8. Following protection for over-speed and regeneration are to be provided:

a. When necessary, over-speed protection of propulsion motors shall be arranged, preventing the speed during maneuvering or fault conditions to exceed the limits for which the machine has been designed.
b. Regenerated power shall not cause any alarms in the propulsion system, neither in planned operating modes nor during emergency maneuvers. Where necessary, braking resistors for absorbing or limiting such energy shall be provided.

4.6.10.9. Circuit protection in an excitation circuit shall not cause opening of the circuit, unless the armature circuits are disconnected simultaneously. For a motor with one excitation winding and two armature windings, a failure in one of the armature circuits, shall not entail disconnection of the excitation circuit in operation.

4.6.10.10. Requirements for discharge protection is be comply with the following:

a. For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened or, alternatively, the induced voltage, when the field circuits are opened, is to be taken as the nominal design voltage.
b. Where excitation is obtained from the auxiliary busbars, means are to be provided to limit the voltage induced at the busbars when the auxiliary circuit-breaker or the distribution circuit-breaker opens.
c. Shunt resistors which are connected across the field circuit of synchronous propulsion motors, when they are functioning as asynchronous motors, are to be suitably insulated for the voltage induced when reversing, and are to be amply rated to allow for inadvertent delay during the reversing operation.

4.6.10.11. Following protection for Direct-current (DC) propulsion are to be provided:

a. Circuit protection:

Direct-current propulsion circuits are not to have fuses. Each circuit is to be protected by overload relays to open the field circuits or by remote-controlled main-circuit interrupting devices. Provision is to be made for closing circuit breakers promptly after opening.

b. Protection for reversal of the rotation:

Where separately driven DC generators are connected electrically in series, means shall be provided to prevent generator upon failure of the driving power of its prime mover.

4.6.10.12. Means are to be provided for selective tripping or rapid reduction of the magnetic fluxes of the generators and motors so that over currents does not reach values which may endanger the plant.

4.6.10.13. Fuses are to be provided for filter circuits. Visual and audible alarms are to be provided at the control station for tripping of the fuse.

4.6.11. Protection for earth leakage

4.6.11.1. Main propulsion circuits

Means for earth leakage detection are to be provided for the main propulsion circuit and be arranged to operate an alarm upon the occurrence of an earth fault. When the fault current flowing is liable to cause damage, arrangements for opening the main propulsion circuit are also to be provided.

4.6.11.2. Excitation circuits

Means are to be provided for earth leakage detection in excitation circuits of propulsion machines, but may be omitted in circuits of brushless excitation systems and of machines rated up to 500 kW.

4.6.11.3. Alternating-current (AC) systems

Alternating-current propulsion circuits are to be provided with an earthing detector alarm or indicator. If the neutral is earthed for this purpose, it is to be through an arrangement which will limit the current at full-rated voltage so that it will not exceed approximately 20 A upon a fault to earth in the propulsion system. An unbalance relay is to be provided to open the generator and motor-field circuits upon the occurrence of an appreciable unbalanced fault.

4.6.11.4. Direct-current (DC) systems

The earthing detector may consist of a voltmeter or lights. Provision is to be made for protection against severe overloads, excessive currents and electrical faults likely to result in damage to the plant. Protective equipment is to be capable of being so set as not to operate on the overloads or over currents experienced in a heavy seaway or when maneuvering.

4.6.12. Safety devices

4.6.12.1. Where separately driven direct current generators are connected electrically in series, means are to be provided to prevent reversal of the direction of rotation of any of them on the failure of the prime movers.

4.6.12.2. Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover, means are to be provided for suitably absorbing or limiting such energy.

4.6.12.3. Contactors and switches used for reversing the rotation of the propulsion motors are to be provided with means for forcibly opening them if they should in advertently remain closed.

4.6.13. Electro-magnetic couplings

Propulsion arrangements incorporating electro-magnetic couplings will receive special consideration.

4.6.14. Identification

All-important circuits, instruments and apparatus are to be clearly labeled for identification.

4.6.15. Cables

4.6.15.1. Conductors in circuits essential for maneuvering or maintenance of propelling power are to be stranded, having not less than seven strands, and are to have a nominal cross-sectional area of not less than 1.5 mm^2. Refer Ch 6, Sec 3, [3.7.] of this part.

4.6.15.2. Cables which are connected to the slip rings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during maneuvering.

4.6.15.3. Cable ends are to be fitted with connectors or connecting sockets of appropriate size and in such a manner as to inhibit corrosion. They are to be arranged and supported in a manner suitable for withstanding the electro-mechanical forces due to a short circuit.

4.6.15.4. Propulsion cables are not to have splices or joints, except terminal joints, and all cable terminals are to be sealed against the admission of moisture or air. Similar precautions are to be taken during installation by sealing all cable ends until the terminals are permanently attached. Cable supports are to be designed to withstand short-circuited conditions. They are to be spaced less than 900 mm (36 in.) apart and are to be arranged to prevent chafing of the cable. Refer Ch 6, Sec 4, [4.4.3.] of this part for cable hangers and cable straps.

4.6.16. Equipment Installation and Arrangements

4.6.16.1. General

The arrangement of bus bars and wiring on the back of propulsion-control assemblies is to be such that all parts, including the connections, are accessible. All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Clearance and creepage distances are to be provided between parts of opposite polarity and between live parts and earth to prevent arcing; Refer [4.4.6.] of this section for low voltage systems and Sec. 5, [5.1.4.1.] of this chapter for high voltage systems.

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/deck head above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200

4.6.16.2. Accessibility and Facilities for Repairs

a. Accessibility

For purposes of inspection and repair, provision is to be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils. Adequate access is to be provided to permit resurfacing of commutators and slip-rings, as well as the renewal and bedding of brushes.

b. Facility for supporting

Facilities are to be provided for supporting the shaft to permit inspection and withdrawal of bearings.

c. Slip-couplings

Slip-couplings are to be designed to permit removal as a unit without axial displacement of the driving and driven shaft, and without removing the poles.

4.6.16.3. Semiconductor Converters

Converters are to be installed away from sources of radiant energy in locations where the circulation of air is not restricted to and from the converter and where the temperature of the inlet air to air-cooled converters will not exceed that for which the converter is designed. Immersed type converters are to use a non-flammable liquid. Where forced cooling is utilized, the circuit is to be so designed that power cannot be applied to or retained on converters unless effective cooling is maintained. Converter stacks are to have at least IP22 protection and mounted in such a manner that they may be removed without dismantling the complete unit.

4.6.16.4. Propulsion Cables

For installation of propulsion cable Refer [4.6.15.] of this section.

4.6.17. Equipment Requirements

4.6.17.1. Material Tests

The following materials intended for main propulsion installations are to be tested in the presence of a Surveyor: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings. Major castings or built-up parts such as frames, spiders and end shields are to be surface inspected and the welding is to be in accordance with the requirements of Part 2.

4.6.17.2. Temperature Rating

When generators, motors or slip-couplings for electric propulsion are fitted with an integral fan and will be operated at speeds below the rated speed with full-load torque, full-load current or full-load excitation, temperature rise limits, according to Ch 4, Sec. 3, Table 4.3.1 of this part, are not to be exceeded.

4.6.17.3. Protection Against Moisture Condensation

Means for preventing moisture condensation, as specified in Ch 4, Sec. 1, [1.3.4.] of this part, is applicable for rotating machines and converters, regardless of the weight of the machines.

4.6.17.4. Prime Movers

a. Capability

The prime mover rated output is to have adequate overloading and build-up capacity for supplying the power which is necessary during transitional changes in operating conditions of the electrical equipment. When maneuvering from full propeller speed ahead to full propeller speed astern with the vessel making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to over speed.

b. Speed control

Prime movers of any type are to be provided with a governor capable of maintaining the pre-set steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

c. Manual controls

Where the speed control of the propeller requires speed variation of the prime mover, the governor is to be provided with means for local manual control as well as for remote control. For turbines driving AC propulsion generators, where required by the system of control, the governor is to be provided with means for local hand control, as well as remote adjustment from the control station.

d. Parallel operation

In case of parallel operation of generators, the governing system is to permit stable operation to be maintained over the entire operational speed range of the prime movers.

e. Protection for regenerated power

Braking resistors or ballast consumers are to be provided to absorb excess amounts of regenerated energy and to reduce the speed of rotation of the propulsion motor. These braking resistors or ballast consumers are to be located external to the mechanical and electric rotating machines.

Alternatively, the amount of regenerated power may be limited by the action of the control system.

4.6.17.5. Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

a. Ventilation and protection

Electric rotating machines for propulsion are to be enclosed ventilated or be provided with substantial wire or mesh screen to prevent personnel injury or entrance of foreign matter. Dampers are to be provided in ventilating air ducts, except when re-circulating systems are used.

b. Fire-extinguishing systems

Electric rotating machines for propulsion which are enclosed or in which the air gap is not directly exposed are to be fitted with fire-extinguishing systems suitable for fires in electrical equipment. This will not be required where it can be established that the machinery insulation is self-extinguishing.

c. Air coolers

Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in [4.6.4.1. a. iii.] of this section, are to have double wall tubes and be fitted with a leak detector feature to monitor for any water leakage. A visual and audible alarm is to be provided at a normally manned location to indicate detection of such water leakage.

d. Temperature sensors

Stator windings of AC machines and inter pole windings of DC machines, rated above 500 kW, are to be provided with temperature sensors. Refer Ch 8, Sec. 2, Table 8.2.6 & Table 8.2.7 of this part.

4.6.17.6. Propulsion Generators

Excitation current for propulsion generators may be derived from attached rotating exciters, static exciters, excitation motor-generator sets or special purpose generating units. Power for these exciters may be derived from the machine being excited or from any ship service, emergency or special purpose generating units.

4.6.17.7. Direct-current (DC) Propulsion Motors

a. Rotors

The rotors of DC propulsion motors are to be capable of withstanding over speeding up to the limit reached in accordance with the characteristics of the over speed protection device at its normal operational setting.

b. Over speed protection

An over speed protection device is to be provided to prevent excessive over speeding of the propulsion motors due to light loads, loss of propeller, etc.

4.6.17.8. Electric Couplings

a. General

Couplings are to be enclosed ventilated or be provided with wire or mesh screen to prevent personnel injury or the entrance of foreign material. All windings are to be specially treated to resist moisture, oil and salt air.

b. Accessibility for repairs

The coupling is to be designed to permit removal as a unit without moving the engine. Refer also [4.6.16.2. a.] of this section.

c. Temperature rating

The limits of temperature rise are to be the same as for alternating-current generators given in Ch 4, Sec 3, Table 4.3.1 of this part, except that when a squirrel-cage element is used, the temperature of this element may reach such values as are not injurious. Depending upon the cooling arrangements, the maximum temperature rise may occur at other than full-load rating so that heat runs will require special consideration; for this purpose, when an integral fan is fitted, the coupling temperatures are not to exceed the limits in Ch 4, Sec 3, Table 4.3.1 of this part when operated continuously at 70% of full-load rpm, full excitation and rated torque. Temperature rises for insulation materials above 180°C will be considered, provided they are in accordance with a recognized standard.

d. Excitation

Excitation is to be provided, as required, for propulsion generators. Refer [4.6.17.6] of this section.

e. Control equipment

Electric-coupling control equipment is to be combined with the prime mover speed and reversing control and is to include a two-pole disconnect switch, short circuit protection only, ammeter for reading coupling current, discharge resistor and interlocking to prevent energizing the coupling when the prime mover control levers are in an inappropriate position.

f. Nameplates

Nameplates of corrosion-resistant material are to be provided in an accessible position of the electric coupling and are to contain the following typical details:

- Manufacturer’s name, serial number and frame designation
- Rated output and type of rating
- Ambient temperature range

- Rated voltage, speed and temperature rise
- Rated exciter voltage and current

4.6.17.9. Semiconductor Converters for Propulsion

a. General

In general, semiconductor converters are to comply with the requirements of a relevant industry standard, such as the IEC 60146 Series. For temperature rise of semiconductor converter, Refer [4.1.2.6.] of this section.

b. Testing and inspection

For testing of Semiconductor converters Refer [4.1.2.10.] of this section.

c. cooling

For forced cooling & liquid cooling of Semiconductor converters Refer [4.1.2.4.(o).] of this section. In case of failure of the cooling system, an audible and visible alarm is to be initiated at the propulsion motor control position.

4.6.17.10. Reactors and Transformers for Semiconductor Converters

a. General

Inter-phase reactors and transformers used with semiconductor converters are to conform to the requirements of [4.1.] of this section and the following.

b. Voltage regulation

Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

c. High temperature alarm

Inter-phase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with a high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in [4.1.1.7. b.] of this section.

4.6.17.11. Switches

a. General design

All switches are to be arranged for manual operation and so designed that they will not open under ordinary shock or vibration; contactors, however, may be operated pneumatically, by solenoids, or other means in addition to the manual method which is to be provided unless otherwise approved.

b. Generator and motor switches

Switches for generators and motors are preferably to be of the air-break type, but for alternating-current systems, where they are to be designed to open full-load current at full voltage, oil-break switches using nonflammable liquid may be used if provided with leak-proof, non-spilling tanks.

c. Field switches

Where necessary, field switches are to be arranged for discharge resistors, unless discharge resistors are permanently connected across the field. For alternating current systems, means are to be provided for de-energizing the excitation circuits by the unbalance relay and earth relay.

4.6.17.12. Propulsion Cables

For propulsion cable Refer Ch 6, Sec 3, [3.7] of this part.

Cable Test after Installation
A voltage withstand test is to be carried out on each completed cable and its accessories before a new high voltage installation, including additions to an existing installation, is put into service.
An insulation resistance test is to be carried out prior to the voltage withstand test being conducted.

For cables with rated voltage (*Uo*/*U*) above 1.8/3 kV (*Um* = 3.6 kV) an AC voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test methods to be used:

4.6.18. Trials

Entire tests are to be carried out including duration runs and maneuvering tests which should consist of a reversal of the ship from full speed ahead to full speed astern, tests for operation of all protective devices and stability tests for control. All tests required to display that each item of plant and the system as a whole are satisfactory for duty are to be performed. Immediately prior to trials, the insulation resistance is to be measured and recorded.

Propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction. The equipment is to have sufficient power for going astern to secure proper control of the ship in all normal circumstances. In passenger ships the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal maneuvering conditions, and so bring the ship to rest from maximum ahead service speed, is to be demonstrated at the sea trial.

SECTION 5 SPECIAL SYSTEMS

Contents

5.1. High Voltage Systems

5.1.1. Application

The requirements in this subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV.

If otherwise not stated herein, construction and installation applicable to low voltage equipment generally apply to high voltage equipment as well.

5.1.2. System Design

5.1.2.1. Standard Voltages

The nominal standard voltage is not to exceed 15 kV. A higher voltage may be considered for special application.

5.1.2.2. Earthed Neutral Systems

a. Neutral earthing

In a neutral earthed system, in case of earth fault the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energized mode.

b. Equipment

Electrical equipment in directly earthed neutral or other neutral earthed systems is to be able to withstand the current due to a single phase fault against earth for a period necessary to trip the protection device.

c. Neutral disconnection

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.

d. Hull connection of earthing impedance

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 will not interfere with radio, radar, communication and control equipment circuits. In systems with neutral earthed, connection of the neutral to the hull is to be provided for each generator switchboard section.

5.1.2.3. Earth Fault Detection

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.

5.1.2.4. Number and Capacity of Transformers

The number and capacity of transformers is to be sufficient, under seagoing conditions, with any three-phase transformer or any one transformer of three single phase transformer bank out of service to carry those electrical loads for essential service and for minimum comfortable conditions of habitability. For this purpose, and for the purpose of immediate continuity of supply, the provision of a single-phase transformer carried onboard as a spare for a three phase transformer bank or V-V connection by two remaining single-phase transformers is not acceptable.

5.1.3. Circuit Protection

Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, and as a minimum, the requirements of IEC Publication 60092-201 are to be followed.

5.1.3.1. Protection of Generator

Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the switchboard and against inter-winding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator. In distribution systems with a low impedance earthed neutral, phase to earth faults are to be likewise treated.

5.1.3.2. Protection of Power Transformers

Power transformers are to be provided with overload and short-circuit protection. Each high voltage transformer intended to supply power to the low-voltage ship service switchboard is to be protected in accordance with sec. 4, [4.5.6.] of this chapter. In addition, the following means for protecting the transformers or the electric distribution system are to be provided:

a. Coordinated trips of protective devices

Discriminative tripping is to be provided for the following. Refer sec. 4, [4.5.15.] of this chapter.

i. Between the primary side protective device of the transformer and the feeder protective devices on the low-voltage ship service switchboard, or
ii. Between the secondary side protective device of the transformer, if fitted, and the feeder protective devices on the low-voltage ship service switchboard.

b. Load shedding arrangement

Where the power is supplied through a single set of three-phase transformer to a low-voltage ship service switchboard, automatic load shedding arrangements are to be provided when the total load connected to the low voltage ship service switchboard exceeds the rated capacity of the transformer. Refer Ch 1, Sec 3, [3.1.1.5.] of this part and Refer Sec 4, [4.5.14.] of this chapter.

c. Protection from electrical disturbance

Means or arrangements are to be provided for protecting the transformers from voltage transients generated within the system due to circuit conditions, such as high-frequency current interruption and current suppression (chopping) as the result of switching, vacuum cartridge circuit breaker operation, or thyrister-switching.

An analysis or data for the estimated voltage transients is to be submitted to show that the insulation of the transformer is capable of withstanding the estimated voltage transients. Refer [5.1.4.5. b.] of this section.

d. Detection of phase-to-phase internal faults

For three-phase transformers of 100 kVA or more, means for detecting a phase-to-phase internal fault are to be provided. The detection of the phase-to-phase internal fault is to activate an alarm at the manned control station or to automatically disconnect the transformer from the high-voltage power distribution network.

e. Protection from earth-faults

Where a Y-neutral of three-phase transformer windings is earthed, means for detecting an earth-fault are to be provided. The detection of the earth fault is to activate an alarm at the manned control station or to automatically disconnect the transformer from the high-voltage power distribution network.

f. Transformers arranged in parallel

When transformers are connected in parallel, tripping of the protective devices at the primary side is to automatically trip the switch or protective devices connected at the secondary side.

5.1.3.3. Voltage Transformers for Control and Instrumentation

Voltage transformers are to be provided with overload and short-circuit protection on the secondary side.

5.1.3.4. Fuses

Fuses are not to be used for overload protection.

5.1.3.5. Overvoltage Protection

Lower voltage systems supplied through transformers from high voltage systems are to be protected against over voltages. This may be achieved by:

a. Direct earthing of the lower voltage system,
b. Appropriate neutral voltage limiters, or
c. Earthed screen between primary and secondary winding of transformers

5.1.3.6. Coordination of Protective Devices

Regardless of the neutral arrangement, coordination of protective devices, in accordance with the intent of Refer Sec. 4, [4.5.15.] of this chapter, is to be provided.

5.1.4. Equipment Design

5.1.4.1. Air Clearance and Creepage Distance

a. Air clearance

Phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than the minimum, as specified in table 2.5.1 below:

Table 2.5.1: Minimum Air Clearance

Nominal Voltage (kV)	Minimum Air Clearance mm (in.)
3 - 3.3	55 (2.2)
6 - 6.6	90 (3.6)
10 - 11	120 (4.8)
15	160 (6.3)

Where intermediate values of nominal voltages are accepted, the next higher air clearance is to be observed. In the case of smaller distances, an appropriate voltage impulse test is to be applied.

b. *Creepage Distances* **-** 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

5.1.4.2. Circuit Breakers and Switches – Auxiliary Circuit Power Supply Systems

a. Source and capacity of power supply

Where electrical energy or mechanical energy is required for the operation of circuit breakers and switches, a means of storing such energy is to be provided with a capacity at least sufficient for two on/off operation cycles of all of the components. However, the tripping due to overload or short-circuit, and under voltage is to be independent of any stored electrical energy sources. This does not preclude the use of stored energy for shunt tripping, provided that alarms are activated upon loss of continuity in the release circuits and power supply failures. The stored energy may be supplied from within the circuit in which the circuit breakers or switches are located.

b. Number of external sources of stored energy

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

5.1.4.3. Rotating Machines

a. Protection

Rotating machines are to have a degree of protection, as per Sec. 4, Table 2.4.16 of this chapter, but not less than IP23; for terminal box, IP44; and for motors accessible to unqualified personnel, IP43.

b. Stator winding

Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

c. Temperature detectors

Rotating machinery is to be provided with temperature detectors in their stator windings to actuate audiovisual 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.

d. Space heater

Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

5.1.4.4. Switchgear and Control-gear Assemblies

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 60298 and the following additional requirements:

a. Protection

The degree of protection of switchgear, control gear assemblies and static converters is in accordance with Sec. 4, Table 2.4.16 of this chapter but not less than IP32. For those installed in a space accessible to unqualified personnel, the protection is to be increased to IP4X.

b. Mechanical construction

Switchgear is to be of metal-enclosed type in accordance with IEC Publication 60298 or of the insulation-enclosed type in accordance with IEC Publication 60466.

c. Configuration

The main bus bars are to be subdivided into at least two independent parts which are to be connected by at least one circuit breaker or other approved means, each part being supplied by at least one generator. The connection of generating sets and any other required duplicated equipment is to be equally divided, as far as possible, between the parts.

d. Locking facilities

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, switches and fixed disconnector are to be possible.

Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving parts.

e. Shutters

The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawn position, the live contacts of the bus bars are automatically covered. Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colors or labels

f. Earthing and short-circuiting facilities

For maintenance purposes, an adequate number of earthing and short-circuiting facilities are to be provided to enable equipment and cables to be earthed or short-circuited to earth before being worked upon.

g. Arc Flash and Associated Installation Requirements

i) Internal Arc Classification (IAC). Switchgear and control gear assemblies are to be Internal Arc Classified (IAC). Where switchgear and control gear are accessible by authorized personnel only accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2). Accessibility Type B is required if accessible by non-authorized personnel. Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).

ii) Calculations, in accordance with the applicable parts of Standard IEEE 1584 or other recognized standard, are to be made to establish:

• The maximum current that can flow in the case of an arc fault

• The maximum time and current that could flow if arc protection techniques are adopted

• The distance, from the location of the arc flash, at which the arc flash energy would be 1.2 calories per cm^2 if the enclosure is open

iii) In addition to the marking required by the equipment design standard, arc flash data consistent with the Design Operating Philosophy and the required PPE is also to be indicated at each location where work on the HV equipment could be conducted.

5.1.4.5. Transformers

a. Application

The provisions of [5.1.4.] of this section are applicable to power transformers for essential services. Refer also sec. 4, [4.1.1.7.] of this chapter. Items [5.1.4.5. c.] of this section and [5.1.4.5. d.] of this section are applicable to transformers of the dry type only. These requirements are not applicable to transformers intended for the following services:

i. Instrument transformers
ii. Transformers for static converters
iii. Starting transformers

Dry type transformers are to comply with the applicable - Publication 60076-11. Liquid filled transformers are to comply with the applicable Parts of the IEC 60076 Series. Oil immersed transformers are to be provided with the following alarms and protections:

i. Liquid level (Low) – alarm
ii. Liquid temperature (High) – alarm
iii. Liquid level (Low) – trip or load reduction
iv. Liquid temperature (High) – trip or load reduction
v. Gas pressure relay (High) – trip

b. Plans

In addition to the details required in sec. 4, [4.1.] of this chapter, the applicable standard of construction and the rated withstanding voltage of the insulation are also to be submitted for review.

c. Enclosure

Transformers are to have a degree of protection, in accordance with Sec. 4, Table 2.4.16 of this chapter, but not less than IP23. However, when installed in spaces accessible to unqualified personnel, the degree of protection is to be increased to IP44. For transformers not contained in enclosures, Refer [5.1.6.] of this section.

For Transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required.

d. Space heater

Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

e. Testing

Three-phase transformers or three-phase bank transformers of 100 kVA and above are to be tested in the presence of the Surveyor. The test items are to be in accordance with the standard applicable to the transformer. In addition, the tests required in sec. 4, [4.1.1.9.] of this chapter are also to be carried out in the presence of the Surveyor for each individual transformer. Transformers of less than 100 kVA will be accepted, subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

Specific requirements are applicable for the following tests:

i. In the dielectric strength test, the short duration power frequency withstand voltage to be applied is to follow the standard applicable to the transformer, but not less than the estimated voltage transient generated within the system. If the short duration power frequency withstand voltage is not specified in the applicable standard, IEC 60076-3 is to be referred to. For the voltage transient, Refer [5.1.3.2. c.] of this section.
ii. The induced overvoltage withstand test (layer test) is also to be carried out in accordance with the standard applicable to the transformers in the presence of the Surveyor. This test is intended to verify the power-frequency

withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings).

If the induced overvoltage withstand test is not specified in the applicable standard, IEC 60076-3 is to be referred to.

f. Nameplate

In addition to the requirements in sec. 4, [4.1.1.4.] of this chapter, the following information is also to be indicated on the nameplate:

i. Applicable standard
ii. Short duration power frequency withstand voltage for verification of insulation level of each winding

5.1.4.6. Cables

Cables are to be constructed to IEC Publication 60092-353, 60092-354, or other equivalent standard. Refer also Ch 6 of this part.

5.1.5. Cable Installation

5.1.5.1. Runs of Cables

In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

5.1.5.2. Segregation

High voltage cables of different voltage ratings are not to be installed in the same cable bunch, duct, pipe or box.

Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in [5.1.4.1. a.] of this section. However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV or less.

5.1.5.3. Installation Arrangements

High voltage cables are to be installed on cable trays or equivalent when they are provided with a continuous metallic sheath or armor which is effectively bonded to earth; otherwise, they are to be installed for their entire length in metallic casings effectively bonded to earth.

5.1.5.4. Termination and Splices

Terminations in all conductors of high voltage cables are to be, as far as practicable, 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, i.e., having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e., tapes, wires etc.). Splices and joints are not permitted in propulsion cables. For purposes of this Rule, propulsion cables are those cables whose service is related only to propulsion

5.1.5.5. Marking

High voltage cables are to be readily identifiable by suitable marking.

5.1.6. Equipment Installation

5.1.6.1. Voltage Segregation

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

5.1.6.2. Large Equipment Enclosure

Where high voltage 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 of such spaces, a suitable marking is to be placed which indicates danger of high voltage and the maximum voltage inside the space. For high voltage equipment installed outside these spaces, a 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/deck head above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200.

5.1.7. Tests

5.1.7.1. Rotating Machine Tests

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

5.1.7.2. Switchgear Tests

A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies. The test procedure and voltages are to be in accordance with IEC Publication 60298.

5.1.7.3. Cable Test after Installation

a. 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.
b. The test is to be carried out after an insulation resistance test.
c. When a DC voltage withstand test is carried out, the voltage is to be not less than:

i. 1.6 ($2.5U_o$ +2 kV) for cables of rated voltage (U_o) up to and including 3.6 kV, or
ii. $4.2U_o$ for higher rated voltages,

Where, U_o is the rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed.

d. The test voltage is to be maintained for a minimum of 15 minutes.
e. After completion of the test, the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.
f. An insulation resistance test is then repeated.
g. An AC voltage withstand test is also acceptable which is carried out upon advice from the high voltage cable manufacturer at a voltage not less than the normal operating voltage of the cable and it is to be maintained for a minimum of 24 hours.
h. Tests in accordance with IEC Publication 60502 will also be considered adequate.

5.2. Three-wire Dual-voltage DC Systems

5.2.1. Three-wire DC Generators

Separate circuit-breaker poles are to be provided for the positive, negative, neutral and also for the equalizer leads, unless protection is provided by the main poles. When equalizer poles are provided for the three-wire generators, the overload trips are to be of the algebraic type. No overload trip is to be provided for the neutral pole, but it is to operate simultaneously with the main poles. A neutral over-current relay and alarm system is to be provided and set to function at a current value equal to the neutral rating.

5.2.2. Neutral Earthing

5.2.2.1. Main Switchboard

The neutral of three-wire dual-voltage direct-current systems is to be solidly earthed at the generator switchboard with a zero-center ammeter in the earthing connection. The zero-center ammeter is to have a full-scale reading of 150% of the neutral-current rating of the largest generator and be marked to indicate the polarity of earth. The earth connection is to be made in such a manner that it will not prevent checking the insulation resistance of the generator to earth before the generator is connected to the bus. The neutrals of three-wire DC emergency power systems are to be earthed at all times when they are supplied from the emergency generator or storage battery. The earthed neutral conductor of a three-wire feeder is to be provided with a means for disconnecting and is to be arranged so that the earthed conductor cannot be opened without simultaneously opening the unearthed conductors.

5.2.2.2. Emergency Switchboard

No direct earth connection is to be provided at the emergency switchboard; the neutral bus or buses are to be solidly and permanently connected to the neutral bus of the main switchboard. No interrupting device is to be provided in the neutral conductor of the bus-tie feeder connecting the two switchboards.

5.2.2.3. Size of Neutral Conductor

The capacity of the neutral conductor of a dual-voltage feeder is to be 100% of the capacity of the unearthed conductors.

5.2.3. Electrical equipment

For electrical equipment of DC systems, unless specifically stated in this part, Refer IEC Publications 60092-201, 60092-202 and 60092-301.

CHAPTER 3 MISCELLANEOUS EQUIPMENT

CONTENTS

SECTION 1 LIGHTING EQUIPMENT

Contents

1.1. Applicable requirements

Lighting fittings are to comply with IEC Publications 60598 and 60092-306. Lighting fittings complying with other standards will be specially considered by INTLREG.

1.2. General

Lighting which is essential for safety and working is to comply with the following provisions:

1.2.1. Lighting fittings installed in engine rooms or any such spaces where they are susceptible to mechanical damage are to be provided with suitable grilled mechanical guards to protect the lamps and glass globes against this kind of damage.

Lighting fittings are to be so arranged as to prevent temperature rises which overheat or damage surrounding materials. They must not impair the integrity of fire divisions.

1.2.2. For power supply to lighting installation Refer Ch 2, Sec 4, [4.2.15.] of this part.

For lighting circuits Refer Ch 2, Sec 4, [4.2.22.7.] of this part.

1.2.3. Lamp holders are to be made of flame retarding non-hygroscopic materials.

1.2.4. Suitable precautions are to be taken in order to ensure that a lamp for one voltage cannot be inserted in a lamp-holder meant for another voltage.

1.3. Construction

1.3.1. The temperature of terminals for connection of supplying cables should not go beyond the maximum conductor temperature permitted for the cable (Refer Ch 6, Sec 3, Table 6.3.1 of this part). Where needed, luminaries are to be fitted with terminal boxes which are thermally insulated from the light source.

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

1.3.3. The temperature rise of parts of luminaries which are in contact with the support should not exceed 50°C. For parts in contact with flammable materials, the rise should not exceed 40°C.

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

1.3.5. High-power lights with higher surface temperatures than those in [1.3.2.] and [1.3.3.] of this section are to be adequately protected against accidental exposure.

1.4. Incandescent lighting

1.4.1. Tungsten filament lamps and lamp holders are to be in accordance with Table 3.1.1 of this section.

Table 3.1.1: Lamps and lamp holders			
Designation	**Maximum lamp rating**		**Maximum lamp-holder current,**
	Voltage, (V)	**Power, (W)**	**(A)**
Screw cap lamps			
E40 (Refer Note 1)	250	3000	16
E27	250	200	4
E14	250	15	2
E10	24	-	2
Bayonet cap lamps			
B22	250	200	4
B15d	250	15	2
B15s	55	15	2
Tubular fluorescent lamps			
G13	250	80	-
G5	250	13	-
Note 1: Lamp holders of type E40 are to be provided with a means of locking the lamp in the lamp holder.			

1.4.2. All metal parts of lamp-holders should have sturdy structure. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable (Refer Ch 6, Sec 3, Table 6.3.1. of this part).

1.5. Fluorescent lighting

1.5.1. The ratings of tubular fluorescent lamps are not to exceed 250 V and 80 W.

1.5.2. Fluorescent lamps and lamp holders are to be in accordance with Table 3.1.1 of this section.

1.5.3. Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are exposed to high temperatures. If mounted separately, then they are to be enclosed in an additional earthed conductive casing.

1.5.4. Where capacitors of 0.5 microfarads and above are installed, adequate means are to be provided to ensure prompt discharge of the capacitors on disconnection of the supply.

1.6. Discharge lighting

1.6.1. When cold cathode luminous discharge lamps of normal operating voltage above 250 V are used, a warning notice calling attention to the voltage is to be displayed at the points of access to the lamps and where otherwise necessary.

1.6.2. Inductance and high reactance transformers are to be installed in positions which are as close as practicable to the associated discharge lamp.

1.6.3. Every capacitor of 0.5mF or more is to be provided with means for reducing the voltage of capacitor to less than 55V within one minute after disconnections from supply source.

1.6.4. All live parts of discharge lamp luminaries are to be so designed, installed and placed that they cannot be touched accidentally or inadvertently. The creepage distance along the surface of the glass tube is to be taken into considerations.

1.6.5. All parts of searchlights or arc lamps to be handled for their operations or adjustment while in use are to be so arranged that there is no risk of shock to the operator. Disconnection of every searchlight or arc lamp is to be by multi-pole disconnecting switches.

If a series resistor is used with an arc lamp, then the disconnecting switch is to be so placed in the supply circuit that both the series resistor and arc lamp are disconnected when the switch is in the "off" position.

1.7. Lighting distribution boards

1.7.1. To prevent the possibility of simultaneous loss of main and emergency lighting distribution boards due to localized fire or other casualty, the distribution boards are to be installed as widely apart as practicable in the machinery spaces.

1.7.2 For spaces other than the machinery space, these lighting distribution boards are to be installed at locations which are separated by a boundary wall. The boundary wall separation is to be a non-combustible partition complying with as a minimum a C-class panel division.
For the navigation bridge, the main and emergency lighting distribution boards are not to be installed in the same compartment of the navigation console or panel

1.7.3 Cables emanating from the main or emergency lighting switchboard to the main or emergency lighting distribution board, respectively, are also to be installed as widely apart as practicable.

SECTION 2 ACCESSORIES

Contents

2.1. Construction

2.1.1. Enclosures for containing and mounting of electrical accessories are to be of metal, effectively protected against corrosion, or of flame retardant insulating materials.

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

2.2. Inspection and draw boxes

If metal conduit systems are used, then inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

2.3. Plugs and socket connections

2.3.1. Applicable requirements

Plug-and-socket connections are to comply with IEC Publication 60092-306 and with the following additional standards in relation to their use:

a. In accommodation spaces, day rooms and service rooms (up to 16A, 250 V AC): IEC Publication 60083 or 60320, as applicable.
b. For power circuits (up to 250A, 690 V AC): IEC Publication 60309.
c. For electronic switchgear: IEC Publications, e.g. 60130 and 60603.
d. For refrigerated containers: ISO 1496-2.

2.3.2. General

2.3.2.1. The temperature rise on the live parts of socket outlet and plugs should not be exceeding 30°C.

2.3.2.2. Socket outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

2.3.2.3. Socket outlets and plugs with a rated current not exceeding 63 A in AC installations and 16 A in DC installations, shall be constructed for making and breaking the rated current by insertion and withdrawal of the plug, unless they are provided with an interlock as described in [2.3.2.4.] of this section.

2.3.2.4. Socket outlets with a rated current above 63 A AC or 16 A DC shall be provided with interlocks in order to ensure that the plug can only be inserted and withdrawn when the switch is in the “off” position.

2.3.2.5. Socket outlets for portable appliances, which are not hand-held during operation (e.g. welding transformers, refrigerated containers), shall be interlocked with a switch regardless of rating, maximum 1000 V can be accepted. A warning sign shall be fitted at each such socket outlet.

2.3.2.6. Higher voltage socket outlets can only be used for special applications.

2.3.2.7. On weather decks, galleys, laundries, machinery spaces and all wet situations socket outlets and plugs are to be effectively shielded against rain and spray and are to be provided with means for maintaining this quality after removal of the plug.

2.3.2.8. All socket outlets shall be provided with an earthing contact, except that this may be omitted in the following cases:

a. Socket outlets on systems with voltage below 50 V AC or DC.
b. Socket outlets with double insulated transformers for handheld equipment.
c. For distribution systems with insulated neutral; socket outlets in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material. The resistance of the insulating material shall be at least 50 kΩ. Earth potential shall not be brought into the space, for instance through earth conductors, piping, etc.

2.3.2.9. Where distribution systems with different voltages are in use, the socket outlets and plugs are to be of such design that a plug for one voltage cannot be inserted into the socket outlet for a different voltage.

2.3.2.10. Attachment plugs for non-permanently fitted equipment operating at more than 50 V are to have an earthing pole and an earthing conductor in the portable cord to earth the dead metal parts of the equipment.

SECTION 3 HEATING & COOKING EQUIPMENT

Contents

3.1. Applicable requirements

Heating and cooking appliances are to comply with the relevant IEC Publications (e.g. those of series 60335), with particular attention to IEC 60092-307.

3.2. General

3.2.1. Parts of heaters or cooking appliances which must necessarily be handled should not become heated to a temperature exceeding 55°C for metallic parts and 65°C for nonmetallic parts; for other parts the temperatures obtained in service are to be such that the various materials are not subjected in the course of normal working to any excessive thermal stress.

3.2.2. 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.

3.3. Heating equipment

3.3.1. General

3.3.1.1. Heating elements are to be enclosed and protected with metal or refractory material. Heaters are to be so constructed, installed and protected in such a manner that clothing, bedding and other inflammable material cannot come in contact with them and cause fire. There is to be no excessive heating of adjacent bulkheads or decks.

3.3.1.2. For power supply to heaters Refer Ch 2, Sec. 4, [4.2.14.] of this part.

3.3.1.3. Each separate element rated more than 15 A is considered as a separate consumer, for which a separate circuit from a switchboard or distribution board is required.

3.3.1.4. The construction of heaters is to give a degree of protection according to IEC 60529.

3.3.2. Temperature rises for heaters

The temperature rises in Table 3.3.1 of this section are accepted.

Table 3.3.1: Temperature rises for heaters

Part	Temperature °C
Enclosure parts against the bulkhead	60
Other accessible parts	130 (Refer Note 1)
Surface of heating elements inside enclosures with through air convection	280

Note 1: Heating elements having a temperature rise exceeding 130°C are generally to be considered as “live parts” and shall be provided with suitable enclosures.

3.3.3. Space heaters

3.3.3.1. Space heaters are generally to be of the convection type, and suitable for installation on bulkheads. Radiation heaters and other space heater types may be accepted after consideration in each case.

3.3.3.2. Space heaters are generally to be constructed with the top plate inclined about 30°, tight against the bulkhead in order to prevent clothing or other flammable material from covering the heaters.

3.3.3.3. Space heaters are normally to be installed on a free bulkhead space, with about 1 m free air above, and ensure that doors cannot touch the heaters. If not constructed as specified in [3.3.3.2.] of this section, an inclined perforated plate of incombustible material shall be mounted above each heater. Space heaters shall not be built into casings of woodwork or any other combustible material.

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

3.3.3.5. 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.

3.3.4. Heating batteries for ventilation systems

Heating batteries in centralized ventilation systems shall be equipped with the following safety / control functions:

a. Heating elements shall be interlocked with respect to the air flow either directly controlled by the power to the fan or by measuring the airflow locally at the heating element.
b. Heating elements shall be equipped with over temperature switch that can be reset manually only.
c. Heating elements shall be equipped with thermostat control gear.

3.3.5. Space heaters combined with air-condition cabinets

The following additional requirements apply for space heaters integrated in air-conditioning cabinets:

a. The maximum temperature rises specified in [3.3.2.] of this section shall be complied with, even when the air supply is completely shut off.

b. Each cabinet shall be provided with an interlocked over temperature thermostat with manual reset, accessible only by use of tool.

c. Combined cabinets for ceiling installation are accepted, the ceiling shall be constructed of incombustible materials.

3.3.6. Water heaters

3.3.6.1. Water heaters are normally to have insulated heating elements and shall be installed as separate units.

3.3.6.2. The requirements for temperature rise specified in Table 3.3.2 of this section apply.

3.3.6.3. Each water heater shall be provided with a thermostat, sensing the water temperature and maintaining this at the correct level.

3.3.7. Oil heaters

3.3.7.1. Electric oil heaters are normally to be installed as separate units. Heating by electric heating elements in the ship's oil tanks is generally not allowed, but may be accepted after special design assessment of the arrangement in each case.

3.3.7.2. The requirements for temperature rise specified in Table 3.3.2 of this section apply. In addition, the maximum surface temperature of the heating elements shall be lower than the boiling point of the oil, under normal working conditions.

3.3.7.3. Each oil heater shall be provided with a working thermostat, sensing the oil temperature and maintaining this at correct level under normal working conditions. In addition, 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.

3.3.8. Electric radiators

Electric radiators, if used, are to be fixed in position and be so constructed as to reduce fire risks to a minimum. Electric radiators of the exposed-element type are not to be used.

3.4. Cooking and another galley equipment

3.4.1 General

3.4.1.1. 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.

3.4.1.2. Cooking equipment is generally to have insulated heating elements. Special equipment, such as for example high frequency ovens or electrode pots, shall be suitable for marine use, and installed in accordance with the manufacturer's instructions.

3.4.1.3. Electrode pots giving earth-connection of the system shall be fed from separate isolating transformers.

3.4.1.4. For oil pots, the requirements for oil heaters in [3.3.7.] of this section apply.

3.4.1.5. The temperature rises in Table 3.3.2 of this section are accepted.

Table 3.3.2: Temperature rises for cooking and other galley equipment

Part	Temperature °C
Enclosure parts against the bulkhead and decks	50
Other accessible surface parts, except hot plates with adjacent top plates	50
Hot plates with adjacent top plates, and heating elements	No limit (Refer Note 1)
Note 1: Construction and temperatures shall be such that damage and hazards are avoided, when the equipment is used as intended.	

SECTION 4 BATTERIES AND CHARGERS

Contents

4.1. Scope

The requirements mentioned in subsequent paragraphs of this section is for Equipment for maintaining essential, emergency and transitional sources of power including the battery charger unit, uninterruptible power system (UPS) unit, and the distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS). Notwithstanding above, the same will also comply with the applicable requirements mentioned in Ch 2, Sec. 4, [4.2.10.], [4.4.6.], [4.5.16.] & [4.5.17.] of this part. The requirements to UPS units, as defined in IEC 62040, apply when providing an alternative power supply or transitional power supply to services. A UPS unit complying with these requirements may provide an alternative power supply as an accumulator battery in terms of being an independent power supply for services.

4.2. Definitions

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.

a. Uninterruptible Power System (UPS):

Combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure (IEC 62040:1999).

b. Off-line UPS unit:

A UPS unit where under normal operation the output load is powered from the bypass line (mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 milli-seconds) break in the load supply.

c. Line interactive UPS unit:

An off-line UPS unit where the bypass line switches to stored energy power when the input power goes outside the preset voltage and frequency limits.

d. On-line UPS unit:

UPS unit where under normal operation the output load is powered from the inverter and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

e. DC UPS unit

A UPS unit where the output is in DC (direct current).

4.3. Battery charging rate

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80 percent capacity in not more than 10 hours without exceeding the maximum permissible charging current. A charging rate other than the above (e.g. fully charged within 6 hours for batteries for starting of motors) may be required in relation to the use of the battery.

4.4. Reversal of charging current

An acceptable means, such as reverse current protection, for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery, is to be fitted.

4.5. Design and Construction of UPS

4.5.1. UPS units are to be constructed in accordance with IEC 62040 or an acceptable and relevant national or international standard.

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

4.5.3. 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.

4.5.4. An external bypass is to be provided.

4.5.5. The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for :

a. Power supply failure (voltage and frequency) to the connected load,
b. Earth fault,
c. Operation of battery protective device,
d. When the battery is being discharged, and
e. When the bypass is in operation for on-line UPS units.

4.5.6. UPS units utilizing valve-regulated sealed batteries may be located in compartments with standard marine or industrial electrical equipment provided that the arrangements comply with. Refer [4.10.2.] of this section. Output power is to be maintained for the duration required for the connected equipment.

4.5.7. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified. Where it is proposed that additional circuits are connected to the UPS unit, details verifying that the UPS unit has adequate capacity is to be submitted for consideration.

4.6. Vented batteries

4.6.1. Vented batteries are those in which the electrolyte can be replaced and freely releases gas during periods of charge and overcharge.

4.6.2. 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.

4.6.3. 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.

4.6.4. It is to be possible to check the electrolyte level and the pH value.

4.7. Valve-regulated sealed batteries

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

4.7.2. The cells of batteries which are marketed as "sealed" or "maintenance free" are fitted with a pressure relief valve as a safety precaution to enable uncombined gas to be vented to the atmosphere; they should be referred to as valve-regulated sealed batteries.

4.7.3. Cell design is to minimize risks of release of gas under normal and abnormal conditions.

4.8. Constructional requirements & characteristics for battery chargers

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

4.8.2. In the absence of indications regarding its operation, the battery charging rate shall be as in [4.3.] of this section above.

4.8.3. 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.

4.8.4. 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.

4.8.5. 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.

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

4.8.7. 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.

4.9. Tests on chargers

Battery chargers are to be subjected to tests in accordance with following table.

Table 3.4.1: Tests to be carried out on battery chargers

NO	Tests	Type test (1)	Routine test (2)
1	Examination of the technical documentation, as appropriate, and visual inspection (3) 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

(1) Type test on prototype battery charger or test on at least the first batch of battery chargers.

(2) The certificates of battery chargers routine tested are to contain the manufacturer's serial number of the battery charger which has been type tested and the test result.

(3) A visual examination is to be made of the battery charger to ensure, as far as practicable, that it complies with technical documentation.

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. The electronic components of the battery chargers are to be constructed to withstand the tests required in Ch 8, Sec 7 of this part. The tests of battery chargers of 5 kW and over intended for essential services are to be attended by a Surveyor of INTLREG.

4.10. Location

4.10.1. Location

The UPS unit is to be suitably located for use in an emergency. The UPS unit is to be located as near as practical to the equipment being supplied, provided the arrangements comply with all other Rules.

4.10.2. Ventilation

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. Since valve regulated sealed batteries are considered low-hydrogen-emission batteries, to establish the gas emission performance of the valve regulated batteries compared to the standard lead acid batteries. Arrangements are to be provided to allow any possible gas emission to be led to the weather, unless the gas emission performance of the valve regulated batteries does not exceed that of standard lead acid batteries connected to a charging device of 0.2 kW.

4.10.3. Battery installation

For battery installation arrangements, Refer [4.11.], [4.13.], [4.14.], [4.15.], [4.16.] of this section.

4.11. Accumulator batteries

4.11.1. Application

These requirements are applicable to batteries which emit hydrogen while in use. Installation design of other battery types is to be submitted for consideration in each case along with operational hazards of the batteries.

4.11.2. Battery cells

Battery cells are to be so constructed as to prevent spillage of electrolyte due to motions of the vessel at sea. Batteries are to be secured to their trays or shelves to prevent their movement.

4.11.3. Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the trays or shelves and are to indicate at least the following information:

a. The manufacturer’s name;

b. The type designation;

c. The rated voltage;

d. The ampere-hour rating at a specific rate of discharge.

e. The specific gravity of the electrolyte (in the case of a lead-acid battery, the specific gravity when the battery is fully charged).

4.11.4. Referenced requirements

The following requirements are also applicable to battery installations:

a. Accumulator batteries as emergency source of electrical power (Refer Ch 2, Sec 3, [3.3.2.b.] of this part).

b. Accumulator batteries as transitional source of electrical power (Refer Ch 2, Sec 3, [3.3.3.] of this part).

c. Protection of accumulator batteries (Refer Ch 2, Sec 4, [4.5.9.] of this part).

d. Battery starting systems (Refer [4.12.] of this section).

4.12. Battery starting systems

4.12.1. Propulsion engine

Where the propulsion engine is arranged for electric starting, at least two separate batteries (or separate set of batteries) are to be fitted. The arrangement is to be such that the batteries (or set of batteries) cannot be connected simultaneously in parallel and each battery (or set) is to be capable of starting the propulsion engine. The combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes if arranged, also to supply starting for the auxiliary engine, the number of starts require in [4.12.2.] of this section.

4.12.2. Auxiliary engines

Electric starting arrangements for auxiliary engines are to have at least two separate batteries (or separate set of batteries) or may be supplied by separate circuits from the propulsion engine batteries, when such are provided. Where one auxiliary engine is arranged for electric starting, one battery (or set) may be accepted in lieu of two separate batteries (or sets). The capacity of the batteries for starting the auxiliary engines is to be sufficient for at least three starts for each engine.

4.12.3. Miscellaneous requirements

The starting batteries (or set of batteries) are to be used for starting and for the engine's own control and monitoring purpose only. When the starting batteries are used for the engine's own control and monitoring purpose, the aggregate capacity of the batteries is to be sufficient for continued operation of such a system in addition to the required number of starting capacity. Provisions are to be made to continuously maintain the stored energy at all times. Battery systems for engine starting may be of the one-wire type and the earth lead is to be carried to the engine frame.

4.13. Maintenance of batteries

4.13.1. Maintenance schedule of batteries

Where batteries are fitted for use for essential and emergency services, a maintenance schedule of such batteries is to be provided and maintained. The schedule is to include at least the following information regarding the batteries, which is to be submitted for review.

a. Type and manufacturer's type designation;

b. Voltage and ampere-hour rating;

c. Location;

d. Equipment and/or system(s) served;

e. Maintenance/replacement cycle dates;

f. Date(s) of last maintenance and/or replacement;

g. For replacement batteries in storage, the date of manufacture and shelf life (Refer Note below).

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

4.13.2. Procedure of maintenance

Procedures are to be put in place to show that, where batteries are replaced, they are to be of an equivalent performance type. Details of the schedule, procedures, and the maintenance records are to be included in the ship's safety management system and integrated into the ship's operational maintenance routine, as appropriate, which are to be verified by the Surveyor.

4.14. Replacement of batteries

Where a vented type battery (Refer [4.6.] of this section) replaces a valve-regulated sealed type battery (Refer [4.7.] of this section), the requirements in Lead-acid or Alkaline Battery Storage Locations are to be complied with on the basis of the charging capacity.

4.15. Lead-acid or alkaline battery storage locations

4.15.1. Battery Room

4.15.1.1. General

Where a group of accumulator batteries is connected to charging devices with total output of more than 2 kW, it is to be installed in a battery room dedicated to batteries only. No other electrical equipment is to be installed in the battery room except that necessary for operational purposes. Each of such equipment is to be of a certified safe type for battery room atmosphere.

4.15.1.2. Ventilation of battery room

Battery room is to be ventilated to avoid accumulation of flammable gas. Natural ventilation may be employed if ducts can be led directly from the top of the battery room to the open air above, with an opening for air inlet near the floor. If natural ventilation is impractical, mechanical exhaust ventilation is to be provided with fan intake at the top of the room. Fan motor is to be of certified safe type, and fan is to be of non-sparking construction (Refer sec 6, [6.17.] of this chapter).The fan is to be capable of completely changing the air in the battery room in not more than two minutes. An alternative fan capacity may be provided if it is able to maintain the flammable gases within the battery room to a level below the lower explosive limit (L.E.L.) at the maximum battery charging current. Where the ventilation capacity is based on low-hydrogen emission type batteries, a warning notice to this effect is to be displayed in a visible place in the battery room

4.15.1.3. Corrosion protection in battery room

Interior of the battery room including structural members, shelves, ventilation inlets and outlets are to be coated with paint resistant to the electrolyte used in the batteries. Shelves for lead acid batteries are to have watertight lining of sheet lead not less than 1.6 mm (1/8 in.) thick, and carried up not less than 75 mm (3 in.) on all sides; and that for alkaline batteries of sheet steel not less than 0.8 mm (1/16 in.) thick. Alternatively, the entire battery room may be fitted with a watertight lead pan (or steel for alkaline batteries), over the entire deck, carried up not less than 150 mm (6 in.) on all sides.

4.15.1.4. Battery trays

For purposes of heat dissipation during equalizing charge, appropriate air spaces are to be provided around each battery. Where placed in trays, batteries are to be chocked with wood strips or equivalent to prevent movement and each battery is to be supported in the tray with nonabsorbent insulator on the bottom and at the sides or with equivalent provision to secure air-circulation space all around each tray.

4.15.2. Deck boxes

4.15.2.1. General

Where a group of accumulator batteries is connected to a charging device with a total output of 0.2 kW up to and including 2 kW, they may be installed in the battery room or, alternatively, in deck boxes. Deck boxes may be located in machinery spaces, or other well ventilated locations.

4.15.2.2. Ventilation of deck boxes

Deck boxes are to be provided with a duct from the top of the box, terminating with a means to prevent entrance of water such as goose-neck or mushroom head. At least two air inlets are to be provided at the lower part and opposite sides of the deck box. Louvers or equivalent are to be fitted at the air inlets at the lower part of the box. Where located in the weather, deck boxes, including openings for ventilation, are to be weather tight.

4.15.2.3. Corrosion protection in deck boxes

Deck boxes are to be fitted with watertight trays with coaming heights not less than 150 mm (6 in.).

4.15.3. Small battery boxes

Batteries not covered, are to be installed in battery boxes and may be located as desired, except they are not to be located in sleeping quarters unless hermetically sealed. Small battery boxes require no ventilation other than openings near the top to allow escape of gas. For corrosion protection, the boxes are to be lined to a depth of 75 mm (3 in.).

4.15.4. Batteries for engine starting

Engine starting batteries are to be installed in the same space where the engine is installed, and are to be located close to the engine.

4.15.5. Batteries of different electrolyte

Where batteries of different types, for which different electrolyte are used, are installed in the same room, they are to be segregated and effectively identified.

4.16. Low-hydrogen-emission battery storage locations

A battery is considered low-hydrogen-emission (LHE) if it does not emit more hydrogen under similar charging condition than a standard lead-acid battery. LHE batteries connected to charging devices with total output of more than 2 kW may be installed as in Deck Boxes, provided calculations are submitted demonstrating that under a similar charging condition, hydrogen emission does not exceed that of standard lead-acid batteries connected to a 2 kW charging device. Similarly, LHE batteries connected to charging device with total output of 2 kW or less may be installed as in Small Battery Boxes, provided calculations are submitted demonstrating that under a similar charging condition, hydrogen emission does not exceed that of standard lead-acid batteries connected to charging device of 0.2 kW. For such installations, a warning-notice is to be displayed to notify maintenance personnel that additional batteries are not to be installed and any replacement battery is to be of the LHE type.

4.17. Performance

4.17.1. The output power is to be maintained for the duration required for the connected equipment as stated in Ch 2, Sec 3, [3.3.], [3.4.] of this part.

4.17.2. No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

4.17.3. 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.

4.17.4. An external bypass, that is hardwired and manually operated, is to be provided for UPS to allow isolation of UPS for safety during maintenance and maintain continuity of load power.

4.17.5. UPS units required to provide emergency services are to be suitably located for use in an emergency.

4.18. Testing and survey

4.18.1. UPS units of 50 kVA and over are to be surveyed during manufacturing and testing.

4.18.2. Appropriate testing is to be carried out to demonstrate that the battery charger units and uninterruptible power system (UPS) units are suitable for the intended environment. This is expected to include as a minimum the following tests:

a. Functionality, including operation of alarms;
b. Temperature rise;
c. Ventilation rate;
d. Battery capacity.

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

4.18.4. Tests at the manufacturer's works are to include such tests necessary to demonstrate the suitability of a UPS unit for its intended duty and location.

4.18.5. This is expected to include as a minimum the following tests:

a. A temperature rise test and battery capacity test on one of each size and type of UPS;
b. The high voltage test;
c. A ventilation rate test; and
d. Functional testing, including operation of alarms.

Details of tests are to be submitted for consideration when required. Refer note.

Note: The following equipment, where intended for use for essential and emergency services, is to be surveyed by the Surveyors during manufacture and testing:

a. Converting equipment of 100 kW and over;
b. Rotating machines of 100 kW and over;
c. Switchboards and section boards; and
d. UPS units of 50 kVA and over.

SECTION 5 LIGHTNING CONDUCTORS

Contents

5.1. General

In order to minimize the risks of damage to the ship and its electrical installation due to lightning, ships having non-metallic masts or topmasts are to be fitted with lightning conductors in accordance with the applicable requirements of IEC 60092-401 Electrical installations in ships. Part 401: Installation and test of completed installation or an alternative and relevant National Standard.

Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having masts or topmasts of wood or other non-conductive material. They need not be fitted to steel ships having steel masts, unless the mast is partly or completely insulated from the ship's hull.

5.2. Construction

5.2.1. In wooden and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a Section not under 100 [mm^2]. These are to be riveted with copper rivets or fastened with copper clamps to an appropriate copper spike not less than 13 [mm] in diameter and projecting at least 150 [mm] above the top of the mast. If tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 13 [mm] diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate having an area of at least 0.2 [mm^2]. This copper plate is to be fixed to the ship's hull well below the light load waterline in such a manner that it is to be immersed under all conditions of heel.

5.2.2. In wooden and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with [5.2.1.] of this section. The copper rope is to be securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

5.2.3. In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike in accordance with [5.2.1.] of this section, at the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of hull of the ship.

5.2.4. Lightning conductors are to be run as straight as possible and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. Soldered connections are not acceptable.

5.2.5. The resistance of the lightning conductors, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0.02 ohms.

5.2.6. Suitable means should be provided to enable ships when in dry-dock or on a slipway to have their lightning conductors or steel hulls connected to an efficient earth on shore. When the ships are in floating docks, suitable means should be provided for earthing these lightning conductors to the sea.

SECTION 6 ELECTRICAL EQUIPMENT IN HAZARDOUS AREA

Contents

6.1. General

6.1.1. Hazardous areas are spaces where flammable or explosive gases, vapors or dust are normally present, or likely to be present. Hazardous areas are to be classified based on the likelihood of presence and the concentration and type of flammable atmosphere, as well as in terms of the extent of the space. Electrical equipment is not to be installed in hazardous areas unless it is essential for safety or for operational purposes. Where the installation of electrical equipment in such location is necessary, it is to be selected based on its suitability for the hazardous area so classified. Such equipment is to be as specified in the appropriate sections of the Rules, as indicated below.

6.1.2. For Acceptable Types of Certified Safe Equipment (i.e. 'Ex ia', 'Ex ib', 'Ex d', 'Ex e', 'Ex p') Refer Ch 1, Sec 2, [2.31.] of this part.

6.1.3. For Flammable Gas Groups (i.e. I, IIA, IIB and IIC) and Temperature Classes (i.e. T1 to T6) Refer Ch 1, Sec 2, [2.31.] of this part.

6.1.4. Fans used for the ventilation of the hazardous areas are to be of non-sparking construction in accordance with [6.17.] of this section.

6.1.5. Portables apparatus served by a flexible cord is not to be used in cargo oil pump rooms or other hazardous areas.

6.2. Hazardous zones and spaces

6.2.1. Hazardous zones or spaces and sources of hazard for ships intended for the carriage in bulk of oil, liquefied gases and other hazardous substances, and the requirements for ships carrying vehicles with fuel in their tanks, are defined (either directly, or by reference to other documents) in [6.12.] to [6.16.] of this section.

6.2.2. Hazardous areas associated with flammable liquids or gases are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

a. Zone 0:

Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is present continuously or for long periods or frequently.

b. Zone 1:

Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is likely to occur in normal operation occasionally.

c. Zone 2:

Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

6.2.3. Hazardous areas associated with solid substances or packaged liquids to which [6.13.]of this section applies are classified into zones based upon the frequency of the occurrence and duration of an explosive atmosphere due to the presence of gas and/or dust, as follows:

a. Hazardous area in which an explosive atmosphere is likely to occur in normal operation (comparable with zone 1).
b. Extended hazardous area in which an explosive atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only (comparable with zone 2). Refer IEC 60079-10-2, Explosive atmospheres: Classification of areas – Combustible dust atmospheres, or IEC 60092-506, Electrical Installation in Ships – Special Features – Ships carrying specific dangerous goods and materials hazardous only in bulk. An explosive atmosphere may exist due to gas and/or dust.

6.2.4. A hazardous zone or space may arise from the presence of any of the following:

a. Spaces or tanks containing either:

i. Flammable liquid having a flashpoint (closed-cup test) not exceeding 60°C.
ii. Flammable liquid having a flashpoint exceeding 60°C heated or rose by ambient conditions to a temperature within 15°C of its flashpoint.
iii. Flammable gas.

b. Piping systems or equipment containing fluid defined by [6.2.4. a.] of this section and having flanged joints or glands or other openings through which leakage of fluid may occur under normal operating conditions.
c. Spaces containing solids, such as coal or grain, liable to release flammable gas and/or combustible dust.
d. Spaces containing dangerous goods in packaged form, of the following Classes as defined in the IMDG Code: 1 (with the exception of goods in division 1.4, compatibility group), 2.1 (inclusive of applicable gas bottles for on board use), 3, 6.1 and 8.
e. Piping systems or equipment associated with processes (such as battery charging /electro chlorination) generating flammable gas as a by-product and having openings from which the gas may escape under normal operating conditions.
f. Piping systems or equivalent containing flammable liquids not defined by [6.2.4. a.] of this section, having flanged joints, glands or other openings through which leakage of fluid in the form of a mist or fine spray may occur under normal operating conditions.

6.2.5. The following zones or spaces are regarded as hazardous, zone 0:

a. The interiors of those spaces, tanks, piping systems and equipment defined by [6.2.4. a. and b.] of this section; and
b. Enclosed, unventilated spaces containing pipe work or equipment defined by [6.2.4. b. and e.] of this section.

6.2.6. The following zones or spaces are regarded as hazardous, zone 1:

a. The interiors of spaces containing dangerous goods as defined by [6.2.4. d.] of this section;
b. Unventilated spaces separated by a single bulkhead or deck from a cargo defined by [6.2.4. a.] of this section;
c. Ventilated spaces containing pipe work or equipment defined by [6.2.4. b. and e.] of this section;
d. Zones within a 1.5 m radius of ventilation outlets, hatches or doorways or other openings into spaces defined by [6.2.6. a., b. or c.] of this section, or within 1.5 m of the ventilation outlets of spaces regarded by [6.6.] of this section as open areas and which contain the pipe work or equipment defined by [6.2.4. b. or e.] of this section. Where the hazard results from flammable gas or vapor having a density relative to that of air of more than

0.75, the hazardous zone is considered to extend vertically downward to solid deck, or for a distance of 9 m, whichever is the lesser;

e. Zones within a 1.5 m radius of flanged joints, or glands or other openings defined by [6.2.4. b.] of this section; in the case of gas or vapor having a relative density of more than 0.75, the hazardous zone is considered to extend vertically downwards as described under [6.2.6. d.] of this section;
f. Zones within a 1.5 m radius of flanged joints, or glands or other openings defined by [6.2.4. e and f.] of this section;
g. Zones within a 1.5 m radius of bunds or barriers intended to contain spillage of liquids defined by [6.2.4. a.] of this section;
h. Zones on open deck within a 1.5 m radius of any opening into a space defined by [6.2.6. a. or b.] of this section; and
i. Enclosed or semi-enclosed spaces with direct opening into a zone 1 hazardous location.

6.2.7. The following zones or spaces are regarded as hazardous, zone 2:

a. Ventilated spaces separated by a single bulkhead or deck from a zone 0 spaces;
b. Zones on open deck extending 1.5 m beyond those defined by [6.2.6. d., e., f., g. or h.] of this section;
c. Zones within a 1.5 m radius of ventilation inlets serving spaces defined by [6.2.6. a. or c.] of this section; and
d. Enclosed or semi-enclosed spaces with direct opening into a zone 2 hazardous location.

6.3. Pressurization

6.3.1. A space having access to a hazardous space or zone defined as zone 1 or zone 2 may be regarded as non-hazardous if fulfilling all the following conditions:

a. Access is by means of an air-lock, having gastight steel doors, the inner of which as a minimum, is self-closing without any hold-back arrangement;
b. It is maintained at an overpressure relative to the external hazardous area by ventilation from a non-hazardous area;
c. The relative air pressure within the space is continuously monitored and so arranged that, in the event of loss of overpressure, an alarm is given and the electrical supply to all equipment not of a type suitable for zone 1 is automatically disconnected. Where the shutdown of equipment could introduce a hazard, an alarm may be given, in lieu of shutdown, upon loss of overpressure, and a means of disconnection of electrical equipment not of a type suitable for zone 1, capable of being controlled from an attended station, provided in conjunction with an agreed operational procedure; where the means of disconnection is located within the space then it is to be effected by equipment of a type suitable for zone 1;
d. Any electrical equipment required to operate upon loss of overpressure, lighting fittings and equipment within the air-lock, is to be of a type suitable for zone 1; and
e. Means are to be provided to prevent electrical equipment, other than of a type suitable for zone 1, being energized until the atmosphere within the space is made safe, by air renewal of at least 10 times the capacity of the space.

6.3.2. A space having access to a hazardous space or zone defined as zone 2 may be regarded as non-hazardous if fulfilling all the following conditions:

a. Access is by means of a self-closing gastight steel door without any hold-back arrangement;
b. It is maintained at an overpressure relative to the external hazardous area by ventilation from a non-hazardous area;

c. The relative air pressure within the space is continuously monitored and so arranged that, in the event of loss of overpressure, an alarm is given. A means of disconnection of electrical equipment not of a type suitable for zone 2 is to be provided; where the means of disconnection is located within the space then it is to be effected by equipment of a type suitable for zone 2;
d. Any electrical equipment required to operate upon loss of overpressure is to be of a type suitable for zone 2.

6.4. Cable and cable installation

6.4.1. Cables in hazardous areas are to be armored or mineral-insulated metal-sheathed, except for cables of intrinsically safe circuits subject to the requirements of Ch 6,Sec 4,[4.2.] of this part. Where cables pass through boundaries of such locations, they are to be run through gastight fittings. No splices are allowed in hazardous areas, except in intrinsically safe circuits

6.4.2. Installations with intrinsically safe circuits are to be erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions, such as a single-phase short circuit or earth fault in non-intrinsically safe circuits, etc.

6.4.3. The installation of the cables is to be arranged as follows:

a. Cables in both hazardous and non-hazardous areas are to meet one of the following requirements:

   i. Intrinsically safe circuit cables are to be installed a minimum of 50 mm (2 in.) from all non-intrinsically safe circuit cables, or
   ii. Intrinsically safe circuit cables are to be so placed as to protect against the risk of mechanical damage by use of mechanical barrier, or
   iii. Intrinsically safe or non-intrinsically safe circuit cables are to be armored, metal sheathed or screened.

b. Conductors of intrinsically safe circuits and non-intrinsically safe circuits are not to be carried in the same cable.
c. Cables of intrinsically safe circuits and non-intrinsically safe circuits are not to be in the same bundle, duct or conduit pipe.
d. Each unused core in a multi-core cable is to be adequately insulated from earth and from each other at both ends by the use of suitable terminations.

6.5. Installation of electrical equipment

6.5.1. The method of installation and application of electrical equipment suitable for use in explosive gas atmospheres or in the presence of combustible dusts is to be in accordance with IEC 60079-14 or the national code of practice relevant to the standard with which the equipment complies. Any special requirements laid down by the equipment certification documentation are also to be observed. The ambient temperature range for which the apparatus is certified is to be taken to be –20°C to 40°C, unless otherwise stated, and account is to be taken of this when assessing the suitability of the equipment for the auto-ignition temperature of the gases and dusts encountered. Any special requirements laid down by the equipment certification documentation are also to be observed. The ambient temperature range for which the apparatus is certified, is to be taken to be minus 20°C to 40°C, unless otherwise stated, and account is to be taken of this when assessing the suitability of the equipment for the auto-ignition temperature of the gases and dusts encountered.

6.5.2. All switches and protective devices from which equipment located in hazardous zones or spaces is supplied are to interrupt all poles or phases and, where practicable are to be located in a non-hazardous zone or space. Such equipment, switches and protective devices are to be suitably labeled for identification purposes.

6.5.3. Arrangements of common enclosure required for installation are to be comply with following requirement:

a. Sub-compartment

When intrinsically safe components are located by necessity within enclosures that contain non-intrinsically safe systems, such as control consoles and motor starters, such components are to be effectively isolated in a sub-compartment by earthed metallic or nonmetallic insulating barriers having a cover or panel secured by bolts, locks, Allen-screws, or other approved methods. The intrinsic safety in the sub-compartment is not to be adversely affected by external electric or magnetic fields under normal operating condition and any fault conditions in non-intrinsically safe circuits.

b. Termination Arrangements

Where it is impracticable to arrange the terminals of intrinsically safe circuit in the sub-compartment, they are to be separated from those for non-intrinsically safe circuits by either of the following methods. Other National or International recognized Standards will also be accepted.

i. When separation is accomplished by distance, then the clearance between terminals is to be at least 50 mm, or
ii. When separation is accomplished by use of an insulating partition or earthed metal partition, the partitions are to extend to within 1.5 mm of the walls of the enclosure, or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the partition.

c. Identification plate

The terminals and sub-compartment for intrinsically safe circuit and components are to have a nameplate indicating that the equipment within is intrinsically safe and that unauthorized modification or repairs are prohibited.

6.6. Ventilation

6.6.1. Where an enclosed or semi-enclosed space(Refer Note) is provided with mechanical ventilation ensuring at least 12 air changes/hour, and leaving no areas of stagnant air, it may be regarded in consideration of hazardous zones as would otherwise be defined by [6.2.5. b.], [6.2.6. c. or i.] and [6.2.7. d.] of this section, as an open area.

Note: Semi-enclosed spaces are considered to be spaces limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation are sensibly different from those obtained on open deck.

6.6.2. Where the rate of ventilation air flow, in relation to the maximum rate of release of flammable substances reasonably to be expected under normal conditions, is sufficient to prevent the concentration of flammable substances approaching their lower explosive limit, consideration may be given to regarding as non-hazardous, the space, ventilation and other openings into it, and the zone around the equipment contained within.

6.6.3. An alarm is to be provided on the navigating bridge, engine control room, and where applicable, cargo control room to indicate any loss of the required ventilation capacity.

6.7. Selection of equipment for use in the presence of combustible dusts

6.7.1. Where equipment is to be installed in hazardous areas, associated with the presence of combustible dusts, it is, when practicable to be of a type certified or approved by a National or other appropriate authority for the dusts and, additionally, any explosive gases encountered.

6.7.2. Electrical equipment for use in such hazardous areas is to be so designed and installed as to minimize the accumulation of dust which may interfere with the safe dissipation of heat from the enclosure.

6.7.3. Where apparatus is to be installed in extended hazardous areas, as defined in [6.2.3 b.] of this section. Associated with the presence of combustible dust, the following may be considered:

a. Apparatus permitted within a hazardous area associated with the combustible dust(s) that can be present;
b. Apparatus having degree of protection IP5X, or better, and having a surface temperature under normal operating conditions not exceeding the auto-ignition temperature of the dust(s) that can be present; and
c. Apparatus of a type which ensures absence of sparks or arcs and hot spots during normal operation.

6.7.4. Where equipment certified for combustible dusts is not available, consideration will be given to the use of apparatus complying as a minimum, with the following requirements provided no explosive gases will be present:

a. The enclosure is to be at least dust protected (IP5X) having, when type tested, ingress of fine dust within the enclosure not exceeding 10 g per m^3 of free air space.
b. The surface temperature of the apparatus, under the most arduous combination of normal operating conditions, but in the absence of a dust layer, is not to exceed two-thirds of the minimum ignition temperature in degrees Celsius of the dust/air mixture(s) that can be present, or
c. The equipment is to be certified intrinsically-safe having a temperature classification ensuring compliance with [6.7.4. b.] of this section, or
d. Pressurized and operated in accordance with procedures ensuring, prior to its re-energization, the absence of dust within the enclosure following loss of pressurization and consequent shutdown, and having surface temperature complying with [6.7.4. b.] of this section.
e. Simple apparatus included in intrinsically-safe circuits or radio aerials, complying with [6.8.5.] or [6.8.6.] of this section respectively.

6.7.5. Consideration may also be given to arrangements complying with IEC 60092-506, Electrical Installation in Ships – Special Features – Ships carrying specific dangerous goods and materials hazardous only in bulk.

6.8. Selection of equipment for use in explosive gas atmospheres

6.8.1. When equipment is to be installed in areas where an explosive gas atmosphere may be present it is generally to be of a type providing protection against ignition of the gases encountered and compliant with the relevant Parts of IEC 60079, (Electrical Apparatus for) Explosive Gas Atmospheres, or an acceptable and relevant National Standard, unless permitted otherwise by [6.8.4.], [6.8.5.] or [6.8.6.] of this section.

6.8.2. The equipment protection type permitted depends on the hazardous zone where the equipment is to be located, as defined in [6.2.] of this section. For certain locations on the ship other requirements may limit installations to specific equipment types and/or particular applications.

6.8.3. Equipment for zone 0 or zone 1, with the exception of simple apparatus as defined in [6.8.4.] or [6.8.5.] of this section, is to be certified or approved by a National or other appropriate authority. Equipment without independent certification or approval may be considered for installation in zone 2.

6.8.4. In zone 0, the following may be considered:

a. Intrinsically safe, category ‘a’ (Ex ‘ia’); or
b. Simple electrical apparatus and components (for example 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 the limits given in IEC 60079-14, Explosive atmospheres Part 14: Electrical installations design, selection and erection.

6.8.5. In zone 1, the following may be considered:

a. Apparatus permitted within zone 0;
b. Intrinsically safe, category ‘b’ (Ex ‘ib’);
c. Simple apparatus as defined above, included in intrinsically-safe circuits of category ‘ib’;
d. Increased safety (Ex ‘e’);
e. Flameproof (Ex ‘d’);
f. Pressurized enclosure (Ex ‘p’);
g. Powder filled (Ex ‘q’); or
h. Encapsulated (Ex ‘m’).

6.8.6. In zone 2, the following may be considered:

a. Apparatus permitted within zone 0 or zone 1;
b. Type of protection ‘n’ or ‘N’ provided it is in a well ventilated area on open deck and not within 3 m of any flammable gas or vapor outlet.
c. Equipment such as control panels, protected by purging and pressurization and capable of being verified by inspection as meeting the requirements of IEC 60079-2.
d. Radio aerials having robust construction, meeting the relevant requirements of IEC 60079-15. Additionally, in the case of transmitter aerials, it is to be shown, by detailed study or measurement, or by limiting the peak radiated power and field strength to 1 W and 30 V/m, respectively, that they present negligible risk of inducing incentive sparking in adjacent structures or equipment.

6.8.7. Apparatus having type of protection ‘ia’, ‘ib’, or ‘d’, is to be of a Group (IIA, IIB or IIC) meeting or exceeding that required for safe operation in the presence of any gas or vapor that can be present, or is to be certified specifically for such gases or vapors.

6.8.8. All apparatus is to be of a temperature classification (T1 to T6) that confirms, or is to be assessed so as to confirm, that its maximum surface temperature will not reach the ignition of any gas or vapor, or mixture of gases or vapors, which can be present. The surface temperature on temperature considered may be that of an internal or external part, according to the type of protection of the apparatus.

6.8.9. Consideration may also be given to other types of protection, selected in accordance with the requirements of IEC 60079-14 or arrangements complying with IEC 60092- 502, Electrical Installations in Ships – Tankers – Special Features, Refer also [6.14.] to [6.16.] of this section.

6.9. Miscellaneous spaces

Hazardous areas & the installation permitted in the areas have been given below:

6.9.1. Paint stores

6.9.1.1. In the areas on 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, following electrical equipment may be installed.

a. Electrical equipment with the type of protection as permitted in paint stores, or
b. Equipment of protection class Exn, or
c. Appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature, or
d. Appliances with simplified pressurized enclosures or vapor proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature.
e. Cables as specified in [6.9.1.4] of this section.

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

a. The door to the paint store is a gastight door with self-closing devices without holding back arrangements,
b. The paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area
c. Warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

6.9.1.3. Electrical equipment for use in paint stores is to have minimum explosion group IIB and temperature class T3.

6.9.1.4. 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 of the following type is acceptable:

a. Certified intrinsically-safe apparatus Ex(i);
b. Certified flameproof Ex(d);
c. Certified pressurized Ex(p);
d. Certified increased safety Ex(e);
e. Certified specially Ex(s).

Cables (through runs or termination cables) of armored type or installed in metallic conduit are to be used.

6.9.1.5. 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.

6.9.2. Battery rooms

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

6.9.2.2. The associated switches are to be installed outside such spaces.

6.9.2.3. Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type.

6.9.2.4. The impeller of the fan is to be of the non-sparking type.

6.9.2.5. Over current protective devices are to be installed as close as possible to, but outside of, battery rooms.

6.9.2.6. Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

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

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

6.9.3. Helicopter refueling facilities

6.9.3.1. Hazardous areas are enclosed space containing components of the refueling pump/equipment; and open deck area within 3 m (10 ft) from ventilation outlet of enclosed space containing refueling pump/equipment, 3 m (10 ft) from tank vent outlet, and 3 m (10 ft) from refueling pump/equipment.

6.9.3.2. Electrical equipment installed in areas defined for helicopter refueling facilities is to be in accordance with IEC Publication 60079 group IIA class T3.

6.9.4. Oxygen-acetylene storage rooms

6.9.4.1. Hazardous areas are space within the storage room; open deck area within 1 m (3 ft) from natural ventilation outlet, and open area within 3 m (10 ft) from power ventilation outlet.

6.9.4.2. Electrical equipment installed in oxygen-acetylene storage room is to be in accordance with IEC Publication 60079 group IIC class T2.

6.10. Lighting circuits in hazardous areas

All switches and protective devices for lighting fixtures in hazardous areas are to interrupt all poles or phases and are to be located in a non-hazardous area. However, a switch may be located in a hazardous area if the switch is of a certified safe type for the hazardous location in which it is to be installed. On solidly grounded distribution systems, the switches need not open the grounded conductor. The switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

6.11. Permanent notice and booklet of certified safe equipment

A booklet containing the list of certified safe equipment, as installed, along with the particulars of the equipment list, is to be maintained onboard. Permanent notices are to be posted in the vicinity of hazardous areas in which such electrical equipment is installed to advice crew of the availability of the booklet so that it can be referenced during repair or maintenance.

6.12. Special requirements for ships with spaces for carrying vehicles with fuel in their tanks, for their own propulsion

6.12.1. Passenger ships with special category spaces above the bulkhead deck for carrying vehicles

6.12.1.1. Electrical equipment fitted within a height of 45 cm above the vehicle deck, or any platform on which vehicles are carried, or within the exhaust ventilation trucking for the space, is to be of a type acceptable for zone 1;

6.12.1.2. Electrical equipment situated elsewhere within the space is to be of a type acceptable for zone 2, or is to have an enclosure of ingress protection rating of at least IP55, Refer IEC 60529: Classification of Degrees of Protection Provided by Enclosures. Smoke and gas detector heads are exempt from this requirement.

6.12.2. Passenger ships with special category spaces below the bulkhead deck for carrying vehicles

Electrical equipment fitted within the space and within the exhaust ventilation trucking for the space, is to be of a type acceptable for zone 1.

6.12.3. Passenger ships with cargo spaces, other than special category spaces, for carrying vehicles

6.12.3.1. Electrical equipment within such a cargo space, or within the exhaust ventilation trucking for the space, is to be of a type acceptable for zone 1;

6.12.3.2. All electrical circuits terminating in the cargo space are to be provided with multi pole linked isolating switches located outside the cargo hold. Provision is to be made for locking in the off position. This does not apply to safety circuits such as those for fire, smoke or gas detection.

6.12.4. Cargo ships with cargo spaces for carrying vehicles

6.12.4.1. Electrical equipment fitted within a height of 45 cm above the vehicle deck, or within a height of 45 cm above the vehicle deck, or within the cargo space's exhaust ventilation trunking, and any equipment associated with safety circuits such as those for fire, smoke or gas detection, located within the cargo space, is to be of a safe type;

6.12.4.2. The requirements of [6.12.1.2.] of this section apply to other equipment within the space;

6.12.4.3. The requirements of [6.12.3.2.] of this section apply to circuits terminating in the space.

6.13. Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk

6.13.1. In order to eliminate potential sources of ignition in enclosed cargo spaces or vehicle spaces in accordance with SOLAS 1974 as amended, Chapter II-2, Regulation 19.3.2, and from associated hazardous areas, electrical equipment is to be selected in accordance with [6.13.2.] and [6.13.3.] of this section and installed in accordance with [6.5.] and [6.13.4.] to [6.13.7.] of this section.

6.13.2. Electrical equipment essential for the safety and operation of the ship is to be of a type providing protection against ignition of the gases and/or dusts that can be present, selected in accordance with IEC 60092-506, Electrical installations in ships – Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk.

6.13.3. In addition to the requirements of IEC 60092-506, pipes such as ventilation and bilge pipes, having ends opening into a hazardous area are to be considered a hazardous area. Enclosed spaces such as pipe tunnels and bilge pump rooms containing such pipes and with equipment and components such as pumps, valves and flanges are to be considered as extended hazardous areas unless protected by overpressure.

6.13.4. Electrical equipment not essential for the safety or operation of the ship and which is not of a type providing protection against ignition of the gases and/or dusts that can be present is to be completely disconnected and protected against unauthorized re-connection. Disconnection is to be made outside the hazardous areas and be effected with isolating links or lockable switches.

6.13.5. Electrical equipment and all cables, including through runs and terminating cables, are to be protected against mechanical damage. Cables are to be either enclosed in screwed heavy gauge steel drawn or seam-welded and galvanized conduit, or protected by electrically continuous metal sheathing or metallic wire armor braid or tape.

6.13.6. Cables joints in cargo spaces are to be avoided where possible. Where joints are unavoidable, they are to be enclosed in metal-clad or high impact strength plastic junction boxes of a type acceptable for zone 1 or a hazardous area or heat-shrink or encapsulated crimp sleeve cable joints.

6.13.7. Cable penetrations of decks and bulkheads are to be sealed against the passage of gas or vapor.

6.14. Requirements for tankers intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed cup test)

6.14.1. The following requirements define the electrical equipment permitted within dangerous spaces and zones and are in addition to the requirements of [6.2.] to [6.6.] of this section.

6.14.2. The requirements for cargo tanks also apply to cargo slops tanks.

6.14.3. The relevant gas group and temperature class for safe type equipment in the defined locations are IIA T3.

6.14.4. Where intrinsically-safe equipment is required, consideration will be given to the use of simple apparatus incorporated in intrinsically-safe circuits like simple non-energy-storing apparatus having negligible surface temperature rise in normal operation, such as limit switches, strain gauges, etc., incorporated in intrinsically-safe circuits.

6.14.5. In cargo tanks intrinsically-safe equipment of category 'ia' may be considered

6.14.6. In cofferdams adjoining cargo tanks following may be considered:

a. Intrinsically-safe equipment of category 'ia';
b. Electric depth-sounding devices hermetically enclosed, located clear of the cargo tank bulkhead, with cables installed in heavy gauge steel pipes with gastight joints up to the main deck;
c. Cables for impressed current cathodic protection systems (for external hull protection only) installed in heavy gauge steel pipes with gas tight joints up to the upper deck;
d. Through runs of cables, installed in heavy gauge steel pipes with gas tight joints.

6.14.7. In cargo pump rooms following may be considered:

a. Intrinsically-safe equipment;
b. Electrical equipment as defined in [6.14.6. b. and c.] of this section;
c. Flameproof lighting fittings (symbol d);
d. Pressurized lighting fittings (symbol p) of either the air driven type, of pressurized from an external source of protective gas and arranged to be de-energies automatically on loss of pressurization;
e. Gas detector heads having sinter-type flame trap protection, included within an intrinsically-safe circuit, the gas detector system is to be certified;
f. General alarm sounders of flameproof type, without internal sparking contacts;

g. Through runs of cables, confined to pump room entrances only, installed in heavy gauge steel pipes with gas tight joints.

6.14.8. Spaces under cargo tanks (e.g. duct keels) electrical equipment as defined in [6.14.6. a. and b.] and [6.14.7. c. to f.] of this section may be considered.

6.14.9. Enclosed or semi-enclosed spaces immediately above cargo tanks or having bulkheads immediately above and in line with cargo tank bulkheads, compartments for cargo hoses, spaces other than cofferdams adjoining and below the top of a cargo tanks, e.g. trunk, passageways and holds:

a. Intrinsically-safe equipment, this is to be of category 'ia' where the spaces or compartments are not mechanically ventilated;
b. Safe type lighting fittings;
c. Through runs of cable;
d. General alarm sounders as defined by [6.14.7. f.] of this section.

6.14.10. Zones on open deck within 3 [m] of any cargo oil tank outlet or vapor outlet (e.g. cargo tank or cofferdam hatch; sight port; tank cleaning opening; ullage opening; sounding pipe cargo pump room entrance and ventilation intakes and exhausts), zones on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) to the full width of the vessel, plus 3 [m] forward and 3 [m] aft of the cargo tank area or any spillage barrier installed aft of the cargo tanks area, up to a height of 2.4 [m] above the deck.

a. Safe type equipment;
b. Through runs of cable, cable expansion bends are not to be within 3 m of any cargo tank or vapor outlet.

6.14.11. Zones within 5 m of any pressure/vacuum valve, or at any height above and within a 10 m radius (measured horizontally) and within a 3 m radius below of any such vent not of the high velocity type:

a. Safe type equipment;
b. Through runs of cable.

6.15. Requirements for ships for the carriage of liquefied gases in bulk

Refer Ch 1 [1.1.12] of this part for relevant details.

6.16. Requirements for ships intended for the carriage in bulk of other flammable liquid cargoes

Refer Ch 1 [1.1.12] of this part for relevant details.

6.17. Non-sparking fans

6.17.1. Design

6.17.1.1. Air gap

The air gap between the impeller and the casing is to be not less than 10 percent of the shaft diameter in way of the impeller bearing but, in any case, not to be less than 2 mm (0.08 in.). It need not be more than 13 mm (0.5 in.).

6.17.1.2. Protection screen

Protection screens of not more than 13 mm (0.5 in.) square mesh are to be fitted in the inlet and outlet of ventilation openings on the open deck to prevent the entrance of object into the fan casing.

6.17.2. Materials

6.17.2.1. Impeller and its housing

Except as indicated in [6.17.2.3.] of this section, the impeller and the housing in way of the impeller are to be made of alloys which are recognized as being spark proof by means of appropriate test procedures.

6.17.2.2. Electrostatic charges

Electrostatic charges both in the rotating body and the casing are to be prevented by the use of anti-static materials. Furthermore, the installation of the ventilation fan is to ensure its bonding to the hull.

6.17.2.3. Acceptable combination of materials

Materials tests referred to in [6.17.2.1.] of this section above are not required for fans having the following combinations:

a. Impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity;
b. Impellers and housings of non-ferrous materials;
c. Impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller;
d. Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm (0.5 in.) tip design clearance.

6.17.2.4. Unacceptable combination of materials

The following impellers and housings are considered as spark-producing and are not permitted:

a. Impellers of an aluminum alloy or magnesium alloy and a ferrous housing, regardless of tip clearance;
b. Housing made of an aluminum alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance;
c. Any combination of ferrous impellers and housings with less than 13 mm (0.5 in.) design tip clearance.

6.17.3. Type test

Type tests on the finished product are to be carried out in accordance with an acceptable national or international standard. Such type test reports are to be made available when requested by the Surveyor.

6.18. Testing and trials

6.18.1. All electric equipment located in hazardous areas is to be examined to ensure that it is of a type permitted by the Rules, has been installed in compliance with its certification, and that the integrity of the protection concept has not been impaired.

6.18.2. Alarms and interlocks associated with pressurized equipment and the ventilation of spaces located in hazardous areas are to be tested for correct operation.

SECTION 7 MOTOR CONTROLLERS AND MOTOR CONTROL CENTERS

Contents

7.1. Application

Main and emergency switchboards, power and lighting distribution boards, motor control centers and motor controllers, and battery charging and discharging boards are to be designed, constructed and tested in accordance with the provisions of this section.

7.2. Construction, Assembly and Components

7.2.1. Enclosures

Enclosures and assemblies are to be constructed of steel or other suitable incombustible, moisture resistant materials and reinforced as necessary to withstand the mechanical, electro-magnetic and thermal stresses which may be encountered under both normal and short-circuit fault conditions.

Enclosures are to be of the closed type. The degree of the protection is to be in accordance with Ch 2, Sec. 4, Table 2.4.16 of this part.

All wearing parts are to be accessible for inspection and be readily renewable.

7.2.2. Disconnecting Device

The rating of the disconnecting devices is to be equal to or higher than the voltage and current ratings of connected load. The disconnect device is to be provided with an indication of whether it is open or closed.

Where the indicating light is fitted to a motor controller to indicate the availability of the power supply, and if the required disconnecting device does not de-energize the indicating light circuits, the voltage of indicating light circuits is not to exceed 150 V.

7.2.3. Bus Bars

7.2.3.1. Bus bars and circuit breakers are to be mounted, braced and located so as to withstand thermal effects and magnetic forces resulting from the maximum prospective short-circuit current.

7.2.3.2. Soldered connections are not to be used for connecting or terminating any cable of 2.5 mm^2 or greater. These connections are to be made by the use of crimp lugs or equivalent.

7.2.3.3. For busbar Refer also Ch 2, Sec. 4, [4.4.6.] of this part.

7.2.4. Circuit Breakers

Circuit breakers are to have sufficient breaking and making capacities, as specified in Ch 2, Sec 4, [4.5.2.] of this part. Refer also Ch 2, Sec 4, [4.5.16.] of this part.

7.2.5. Fuses

Fuses are to be designed, constructed and tested in accordance with IEC Publication 60269 or other recognized standard. The certificates of tests are to be submitted upon request from INTLREG. Refer also Ch 2, Sec 4, [4.5.17.] of this part.

7.2.6. Internal Wiring

Internal instrumentation and control wiring is to be of the stranded type and is to have flame-retarding insulation. They are to be in compliance with a recognized standard.

7.2.7. Circuit Identification

Identification plates for feeders and branch circuits are to be provided and are to indicate the circuit designation and the rating or settings of the fuse or circuit breaker of the circuit.

7.3. Location

7.3.1. Location of motor control center

Motor control centers are to be located in a dry place. Clear working space is to be provided around motor control centers to enable doors to be fully opened and equipment removed for maintenance and replacement.

7.3.2. Location of the Disconnecting Device

The disconnecting device may be in the same enclosure with the controller, in which case it is to be externally operable. The branch-circuit switch or circuit breaker on the power-distribution panel or switchboard may serve as the disconnect device if it is located in the same compartment as the controller. In any case, if the disconnecting device is not within sight of both the motor and the controller, or if it is more than 15 m (50 ft) from either, it is to be arranged for locking in the open position. The disconnect switch, if not adjacent to the controller, is to be provided with an identification plate.

7.3.3. Location of Resistors for Control Apparatus

Controllers fitted with resistors are to be located in well-ventilated compartments and are to be mounted with ample clearances [about 300 mm (12 in.)] from vessel structures and unprotected combustible materials. Refer also [7.4.3.] of this section.

7.4. Protection

7.4.1. Overload and Under-voltage Protection

Overload protection and under voltage protection where provided in the motor controllers are to be in accordance with Ch 2, Sec 4, [4.5.7.2.] & [4.5.7.3.] of this part.

7.4.2. Disconnecting Means

A circuit-disconnecting device is to be provided for each branch circuit of motor rated 0.5 kW or above so that the motor and the controller may be isolated from the power supply for maintenance purposes. However, for a pre-assembled or skid-mounted unit having two or more motors (e.g., fuel oil blender), a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6A. The circuit-disconnecting device is to be operable externally. For disconnecting devices Refer also [7.2.2.] of this section.

7.4.3. Resistor for Control Apparatus

Resistors are to be protected against corrosion either by rust-proofing or embedding in a protective material. Where fitted, the enclosure is to be well-ventilated and so arranged that other electrical equipment and wiring within will not be exposed to a temperature in excess of that for which they are designed. For location of controllers fitted with resistors Refer [7.3.3.] of this section.

7.5. Testing

Motor controllers are to be inspected by, tested in the presence of and certified by the Surveyor, preferably at the plant of the manufacturer. Test certificates are to be submitted upon request by INTLREG. For insulation resistance measurement, dielectric strength test & operational test, Refer Ch 2, Sec 4, [4.2.10.7.] of this part.

CHAPTER 4 ROTATING MACHINES

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1. General

1.1.1. Application

All generators and motors of 100 kW (135 hp) and over intended for essential services (Refer Ch 1, sec 2, [2.2.] of this part) are to be designed, constructed and tested in accordance with the requirements of this chapter. All other rotating electrical machines are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests for rotating electrical machines less than 100 kW (135 hp) for essential services or are to include at least the tests described in sec 4 of this chapter regardless of the standard of construction. The test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance after installation.

1.1.2. Definitions

1.1.2.1. Periodic duty rating

The periodic duty rating of a rotating machine is the rated kW load at which the machine can operate repeatedly, for specified period (N) at the rated load followed by a specified period (R) of rest and de-energized state, without exceeding the temperature rise given in sec 3, Table 4.3.1 of this chapter; where N + R = 10 minutes, and cyclic duty factor is given by N/ (N + R) %.

1.1.2.2. Short-time rating

The short-time rating of a rotating electrical machine is the rated kW load at which the machine can operate for a specified time period without exceeding the temperature rise given in sec 3, Table 4.3.1 of this chapter. A rest and de-energized period sufficient to re-establish the machine temperature to within 2°C (3.6°F) of the coolant prior to the next operation is to be allowed. At the beginning of the measurement, the temperature of the machine is to be within 5°C (9°F) of the coolant.

1.1.2.3. Non-periodic duty rating

The non-periodic duty rating of a rotating electrical machine is the kW load which the machine can operate continuously, for a specific period of time, or intermittently under the designed variations of the load and speed within the permissible operating range, respectively; and the temperature rise, measured when the machine has been run until it reaches a steady temperature condition, is not to exceed those given in sec 3, Table 4.3.1 of this chapter.

1.1.2.4. Continuous rating

The continuous rating of a rotating electrical machine is the rated kW load at which the machine can continuously operate without exceeding the steady state temperature rise given in sec 3, Table 4.3.1 of this chapter.

1.2. Rating

Ship's service generators including their exciters and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without exceeding the limits of temperature rise in Sec 3. Other generators and motors are to be rated in accordance with the duty which they are to perform, and when tested under rated load conditions the temperature rise is not to exceed the values in Sec 3 of this chapter.

1.3. Construction and installation

1.3.1. Shafting

1.3.1.1. Rotors of non-integrated auxiliary machinery

The design of the following specified rotating shafts and components, when not integral to the propulsion shafting, should be in compliance with the following:

a. Rotor shaft: Pt 5A, Ch 2, sec 4, [4.3.2.]and 5A Ch 2 [4.3.2.2] ;
b. Hollow shaft: Pt 5A, Ch 4, Sect 3[3.2] ;
c. Key: Pt 5A, Ch 4, sec 3 [3.4] ;
d. Coupling flanges and bolts: Pt 5A, Ch 4,sect 3[3.10]

1.3.1.2. Rotors of integrated auxiliary machinery

The shaft diameters of the shaft motors and shaft generators which are an important part of the line shafting should be evaluated as per Pt 5A,Ch 3,sec 3,[3.7.1], 5A-3-Sect [3.7.6 i & ii] and Sect 3,, for maximum torsional moment (steady and vibratory) acing within the operating speeds, instead of torsional moment T at rated speed.

The shaft diameter of the motors and generators, that are an integral part of the line shafting, may also be designed as per Pt 5A, Ch 4, sect 3, [3.1] and are to be evaluated on the basis of engineering analyses as per Pt 5A, Ch 4, sec 1, [1.1.] .

1.3.2. Shaft circulating current

Means should be provided for preventing circulating currents from passing between the bearings and the journals, where the design and arrangement of the machine is such that damaging current might be expected due to the unbalance of magnetic fields.

1.3.3. Lubrication

1.3.3.1. Lubrication of rotating machines shall be effective under all operating conditions.

1.3.3.2. Each self-lubricated sleeve bearings shall be fitted with an inspection lid and means for visual indication of oil level or use of an oil gauge. Similar requirement applies to self-contained oil lubricated roller bearings.

1.3.3.3. Provision shall be made for preventing the lubricant from gaining access to windings or other insulated or bare current-carrying parts.

1.3.4. Moisture condensation prevention

When the weight of the generator and propulsion motor, excluding the shaft, is over 455 kg (1000 lb.), means are to be provided to prevent moisture condensation in the machine when idle.

1.3.5. Stator temperature detection

AC propulsion generators and motors rated above 500 kW (670 hp) are to be provided with a means of obtaining the temperatures at each phase of the stationary windings.

1.3.6. Clearances and creepage distances inside terminal boxes

1.3.6.1. Clearances and creepage distances inside terminal boxes of rotating machines are not to be less than the values given in following table.

1.3.6.2. The requirements specified in [1.3.6.1.] of this section above are not to be applied in cases where insulating barriers are used and also they are not to be applied to small motors such as controlling motors, synchros, etc.

Table 4.1.1 Minimum clearances and creepage distances inside terminal boxes of rotating machines

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

1.3.7. Balance

Machines shall be constructed in such a manner that at the time of running at any and every working speed, all revolving parts are well balanced.

1.3.8. Brush gear

1.3.8.1. The final running position of brush gear is to be clearly and permanently marked.

1.3.8.2. Direct current motors and generators are to operate with fixed brush setting from no load to the momentary overload specified without injurious sparking, or damage to the commutator or brushes. The commutation is to be checked with an excess current of 20 per cent and for a period of time sufficient to judge its quality.

1.3.8.3. Alternating current commutator motors are to operate over the specified range of load and speed without injurious sparking.

1.3.9. Nameplate data

Nameplates of corrosion-resistant material are to be provided and are to indicate at least the following, as applicable:

a. The manufacturer's serial number (or identification mark);
b. Type of machine;
c. Rating;
d. The rated voltage;
e. The rated speed;
f. The rated ambient temperature;
g. The rated frequency;
h. Type of winding connections;
i. Rated exciter current;
j. The manufacturer's name;
k. The year of manufacture;
l. Degree of protection by IP code;
m. The rated output;
n. The rated current;
o. The class of insulation;
p. Number of phase;
q. The rated power factor;
r. Rated exciter voltage.

1.3.10. Installation

Generators, motors and other rotating machines are to be installed preferably with their shafts in a fore-and-aft direction of the vessel. Arrangements are to be made to protect generator and motors from bilge water. Precautions are also to be taken to preclude any oil which may escape under pressure from entering machine windings.

1.4. Overload capacity

Overload capabilities for AC and DC generators and motors are to be in accordance with IEC Publication 60034-1. For convenience, the following requirements for AC generators and motors are provided.

1.4.1. AC Generators

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds. The test may be performed in conjunction with the short-circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

1.4.2. AC Motors

1.4.2.1. Over current capacity

Three phase induction motors having rated output not exceeding 315 kW (422 hp) and rated voltage not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three phase induction motors having rated outputs above 315 kW (422 hp), the over current capacity is to be in accordance with the manufacturer's specification. The test may be performed at a reduced speed.

1.4.2.2. Overload capacity for induction motors.

Three phase induction motors, regardless of duty, are to be capable of withstanding for 15 seconds without stalling, or abrupt change in speed, an excess torque of 60% above the rated torque, the voltage and frequency being maintained at the rated values.

1.4.2.3. Overload capacity for synchronous motors.

Three phase synchronous motors, regardless of duty, are to be capable of withstanding an excess torque as specified below for 15 seconds without falling out of synchronism, the excitation being maintained at the value corresponding to the rated load:

a. Synchronous (wound rotor) induction motors: 35% excess torque.
b. Synchronous (cylindrical rotor) motors: 35% excess torque.
c. Synchronous (salient pole) motors: 50% excess torque.

Synchronous motors fitted with automatic excitation are to meet the same excess torque values with the excitation equipment operating under normal conditions.

1.5. Over speed capacity

Rotating machines shall be capable of withstanding 1.2 times the rated maximum speed for a period of 2 minutes.

1.6. Generator control

1.6.1. Operating governors

An operating governor is to be fitted to each prime mover driving main or emergency generator and is to be capable of automatically maintaining the speed within the following limits:

a. Steam or gas turbine prime movers:

i. The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:

- Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off; in the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the over speed protective device, fitted in addition to the governor, as required by Pt 5A,ch2,sec 3,[3.4.] or Pt 5A,ch2,sec 4,[4.4] , is not activated.
- Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state. In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds.

ii. The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

iii. For gas turbines driving emergency generators, the requirements of [1.6.1.a.i.] and [1.6.1.a ii.] of this section above are to be met. However, for purpose of [1.6.1.a.i.] of this section, where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used.

b. Diesel engine prime mover:

i. The transient frequency variations in the electrical network when running at the indicated loads below is to be within ±10% of the rated frequency when:

- Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off: in the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the over speed protective device, fitted in addition to the governor, as required by Pt 5A, ch2, sec 1. [1.4.] , is not activated.
- Running at no load and 50% of the full load of the generator is suddenly thrown on, followed by the remaining 50% after an interval sufficient to restore the frequency to steady state. In all instances, the frequency is to return to within ±1% of the final steady state condition in no more than five (5) seconds. Consideration can be given to alternative methods of load application as provided in Pt 5A, ch2, sec 1, [1.4.] for electrical systems fitted with power management systems and sequential starting arrangements.

ii. The permanent frequency variation is to be within ±5% of the rated frequency at any load between no load and the full load.

iii. For emergency generators, the requirements of [1.6.1.b.i.] and [1.6.1.b ii.] of this section above are to be met. However, for the purpose of [1.6.1.b.i.] of this section, where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used.

1.6.2. Parallel operation

1.6.2.1. General

When it is intended that two or more generators be operated in parallel, means are to be provided to divide the reactive power equally between the generators in proportion to the generator capacity.

1.6.2.2. Reactive load sharing

The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the smallest generator, whichever is the less.

1.6.2.3. KW load sharing

In the range between 20% and 100% of the sum of the rated loads of all generators, the kW load on any generator is not to differ more than ±15% of the rated output kW of the largest generator, or 25% of the rated output kW of the individual generator, whichever is the less, from its proportionate share. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% load with each generator carrying its proportionate share.

1.6.2.4. Parallel operation on nets with earthed neutral

When generators are run in parallel on nets with earthed neutral, it shall be ensured that the equalizing current resulting from harmonics does not exceed 20% of the rated current of each generator.

1.6.3. Automatic voltage regulation system

The following requirements are for AC generators. For DC generators, refer to IEC Publications 60092-202 and 60092-301.

1.6.3.1. General

An automatic voltage regulator is to be fitted for each generator. Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machines being controlled

1.6.3.2. Variation from rated voltage – steady state

The automatic voltage regulator is to be capable of maintaining the voltage under steady conditions within ±2.5% of the rated voltage for all loads between zero and the rated load at the rated power factor, taking the governor characteristics of generator prime movers into account. These limits may be increased to ±3.5% for generators for emergency services.

1.6.3.3. Variation from rated voltage – transient

Momentary voltage variations are to be within the range of −15% to +20% of the rated voltage, and the voltage is to be restored to within ±3% of the rated voltage in not more than 1.5 seconds when:

a. A load equal to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and
b. A load equal to the above is suddenly thrown off.

Consideration may be given to performing the test required by sec 4, [4.1.2.4.] of this chapter according to precise information concerning the maximum values of the sudden loads instead of the values indicated above, provided precise information is available. The precise information concerning the maximum values of the sudden loads is to be based on the power management system arrangements and starting arrangements provided for the electrical system.

1.6.3.4. Generator short circuit capabilities

Short-circuit capabilities of generators are to be in accordance with IEC Publication 60034-1. Under short circuit conditions, generators are to be capable of withstanding the mechanical and thermal stresses induced by a short-circuit current of at least three times the full load current for at least 2 seconds. Under short-circuit conditions, the excitation system is to be capable of maintaining a steady-state short-circuit current for 2 seconds or for such magnitude and duration as required to properly actuate the electrical protective devices.

SECTION 2 MACHINE ENCLOSURE

Contents

2.1. Enclosure

Enclosures of rotating machines including the cable terminal boxes are to be such as to eliminate mechanical injury and the risk of damage from water, oil and shipboard atmosphere. The minimum degree of protection is to be in accordance with Ch 2, Sec 4 Table 2.4.16 of this part.

2.1.1. Ventilation and cooling

The construction of machines using cooling media other than air shall be agreed with INTLREG with due regard to the operating conditions.

2.1.1.1. Draught ventilation

The air supply to draught ventilated machines should be free of oil vapors, dust and moisture.

2.1.1.2. Enclosed air cooling circuit

Where heat-exchangers are used in the air circuit, they must be designed and mounted in such a way that condensation- or leakage water from the exchanger system is kept away from the machine windings. Leakage monitoring is required. The water supplies lines and re circulating lines of each heat-exchanger are to be fitted with shut-off valves. The air ducts must be provided with inspection holes for visual observation of the heat-exchanger. If a fault of cooling is possible during operation (air filters, fan flaps, forced ventilation, re-cooling), a fault alarm must be provided. Machines fitted with brushes should be ventilated in such direction that a fine from the brushes does not enter the inside of the machine.

2.1.1.3. Surface cooling

Surface-cooled machines present on the open deck shall have external fans only if they have full protection against icing.

SECTION 3 TEMPERATURE RISE

Contents

3.1. Limit of Temperature Rise

3.1.1. The limits of temperature rise as specified in Table 4.3.1 of this section are based on a cooling air temperature of 45^0 C and a cooling water temperature of 30^0C.

3.1.2. If the temperature of the cooling medium is going beyond the value as specified in [3.1.1.] of this section, the permissible temperature rise is to be decreased by an amount equal to the excess temperature of the cooling medium. These temperature rises are, if required to be reduced for satisfying the requirements of flame-proof equipment.

3.1.3. If the temperature of the cooling medium is permanently less than the value specified in [3.1.1.] of this section, then the permissible temperature rise may be increased by an amount which equals to the difference between the declared temperature and that specified in [3.1.1.] of this section, up to a maximum of 15^0 C.

Table 4.3.1: Limits of temperature rise in °C

Item		Part of machines	Method of measurement of Temp.	Temperature rise °C					
				Air cooled machines insulation class			Water cooled machines insulation class		
				A	E	B	A	E	B
1	(a)	A.C. windings of turbine type machines having output of 5000 KVA or more	ETD or R	50	60	70	70	80	90
	(b)	A.C. windings of salient-pole and of induction machines having output of 5000 KVA or more, or having a core length of one meter or more	ETD or R	50	60	70	70	80	90
2	(a)	A.C. windings of machines smaller than in item 1	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(b)	Field windings of a.c. and d.c. machines having d.c. excitation other than those in items 3 and 4	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(c)	Windings of armatures having commutators	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
3		Field windings of turbine-type machines having d.c. excitation	R	-	-	80	-	-	100
4	(a)	Low-resistance field windings of more than one layer and compensating windings	T,R	50	65	70	70	85	90
	(b)	Single-layer windings with exposed bare surfaces	T,R	55	70	80	75	90	100
5		Permanently short-circuited insulated windings	T	50	65	70	70	85	90
6		Permanently short-circuited windings, uninsulated	T	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					

7		Iron core and other parts not in contact with windings	-	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
8		Iron core and other parts in contact with windings	T	50	65	70	70	85	90
9		Commutators and slip-rings, open or enclosed	T	50	60	70	70	80	90

Notes: -

1. T = Thermometer method

   R = Resistance method

   ETD = Embedded Temperature Detector

2. When the commutators, slip rings or bearings of machines provided with water coolers are not in the enclosed air circuits cooled by the water cooler, but are cooled by the ambient cooling air, the permissible temperature rise above the ambient cooling air should be the same as for ventilated machines.
3. When Class F or Class H insulation is employed, the permitted temperature rises are respectively 20°C and 40°C higher than the values given for Class B insulation.
4. Classes of insulation are to be in accordance with IEC Publication 85 (1957) - "Recommendations for the classification of material for the insulation of electrical machinery and apparatus in relation to their thermal stability in service".

3.1.4. The limits of temperature rise of electric slip couplings should be in accordance with Table 4.3.1 of this section, except that when a squirrel cage element is used the temperature of this element is not to reach an injurious value. The temperature of the field windings is not to exceed these limits at all speeds of operation. Arrangements for reducing the excitation of self-ventilated couplings at low operational speeds are permissible.

3.1.5. Alternating current machines of 5000 kVA output and above and propulsion motors having a total axial core length of 1m or more (including the ventilating duct), are to have at least three embedded temperature detectors. With multi core machines the total length is to be taken as the sum of the individual core lengths.

SECTION 4 TESTING & ACCEPTANCE CRITERIA

Contents

4.1. Testing of Rotating Machines

4.1.1. General

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

4.1.1.2. 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.

4.1.1.3. Such test reports are to be provided to INTLREG, for machines for essential services. For other machines, these test reports are to be made available upon request of INTLREG.

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

4.1.1.5. Type tests are to be carried out on a prototype machine or on the first of a batch of machines, and routine tests carried out on subsequent machines in accordance with following table. Where the test procedure is not specified, the requirements of IEC 60034-1 apply.

Table 4.4.1: Tests to be carried out on electrical rotating machines

Tests		AC generators		AC motors		DC machines	
		Type Test (1)	Routine Test (2)	Type Test (1)	Routine Test (2)	Type Test (1)	Routine Test (2)
1	Visual inspection.	x	x	x	x	x	x
2	Insulation resistance measurement.	x	x	x	x	x	x
3	Winding resistance measurement.	x	x	x	x	x	x
4	Verification of voltage regulation system.	x	x (3)				
5	Rated load test and temperature rise Measurement.	x		x		x	
6	Overload/over current test.	x	x (4)	x	x (4)	x	x (4)
7	Verification of steady short-circuits condition.	x					
8	Over speed test.	x	x	x (6)	x (6)	x (6)	x (6)
9	Dielectric strength test.	x	x	x	x	x	x
10	Running balance test.	x	x	x	x	x	x
11	Verification of degree of protection.	x		x		x	
12	Bearing check after test.	x	x	x	x	x	x
13	Air gap measurement.	x	x			x	x
14	Commutation check.					x	

Notes:

1. A type test applies to prototype machines or to at least the first of a batch of machines.
2. Machines to be routine tested are to have reference to the machine of the same type that has passed a type test. Reports of routine tested machines are to contain manufacturers' serial numbers of the type tested machines and the test results.
3. Only functional test of voltage regulator system.
4. Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.
5. Verification at steady short-circuit condition applies to synchronous generators only.
6. Where so specified and agreed upon between purchaser and manufacturer. Not required for squirrel cage motors.
7. Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearings, or with incomplete set of bearings.

4.1.2. Description of the test

4.1.2.1. Examination of the technical documentation, as appropriate, and visual inspection:

a. Examination of the technical documentation

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

b. Visual inspection

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

4.1.2.2. Insulation resistance measurement

The insulation resistance of a new, clean dry machine, immediately after the temperature rise test has been carried out is to be at least 1 MΩ. Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a. All current carrying parts connected together and earth;
b. All current carrying parts of different polarity or phase, where both ends of each polarity or phase can be accessed individually. The minimum values of test voltages and corresponding insulation resistances are given in following table. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

Table 4.4.2: Minimum insulation resistance

Rated voltage U_n, in V	Minimum test voltage, in V	Minimum insulation resistance, in MΩ
$U_n \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$(U_n/1000) + 1$
$7200 < U_n \leq 15000$	5000	$(U_n/1000) + 1$

4.1.2.3. Winding resistance measurement

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

4.1.2.4. Verification of the voltage regulation system

a. 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, the rated voltage at the rated power factor is maintained under steady conditions within ± 2.5%. These limits may be increased to ± 3.5% for emergency sets.
b. When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage.
c. 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 5s.
d. 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.

4.1.2.5. Rated load test and temperature rise measurements

The temperature rises are to be measured at the rated output, voltage and frequency and for the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC Publication 60034-1, or by means of a combination of other tests. The limits of temperature rise are those specified in Table 6 of IEC Publication 60034-1 adjusted as necessary for the ambient reference temperatures specified in Pt 5A, Ch 1, sec 4, [4.6.] .

4.1.2.6. Overload/over current tests

a. Overload test is to be carried out as a type test for generators as proof of overload capability of generators and the excitation system, for motors as proof of momentary excess torque as required in IEC Publication 60034-1. The overload test can be replaced at a routine test by an over current test. The over current test is to be proof of the current capability of the windings, wires, connections etc. of each machine. The over current test can be performed at reduced speed (motors) or at short-circuit (generators).
b. In the case of machines for special uses (e.g. for windlasses), overload values other than the above may be considered.

4.1.2.7. Verification of steady short-circuit conditions

It is to be verified that under steady state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, 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.

4.1.2.8. Over speed test

Machines are to withstand the over speed test as specified in IEC Publication 60034-1. This test is not applicable for squirrel cage motors.

4.1.2.9. Dielectric strength test

a. New and completed rotating machines are to withstand a dielectric test as specified in IEC Publication 60034-1.
b. An impulse test is to be carried out on the coils of high voltage machines in order to demonstrate a satisfactory withstand level of the inter-turn insulation to voltage surges. The test is to be carried out on all coils after they have been inserted in the slots and after wedging and bracing. Each coil shall be subjected to at least five impulses of injected voltage, the peak value of the injected voltage being given by the formula:

   $V_{peak} = 2.45V$ where
   V = rated line voltage r.m.s.

   Alternative proposals to demonstrate the withstand level of inter-turn insulation will be considered.

c. 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 Publication 60034-1.
d. Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.
e. Partially rewound windings are to be tested at 75% of the test voltage required for new machines. The old part of the winding is to be carefully cleaned and dried prior to the test.
f. 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.
g. The high voltage test is to be carried out at 1000 plus twice the rated voltage with a minimum of 2000 V on new machines, preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings or sections of windings not under test. Where both ends of each phase are brought out to accessible separate terminals, each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 Hz of approximately sine wave form. The test is to be commenced at a voltage of not more than one half of the full-test voltage and is to be increased progressively to full value, the time allowed for the increase of the voltage from half to full value being not less than 10 seconds. The full test voltage is then to be maintained for one minute and then reduced to one half full value before switching off.
h. 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 performed, the test voltage to be applied to such assembled group is 80% of the lowest test voltage appropriate for any part of the group.

Note: For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

4.1.2.10. No load test

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 mean and excited to give rated terminal voltage. During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.1.2.11. Running balance test

Motors are to be operated at no load and at rated speed while being supplied with a rated voltage and frequency; and in the case of a generator, driven by a suitable means and excited to give rated terminal voltage. The vibration of the machine and operation of the bearing lubrication system, where applicable, are to be checked and found satisfactory.

4.1.2.12. Verification of degree of protection

As specified in IEC Publication 60034-5.

4.1.2.13. Verification of bearings

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.

4.1.2.14. Shipboard Tests

a. Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor.
b. Each generator is to be operated for a time sufficient to show satisfactory operation, individually and in parallel, and with all possible load combinations.
c. Each motor is to be operated for a time sufficient to show satisfactory performance at such load as can readily be obtained.

CHAPTER 5 NAVIGATION SYSTEM

CONTENTS

SECTION 1 NAVIGATION LIGHT

Contents

1.1. Navigation Lights

1.1.1. Navigation lights are to be connected separately to a distribution board reserved for this purposes only, and connected directly or through transformers to the main or emergency switchboard. The distribution board is to be accessible to the officer of the watch on the bridge. Provision is to be made on the bridge for such navigation lights to be transferred to an alternate circuit.

1.1.2. Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit-breaker mounted on the distribution board.

1.1.3. Each navigation light is to be provided with an automatic indicator giving audible and/or visual indication of failure of the light. If an audible device alone is fitted, it is to be connected to an independent source of supply, e.g. a battery, with means provided to test this supply. If a visual signal is used connected in series with the navigation light, means are to be provided to prevent extinction of the navigation light due to failure of the signal. The requirements of this paragraph do not apply to tugs, trawlers and similar small ships.

1.1.4. Each navigation light is to be fitted with duplicate lamps. For navigation lights using light emitting diodes (consisting of multiple light sources) means to ensure that the overall luminous intensity of the navigation light is sufficient are to be provided in addition to the alarm to indicate the complete loss of the navigation light illumination required by [1.1.3.] of this section. For replacement navigation lights, from an existing incandescent lamp type navigation light with a light emitting diode type navigation light, details are to be submitted for consideration that demonstrate compliance. Light emitting diode type navigation lights failure detection arrangements are to satisfy the requirements as mentioned and also [1.1.5.] of this section.

1.1.5. In order to satisfy [1.1.4.] of this section, an audible and visual alarm is to be activated to notify the Officer of the Watch when the luminous intensity of the light reduces below the level required by the IMO Convention on the International Regulations for Preventing Collisions at Sea. Alternative measures to ensure continuing acceptable performance of navigation lights using light emitting diodes may be considered that are in accordance with:

a. IMO Res. MSC.253 (83), Performance Standards for Navigation Lights, Navigation Light Controllers and associated Equipment, and
b. EN 14744, Inland navigation vessels and sea-going vessels – Navigation light, or a relevant National or International Standard. Where alternative measures are proposed that require verification by personnel of the luminous intensity of navigation lights using light emitting diodes, details of the inspection implementation in the ship's safety management system and acceptance by the National Administration are to be submitted for consideration.

1.1.6. Navigation light power supply units installed to convert, control and/or monitor the distribution board power supply required by [1.1.1.] of this section above for connection to the light source(s) (e.g. for LED type navigation lights) are, in the event of a short-circuit on the unit output, to disconnect or limit the supply to prevent further damage and activate an alarm.

1.1.7. Navigation light power supply units are to be self-checking, detecting failures of the unit itself and activating an alarm. These are to include:

a. Detection of system lock-ups (program hangs);
b. Means for detecting failure of navigation light switching command input circuits or links; and

c. Means for detecting failure of the navigation light monitoring arrangements required to provide the alarms as per the requirements of [1.1.3.] and [1.1.4.] of this section, as applicable.

1.1.8. The navigation light power supply failure alarms required by [1.1.1.] of this section are not to be displayed as a group alarm. Other navigation light alarms may be grouped for each navigation light where means are provided for personnel to determine the cause of the alarm. Activation of more than one of the navigation light alarms as a result of a single failure is to be prevented.

1.1.9. Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

1.1.10. Where navigation lanterns are supplied from the main source of electrical power, the voltages at the lamp-holders shall not permanently deviate by more than 5 % above or below the rated voltage. Where, in the event of a failure of the main electric power, navigation lanterns are supplied from the emergency source of electrical power, the voltages at the lamp-holders may temporarily deviate by up to 10 % above or below the rated voltage

SECTION 2 AIDS FOR NAVIGATION

Contents

2.1. Navigation workstation

2.1.1. A workstation for navigation is to be arranged to enable efficient operation by one person under normal operating conditions. The workstation area is to be sufficient to allow at least two operators to use the equipment simultaneously. The arrangement of instruments and controls is to allow the use of all instruments and controls necessary for navigating and maneuvering in any normal working position.

2.1.2. An adequate conning position is to be provided close to the forward center window. If the view in the centerline is obstructed by large masts, cranes, etc. two additional conning positions giving a clear view ahead are to be provided, one on the port side and one on the starboard side of the centerline, no more than 5 m apart. In addition to the conning position, a second position with a view of the area immediately in front of the bridge superstructure is to be provided close to a forward window or, alternatively, the conning position is to be wide enough to accommodate two persons.

2.1.3. The main steering position is to be located on the ship’s centerline, unless the view ahead is obstructed by large masts, cranes, etc. In this case, the steering position is to be located a distance to starboard of the centerline sufficient to obtain a clear view ahead and special steering references for use by day and night are to be provided, e.g. sighting marks forward.

2.1.4. The following equipment facilities are to be provided at the navigation workstation:

a. Radar and radar plotting facilities Refer [2.1.5.] of this section;
b. Position-fixing system displays, Refer [2.1.6.] of this section;
c. Echo sounder display;
d. Speed and distance indications, Refer [2.1.11.] and [2.1.12.] of this section;
e. Gyrocompass displays Refer [2.1.7.] of this section;
f. Magnetic compass display;
g. Wind speed and direction indication;
h. Steering controls and indication, Refer sec 3 [3.2.], [3.4.], [3.5.], [3.6.] of this chapter;
i. Rate of turn indication;
j. Course/track controls and indications, Refer [2.1.8.] to [2.1.10.] of this section;
k. Main propulsion and thruster controls and indication;
l. Watch safety system acknowledge;
m. Watch safety system manual initiation;
n. Internal communications system;
o. VHF radiotelephone;
p. Time indication;
q. Window clear view controls;
r. Navigation lights controls;
s. Whistle control;
t. Morse light keys;
u. Wheelhouse/equipment lighting controls;
v. Automatic ship identification system (AIS) information;
w. Sound reception system where fitted;
x. Means to cease the distribution of long-range identification and tracking information, where required by SOLAS Ch V, Reg.19-1, 7.

2.1.5. Two functionally independent radars or alternative means are to be provided to determine and display the range and bearing of radar transponders and other surface craft, obstructions, buoys, shorelines and navigational marks. One of the radars is to operate in the X-band (9 GHz) and the other is to operate in the S-band (3 GHz).

2.1.6. At least two different automatic position-fixing systems giving a continuous display of latitude and longitude are to be provided. One of these is to be GPS or equivalent. The other is to be Loran C or equivalent, depending on the area of operation.

2.1.7. A gyrocompass or alternative means for determining, displaying and transmitting the ship's heading by ship borne, non-magnetic means, is to be provided and is to be clearly readable by the helmsman at the main steering position. The heading information is to be used directly by the radars, radar plotting aids and automatic identification system, refer to [2.1.5.] and [2.1.13.] of this section. The gyrocompass is to be provided with a gyrocompass heading repeater located at the emergency steering position in the steering gear compartment and a gyrocompass bearing repeater allowing bearings to be taken over 360°.

2.1.8. An autopilot, track control system or alternative means of automatically maintaining the ship's heading or a straight track is to be provided. At any time, it is to be possible to immediately restore manual control.

2.1.9. Heading monitoring is to be provided to monitor the actual heading information by independent heading sources. An off-course warning is to be given if the actual heading of the ship deviates from the set track course beyond a pre-set value. The pre-set off-course warning limit is to be large enough to prevent unnecessary alarms.

2.1.10. Where automatic track following is provided, sufficient warning is to be given of the approach of a waypoint, so that, in the event of no acknowledgement from the officer of the watch, there is adequate time for the backup navigator to reach the bridge and accept the change of course.

2.1.11. A speed log or alternative means of indicating the ship's speed and distance through water is to be provided. The speed through water measurement is to be used directly by the ARPA as an aid to collision avoidance.

2.1.12. A speed log or alternative means of indicating the ship's speed and distance over ground is to be provided. Speed over ground is to be indicated in both the fore-aft and athwart ships directions.

2.1.13. Navigational systems and equipment are to be of a type approved by the national administration and in conformity with appropriate performance standards not inferior to those adopted by IMO from time to time. Documentary evidence to this effect is to be submitted. Refer SOLAS 1974 as amended, Ch V, Reg. 18.

2.1.14. Where alternative means of fulfilling the navigational requirements are permitted, the means are to be approved by the national administration and in conformity with appropriate performance standards.

2.1.15. Precautions are to be taken in connection with apparatus and wiring in the vicinity of the magnetic compass to prevent disturbance of the needle from external magnetic fields.

2.1.16. Additional requirements for the navigation systems are to be comply with the following:

a. The requirements are based on the understanding that the applicable regulations and guidelines issued by the International Maritime Organization are complied with, in particular:

i. Regulations 15 to 28, Chapter V of the 1974 "International Convention for the Safety of Life at Sea" (SOLAS) and applicable amendments

ii. The international Regulations for Preventing Collisions at Sea and all other relevant Regulations relating to Radiotelegraphy, Radiotelephony and Safety of Navigation required by Chapters IV and V of SOLAS 1974, as amended
iii. The Provisional Guidelines for the Conduct of Trials in which the Officer of the Navigational Watch acts as the sole Lookout in Periods of Darkness (MSC Circular 566 of 2 July 1991)
iv. IMO A.694: 1991, General requirements for ship borne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids
v. IMO Performance Standards for navigational equipment applicable to:

- magnetic compasses (Resolution A.382)
- gyrocompasses (Resolution A.424)
- radar equipment (Resolutions A.222, A.278, A.477, MSC.64 (67) Annex 4)
- ARPA (Resolution A.422, A.823 (19))
- speed and distance measuring equipment (Resolution A.478, A.824, MSC.96 (72))
- echo sounding equipment (Resolution A.224, MSC.74 (69) Annex 4)
- radio direction finder (Resolution A.223)
- electronic navigational aids – general requirements (Resolution A.574)
- VHF Radio installation (Resolution MSC.68 (68) Annex 1, A.524 (13), A.803 (19))
- heading control systems (HCS) (Resolution A.342, MSC.64 (67) Annex 3)
- rate-of-turn indicators (Resolution A.526)
- VHF watch keeping receiver (Resolution A.803 (19), MSC.68 (68) Annex 1).

b. The requirements and guidelines of the following international standards are applicable:

i. ISO 8468 "Ships bridge layout and associated equipment – Requirements and guidelines"
ii. IEC 60872: ARPA – Operational and performance requirements – Methods of testing and required test results
iii. IEC 60936: Ship borne radar – Operational and performance requirements – Methods of testing and required test results
iv. IEC 61023: Marine speed and distance measuring equipment (SDME) – Operational and performance requirements – Methods of testing and required test results.
v. IEC Document 18 (Central Office) 534: Special features – Control and instrumentation.

c. Additional requirements may be imposed by the national authority with whom the ship is registered and/or by the Administration within whose territorial jurisdiction it is intended to operate.

2.2. Alarm and warning systems

2.2.1. Alarms associated with navigation equipment are to be both audible and visual and are to be centralized for efficient identification. Repeater displays may be fitted on the bridge wings and at other appropriate positions on the bridge where necessary.

2.2.2. The following alarms are to be provided:

a. Closest point of approach;
b. Shallow depth;
c. Waypoint approaching (where automatic track following is provided);

d. Off-course;
e. Off-track (where automatic track following is provided);
f. Steering alarms Refer sec 3, Table 5.3.1 of this chapter;
g. Navigation light failure alarms Refer sec 1, [1.1.8.] of this chapter;
h. Gyrocompass failure;
i. Watch safety system failure;
j. Failure of any power supply to the distribution panels referred to in [2.3.1.] of this section.

2.2.3. Audible signals are to be designed not to startle operators. Suitable types are shown in following table .

Table 5.2.1: Suitable audible signals

Type	Typical characteristics	Considerations
Buzzer	Low intensity and frequencies	Good alerting in quiet environment without startling
Bell	Moderate intensity and frequencies	Penetrates low frequency noise well, abrupt onset has a high alert value
Chime	Moderate intensity and frequencies	Good in quiet environment non- startling
Tone	Moderate intensity and limited frequency range	Convenient for intercom transmission, high alert value if intermittent

2.3. Power supplies

2.3.1. Local distribution panels are to be provided for all items of electrically operated navigational equipment, the telephone system, the watch safety system and the clear view systems. These panels are to be supplied by two exclusive circuits, one fed from the main source of electrical power and one fed from an emergency source of electrical power. Each item of equipment is to be individually connected to its distribution panel. The power supplies to the distribution panels are to be arranged with automatic changeover facilities between the two sources. Failure of any power supply to the distribution panels is to initiate an audible and visual alarm. This alarm should be included in the ship's alarm system, as required by Ch 8, Sec 2, [2.7.] of this part, where applicable.

2.3.2. During blackout conditions, the watch safety system and the telephone system are to remain operational, for blackout conditions Refer Ch 1, Sec 2, [2.14.] of this part.

2.3.3. Following a loss of power which has lasted for 45 seconds or less, all navigation functions are to be readily re-instated. In this respect, all navigational equipment is to recover within five minutes, with minimum operator intervention, by virtue of the emergency source and, where necessary, an uninterruptible power source.

2.4. Radio installation

2.4.1. Every radio installation as required by SOLAS 1974 as amended, Chapter IV, Part C, is to be provided with reliable, permanently arranged electrical lighting, independent of the main and emergency sources of electrical power, for the adequate illumination of the radio controls for operating the radio installation.

2.4.2. A reserve source or sources of energy is to be provided on every ship, for the purpose of conducting distress and safety radio communications, in the event of failure of the ship's main and emergency sources of electrical power. The reserve source or sources of energy is to be capable of simultaneously operating the VHF radio installation and, as appropriate for the sea or sea area for which the ship is equipped, either the MF radio installation, the MF/HF radio installation, or the INMARSAT ship earth station and any of the additional loads mentioned in [2.4.4.], [2.4.5.] and [2.4.7.] of this section for a period of at least one hour. The reserve source or sources of energy need not supply independent HF and MF radio installations at the same time.

2.4.3. The reserve source or sources of energy is to be independent of the propelling power of the ship and the ship's electrical system.

2.4.4. Where, in addition to the VHF radio installation, two or more of the other radio installations, referred to in [2.4.2.] of this section, can be connected to the reserve source or sources of energy, the reserve source or sources are to be capable of simultaneously supplying, for the period specified by [2.4.2.] of this section, the VHF radio installation and:

a. All other radio installations which can be connected to the reserve source or sources of energy at the same time; or
b. Whichever of the other radio installations will consume the most power, if only one of the other radio installations can be connected to the reserve source or sources of energy at the same time as the VHF radio installation.

2.4.5. The reserve source or sources of energy may be used to supply the electrical lighting required by [2.4.1.] of this section.

2.4.6. Where a reserve source of energy consists of a rechargeable accumulator battery or batteries a means of automatically charging the batteries is to be provided which is to be capable of recharging them to minimum capacity requirements within 10 hours.

2.4.7. If an uninterrupted input of information from the ship's navigational or other equipment to a radio installation as referred to in [2.4.2.] of this section is needed to ensure its proper performance, means are to be provided to ensure the continuous supply of such information in the event of failure of the ship's main or emergency source of electrical power.

SECTION 3 STEERING GEAR

Contents

3.1. Steering control systems: General

3.1.1. Control for steering gear is to be provided as following:

a. For the main steering gear, both on the navigating bridge and in the steering gear compartment;
b. Where the arrangement of the main steering gear is according to Pt 5A Ch 6, sec 1, [1.1.] by two independent control systems, it shall be possible that both are operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted, except in a tanker, chemical tanker or gas carrier of 10,000 tons gross and upwards;
c. For the auxiliary steering gear, in the steering gear compartment and, if power operated, it is to be also operable from the navigating bridge and is to be independent of the control system for the main steering gear.
d. Where the steering gear is so arranged that more than one control system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

3.1.2. Any main and auxiliary steering gear control system that can be operated from the navigating bridge should be in compliance with the following:

a. Provisions are to be made in the steering gear compartment for disconnecting any control system that is operable from the navigating bridges from the steering gear it serves.
b. The system should be capable of being brought into operation from a position on the navigating bridge.

3.1.3. The angular position of the rudder should be as following:

a. If the main steering gear is power operated, be indicated on the navigating bridge. The rudder angle indication is to be independent of the steering gear control system.
b. Be recognizable in the steering gear compartment.

3.1.4. Appropriate operating instructions with a block diagram showing the change-over procedures for steering gear control systems and steering gear actuating systems are to be permanently displayed in the wheelhouse and in the steering gear compartment.

3.1.5. Where the system failure alarms for hydraulic lock, refer to Table 5.3.1 of this section. Appropriate instructions shall be placed on the navigating bridge for shutting down the system a fault.

3.2. Electric power circuits

3.2.1. Two exclusive circuits are to be provided for each electric or electro hydraulic steering gear arrangement consisting of one or more electric motors.

3.2.2. The main switchboard should feed each of the circuits. One of these circuits may be from emergency switchboard.

3.2.3. One of these circuits may be connected to the motor of an associated auxiliary electric or electro hydraulic power unit.

3.2.4. Each of these circuits should have the adequate capability to supply all the motors which can be connected to it and which can operate simultaneously.

3.2.5. These circuits should be separated throughout their length as widely as is practicable.

3.2.6. In ships lesser than 1600 gross tonnage, if an auxiliary steering gear is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard. Other protective arrangements than the ones described in [3.5.1.] of this section would be given consideration, for such a motor mainly intended for other services.

3.3. Motors and associated control gear

3.3.1. To determine the required characteristics of the electric motors for power units, the breakaway torque and maximum working torque of the steering gear under all operating conditions are to be considered. The ratio of pullout torque to rated torque is to be at least 1.6.

3.3.2. Motors for steering gear power units may be rated for intermittent power demand. The rating is to be determined on the basis of the steering gear characteristics of the ship in question; the rating is always to be at least:

a. S3 - 40% for motors of electric steering gear power units.
b. S6 - 25% for motors of electro hydraulic steering gear power units and for converters.

3.3.3. Each electric motor of a main or auxiliary steering gear power unit is to be provided with its own separate motor starter gear, located within the steering gear compartment.

3.4. Electric control circuits

3.4.1. Electric control systems should be independent and separated as far as practicable throughout their length.

3.4.2. Each primary and auxiliary electric control system which can be operated from the navigating bridge is to be in compliance with the following :-

a. It is to be served with electric power by a separate circuit supplied from the associated steering gear power circuit, from a point within the steering gear compartment, or directly from the same section of the switchboard bus bars, main or emergency, to which the associated steering gear power circuit is connected.
b. Each separate circuit should be provided with short circuit protection only.
c. In the event of a failure of electrical power supply to the control system, an audible and visual alarm is to be given on the navigating bridge.

3.5. Circuit protection

3.5.1. Short circuit protection, an overload alarm and, in the case of poly-phase circuits, an alarm to indicate single phasing is to be provided for each main and auxiliary motor circuit. Protective devices are to operate at not less than twice the full load current of the motor or circuit protected and is to allow excess current to pass during the normal accelerating period of the motors.

3.5.2. Only short-circuit protection is to be provided for steering gear control system supply circuits.

3.5.3. Protection against overload current (e.g. by thermal relays), including starting current, if provided for power circuits, is to be for not less than twice the full load current of the motor circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

3.5.4. The current ratings should be two steps higher than the rated current of the motors in case where fuses are fitted. However, in case of intermittent service motors, the fuse rating is not to go beyond 160% of the rated motor current.

3.5.5. The instantaneous short-circuit trip of circuit breakers is to be set to a value not exceeding 15 times the rated current of the drive motor.

3.5.6. The protection of control circuits is to correspond to at least twice the maximum rated current of the circuit, though not, if possible, below 6 A. Refer also Ch 2, Sec 4, [4.5.7.5.] of this part.

3.6. Monitoring and alarms

3.6.1. The alarms as per the requirement of [3.5.1.] of this section are to be provided on the bridge and in the main machinery space or control room from which the main machinery is controlled normally.

3.6.2. Indicators for running indication of each main and auxiliary motor are to be installed on the navigating bridge and at a suitable main machinery control position.

3.6.3. A low-level alarm is to be provided for each power actuating system hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Alarms are to be given on the navigation bridge and in the machinery space where they can be readily observed.

3.6.4. Alarms and monitoring requirements are specified in [3.6.5.] and Table 5.3.1 of this section.

3.6.5. The alarms mentioned and described in following table are to be indicated on the navigating bridge. The additional locations described should be in compliance with the alarm system specified in Ch 8, Sec 2, [2.7.] of this part.

Table 5.3.1: Alarm requirements

Item	Alarm	Note
Rudder position	-	Indication, Refer [3.1.3.]of this section
Steering gear power units, power	Failure	-
Steering gear motors	Overload,	For alarm and running indication locations,
	Single phase	Refer [3.6.1.] and [3.6.2.] of this section
Control system power	Failure	-
Steering gear hydraulic oil level	Low	Each reservoir to be monitored. For alarm locations, Refer [3.6.3.] of this section
Auto pilot	Failure	Running indication
Hydraulic oil temperature	High	Where oil cooler is fitted
Hydraulic lock	Fault	Where more than one system (either power or control) can be operated

		simultaneously each system is to be monitored, Refer Note
Hydraulic oil filter differential pressure	High	When oil filters are fitted
Note: This alarm is to identify the system at fault and to be activated when (for example): • position of the variable displacement pump control system does not correspond with given order; or • Incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.		

3.7. Starting and stopping of motors for steering gear power units

3.7.1. Motors for power units should be capable of being started and stopped from a position on the navigation bridge and from a point within the steering gear compartment.

3.7.2. Means are to be provided at the position of motor starters for isolating any remote control starting and stopping devices (e.g. by removal of the fuse-links or switching off the automatic circuit breakers).

3.7.3. Main and auxiliary steering gear power units are to be arranged to restart automatically when power is restored after a power failure.

3.8. Separation

3.8.1. Duplicated electric power circuits & control systems are to be separated as far as practicable.

3.8.2. Cables for duplicated electric power circuits & control systems with their associated components are to be separated as far as practicable. They are to follow different routes separated both vertically and horizontally, as far as practicable, throughout their entire length.

3.8.3. Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated as far as practicable. Where physical separation is not practicable, separation may be achieved by means of a fire-retardant plate.

3.8.4. All electrical components of the steering gear control systems are to be duplicated. This does not require duplication of the steering wheel or steering lever.

3.8.5. In the event of double follow-up control, the amplifier is to be designed and fed in such a manner so that it is electrically and mechanically separated. In the event of non-follow-up control as well as follow-up-control, it is necessary to make sure that the follow-up amplifier is protected selectively.

3.8.6. Control circuits for additional control systems for example autopilot or steering lever, are to be designed for all pole disconnection.

3.8.7. The feedback units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

3.8.8. Actuators in control of the power systems of the steering gear for example magnetic valves are to be duplicated and separated.

3.9. Emergency power for steering gear

3.9.1. Where the rudder stock is required to be over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice, an alternative power supply, sufficient at least to supply the steering gear power unit which complies with the requirements stated in Pt 5A ,Ch 6,sec 1, [1.1.] and also its associated control system and the rudder angle indicator, shall be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power shall be used only for this purpose.

3.9.2. In every ship of 10000 gross tonnages and beyond it, the alternative power supply is required to have a capacity of operating continuously for at least 30 minutes and in case of any other ship for at least 10 minutes.

Where an engine driven pump or a generator is the alternative power source, the starting arrangements should be in compliance with the requirements related to the starting arrangements of emergency generators.

3.9.4 Communication

A means of communication is to be provided between the navigation bridge and the steering gear compartment. Additionally, communication is to be provided between these spaces and the main propulsion control station.

SECTION 4 THRUSTER

Contents

4.1. Electric installations

4.1.1. General

4.1.1.1. Thrusters shall be served separately by exclusive circuits fed directly from main switchboards. Where there are three or more thrusters, such exclusive circuits may be composed of at least two systems. Any one of the circuit may be supplied through emergency switchboards.

4.1.1.2. Cables used in those exclusive circuits as required in [4.1.1.1.] of this section are to be separated, as far as practicable, throughout their length.

4.1.1.3. Audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled in the event of any power failure to electric motors for propulsion and steering.

4.1.1.4. For items not specified in [4.1.1.] of this section, those requirements specified in Ch 2 of the part are to apply.

4.1.2. Maintenance of electric supplies

4.1.2.1. In cases where any generators in service are lost, main sources of electric power are to be so arranged that electric supplies to any relevant equipment are maintained or restored immediately in order to ensure the functions of propulsion and steering of at least one thruster, its associated control systems and indication devices for azimuth angles by the following arrangements:

a. In cases where electrical power is normally supplied by one generator, adequate provisions are to be made for the automatic starting and the connecting to main switchboards of standby generators of sufficient capacities to maintain the functions of the above with automatic restarting of important auxiliaries, including sequential operations, in cases of loss of electrical power to generators in operation.
b. If electrical power is normally supplied by more than one generator simultaneously in parallel operations, provisions are to be made to ensure that, in cases of loss of electrical power to one of such generating sets, the remaining ones are kept in operation to maintain the functions of those above. Refer Ch.2, sec 4, [4.5.14.] of this part.

4.1.2.2. In cases where propulsion power exceeds 2,500 kW per thruster unit, an alternative source of power is to be provided in accordance with the following:

a. The alternative source of power is to be either:

   i. An emergency source of electric power; or
   ii. An independent source of power located in the steering gear compartment and used only for this purpose.

b. Any alternative source of power is to be capable of automatically supplying alternative power within 45 seconds to the steering arrangement and its associated control system and its indication devices for azimuth angles. Alternative sources of power are to have enough capacity for the continuous operation of such systems for at least 30 minutes in every ship of 10,000 gross tonnages or more, and for at least 10 minutes in every other ship.

c. Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in [4.1.2.2. a. ii.] of this section are to comply with the requirements for starting devices and performance in (Refer Ch 2, sec 3, [3.2.] of this part).

4.2. Power generation and distribution system

For Power generation system and distribution system of vessels with DPS Notation refer Part 6 Ch 7

4.3. Position reference system and environment sensor

For position reference system and environment sensor of vessels with DPS Notation refer Pt 5A Ch 7.

4.4. Control

4.4.1. Thrusters should be capable to be brought into operation and controlled from navigation bridges.

4.4.2. Control of the Azimuth steering gears should be carried out from Azimuth thruster compartments. Provisions are to be made in the Azimuth thruster compartments for disconnecting any control system operable from navigation bridges from the steering system it serves.

4.4.3. Independent control devices are to be provided for thrusters. In cases where multiple thrusters are designed to operate simultaneously, they may be controlled by a single device such as a joystick.

4.4.4. The control devices mentioned in [4.4.3.] of this section are to be designed in such a manner that in case one control device fails, it does not result in the failure of the others.

4.4.5. As far as practicable, cables and pipes of control systems are to be separated throughout their length.

4.4.6. In cases where control systems are electric, they are to be served by their own separate circuits supplied from power circuits for thrusters from points in azimuth thruster compartments, or directly from switchboard bus bars supplying such power circuits for thrusters at points on those switchboards adjacent to such supplies to power circuits for thrusters.

4.4.7. Only control supply circuits are to have short circuit protections.

4.4.8. Audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled, in the event of any failure of control systems or of electrical power supplies to such control systems.

4.4.9. The following instruments are to be provided on navigation bridges and at all control stations of thrusters:

a. Indication devices for propeller speeds and direction of rotation in the cases of solid propellers.
b. Indication devices for propeller speeds and pitch positions in the case of controllable pitch propellers.

c. Indication devices for Azimuth angles.

4.4.10. Indication devices for those azimuth angles specified in [4.4.9.c.] of this section are to be independent of control systems.

4.4.11. Means of communication is to be provided between all control stations and navigation bridges for thrusters.

4.4.12. Thrusters of ships provided with automatic steering are to be capable of immediate change-over from automatic to manual steering.

4.4.13. Control system for dynamic positioning systems of vessels intended to be assigned with DPS notations refer Pt 5A Ch 7.

CHAPTER 6 ELECTRIC CABLES

CONTENTS

SECTION 1 GENERAL

Contents

1.1. General

The requirements of this Chapter are applicable to fixed cables on permanent installations unless otherwise exempted.

1.1.1. Cables are to be of a type approved by INTLREG or surveyed by the Surveyors during manufacture and testing to assess conformity to the applicable International or National Standards and application of an acceptable quality management system.

1.1.2. Electric cables for fixed wiring are to be designed, manufactured and tested as per the relevant IEC Publication stated in Table 6.1.1 of this section or an acceptable relevant standard.

Table 6.1.1: Electric cables

Application	IEC Publication
General constructional and testing requirements	60092-350
Fixed power and control circuits	60092-353
Instrumentation, control and communication circuits up to 60 V	60092-375
Control circuits up to 250 V	60092-376
Fixed high voltage power circuits	60502
Mineral insulated	60702

1.1.3. The use of flexible cables on permanent installations is to be limited to applications where flexibility is essential, and the lengths of such flexible cables are to be kept as short as possible. Additional requirements may be specified for flexible cable, depending on the applications.

1.1.4 For electric cables in hazardous areas, the electric cable construction and the cable glands are to achieve the appropriate seal, such that gas cannot migrate through the cable.

Note: Refer clause 3.16 and clause 4.6 of IEC 60092-350 concerning the provision of an extruded impervious inner sheath that will prevent the migration of gas through the cable.

SECTION 2 CONDUCTORS

Contents

2.1. General

2.1.1. Conductors are to be of annealed electrolytic copper with a resistivity not surpassing 17. 241 Ω-mm^2/ km at 20°C, as per IEC 60228.

2.1.2. Where the conductor insulation is made of a synthetic rubber likely to contain sulphides or vulcanized rubber, the copper wires are to be tinned or alloy coated and the surface is to be bright. Likewise, the copper wires are to be tinned or alloy coated when the insulation is composed of cambric impregnated with a product other than bitumen, unless a proficient separator is introduced in between the insulation and conductor.

2.1.3. Conductor composition and stranding is to be chosen so that sufficient flexibility of the finished cable is guaranteed. Conductors of nominal cross-section 2.5 mm^2 and less need not be stranded. This requisite does not apply to mineral-insulated cables which have solid conductors.

2.1.4. Cores of multi-core cables are to be easily identifiable.

2.2. Current rating

2.2.1. The maximum continuous load carried by a cable is not to surpass its current rating. The diversity factor (Refer Ch 2, Sec 4, [4.2.3.2.] of this part) of the individual loads and the duration of the maximum demand may be permitted for when approximating the maximum continuous load and is to be shown on the plans submitted for approval.

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

2.2.3. Cables supplying winches, cranes, windlasses and capstans are to be aptly rated for their duty. Unless the duty is such that requires a longer time rating, cables for winch or crane motors may be half hour rated on the basis of the half hour (kW) rating of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour (kW) rating of the motor. In all cases, the rating is to be subject to the voltage drop being within the specified limits.

2.2.4. The current carrying capacity for continuous service of cables given in Table 6.2.1 to Table 6.2.5 of this section is based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

Table 6.2.1 : 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 (mm^2)	**Number of conductors**		
	1	**2**	**3 or 4**
1	8	7	6
1.5	12	10	8
2.5	17	14	12
4	22	19	15
6	29	25	20
10	40	34	28
16	54	46	38
25	71	60	50
35	87	74	61
50	105	89	74
70	135	115	95
95	165	140	116
120	190	162	133
150	220	187	154
185	250	213	175
240	290	247	203
300	335	285	235

Table 6.2.2 : Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 75°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors		
	1	2	3 or 4
1	13	11	9
1.5	17	14	12
2.5	24	20	17
4	32	27	22
6	41	35	29
10	57	48	40
16	76	65	53
25	100	85	70
35	125	106	88
50	150	128	105
70	190	162	133
95	230	196	161
120	270	230	189
150	310	264	217
185	350	298	245
240	415	353	291
300	475	404	333

Table 6.2.3: Current carrying capacity, in A, in continuous service for cables based on maximum conductor operating temperature of 80°C (ambient temperature 45°C)

Nominal section (mm^2)	Number of conductors		
	1	2	3 or 4
1	15	13	11
1.5	19	16	13
2.5	26	22	18
4	35	30	25
6	45	38	32
10	63	54	44
16	84	71	59
25	110	94	77
35	140	119	98
50	165	140	116
95	260	221	182
70	215	183	151
120	300	255	210
150	340	289	238
185	390	332	273
240	460	391	322
300	530	450	371

Table 6.2.4: 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 (mm^2)	Number of conductors		
	1	2	3 or 4
1	16	14	11
1.5	20	17	14
2.5	28	24	20
4	38	32	27
6	48	41	34
10	67	57	47
16	90	77	63
25	120	102	84
35	145	123	102
50	180	153	126
70	225	191	158
95	275	234	193
120	320	272	224
150	365	310	256
185	415	353	291
240	490	417	343
300	560	476	392

Table 6.2.5: 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 (mm^2)	Number of conductors		
	1	2	3 or 4
1	20	17	14
1.5	24	20	17
2.5	32	27	22
4	42	36	29
6	55	47	39
10	75	64	53
16	100	85	70
25	135	115	95
35	165	140	116
50	200	170	140
70	255	217	179
95	310	264	217
120	360	306	252
150	410	349	287
185	470	400	329
240	570	485	399
300	660	560	462

2.3. Correction factors for current rating

2.3.1. Bunching of cables

Where more than six electric cables, which may be expected to work together at their full rated capacity, are laid close together in a cable bunch in a manner that there is no free air circulation around them, a correction factor of 0.85 is to be applied. Signal cables may be freed from this requirement.

2.3.2. Ambient temperature

The current ratings in Table 6.2.1 to Table 6.2.5 of this section are based on an ambient temperature of 45°C. However, for other values of ambient temperature, the correction factors shown in Table 6.2.6 of this section are to be applied.

Table 6.2.6 : Correction factors for various ambient air temperatures											
Maximum conductor temperature (°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	-	-	-	-	-	-	-
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	-	-
95	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

2.3.3. Short-time load

Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service (e.g. mooring winches or bow thruster propellers), the current carrying capacity attained from Table 6.2.1 to Table 6.2.5 of this section may be increased by applying the corresponding correction factors given in Table 6.2.7 of this section. In no case, a period shorter than1/2-hour is to be used, whatever the effective period of operation.

Table 6.2.7 : 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

2.3.4. Intermittent service

For supply cables to single services for intermittent loads (e.g. cargo winches or machinery space cranes), the current carrying capacity attained from Table 6.2.1 to Table 6.2.5 of this section may be increased by applying the correction factors given in Table 6.2.8 of this section. The correction factors are calculated with rough approximation for periods of 10 minutes of which 4 minutes with a constant load and 6 minutes without load.

Table 6.2.8 : Correction factors for intermittent service

Sum of nominal cross-sectional areas of all conductors (in mm^2)		Correction factor
Cables with metallic sheath and armored cables	**Cables without metallic sheath and non-armored cables**	
	S <= 5	1.10
	5 < S <= 8	1.15
	8 < S <= 16	1.20
S <= 4	16 < S <= 25	1.25
4 < S <= 7	25 < S <= 42	1.30
7 < S <= 17	42 < S <= 72	1.35
17 < S <= 42	72 < S <= 140	1.40
42 < S <= 110	140 < S	1.45
110 < S	-	1.50

2.3.5. Diversity

Where cables are used to supply two or more final sub-circuits, any diversity factors which may apply are taken into account. Refer Ch 2, Sec4, [4.2.3.2.] of this part.

2.4. Voltage drop

In determining cable size, voltage drop is to be taken into account. Under normal steady condition, the voltage drop in the conductors while carrying the maximum current is not to surpass 6% of the nominal voltage at any point of the installation. For cables connected to batteries with a voltage not surpassing 50 V, this figure may be increased to 10%.

2.5. Conductor size

2.5.1. In general, the minimum allowable conductor cross-sectional areas are those given in Table 6.2.9 of this section.

Table 6.2.9: Minimum nominal cross-sectional areas

Service	Nominal cross-sectional area	
	External wiring (mm^2)	Internal wiring (mm^2)
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

2.5.2. The cross-sectional area of the conductors is to be sufficient to ensure that, under short-circuit conditions, the maximum rated conductor temperature for short-circuit operation is not exceeded, taking into consideration the time current characteristics of the circuit protective device and the peak value of the prospective short-circuit current.

2.5.3. In three-phase distribution systems, the nominal cross-sectional area of the neutral conductor is to be equal to minimum 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm^2. In such a case, the cross-sectional area of the neutral conductor is to be equal to that of the phase.

2.5.4. For the sizing of earthing Conductors Refer Ch 2, Sec 4, Table 2.4.13 of this part.

SECTION 3 CONSTRUCTION

Contents

3.1. General

3.1.1. Electric cables constructed of stranded copper conductors, thermoplastic, elastomeric or other insulation, moisture-resistant jackets, and, where applicable, armoring and outer-sheathing are to be in accordance with IEC Publication 60092-350, 60092-351, 60092-352, 60092-353, 60092-354, 60092-359, 60092-373, 60092-374, 60092-375, 60092-376, IEEE Std-45 or other marine standards acceptable to INTLREG.

Network cables are to comply with a recognized industry standard. For electric cables in hazardous areas, the electric cable construction and the cable glands are to achieve the appropriate seal, such that gas cannot migrate through the cable.

3.1.2. Electrical cables are to be flame retardant and conforming to any of the following:

a. Depending on the intended installation, cables constructed to IEC Publication 60092 standards are to comply with the flammability criteria of IEC Publication 60332-3, category A/F or A/F/R. or
b. Cables constructed to IEEE Standard 45 are to conform to the flammability criteria contained therein.
c. Cables constructed to other standards are to comply with the flammability criteria of IEC Publication 60332-3, category A/F or A/F/R (depending on the intended installation) or other acceptable standards.

Flame-retardant marine cables which have not passed the bunched cable flammability criteria as per IEC Publication 60332-3 may be considered provided that the cable is treated with approved flame-retardant material or the installation is provided with approved fire stop arrangements. Consideration will be also given to the special types of cables such as radio frequency cable or digital communication systems which do not comply with the above requirements.

Where the network cables are installed in bunched configuration and they do not comply with IEEE Standard 45 or IEC Publication 60332-3 Category A/F or A/F/R. the installation is to be provided with approved fire stop arrangements.

3.1.3. Exemption from the requirements of [3.1.2.] of this section for applications such as radio frequency or digital communication systems, which require the use of particular types of cable, will be subject to special consideration.

3.1.4. Where electrical cables are required to be fire resistant they are to conform to the requirements of IEC Standard 60331-31 for cables with overall diameter greater than 20 mm. Otherwise, they are to conform to the IEC Standard 60331-21 for cable diameters 20 mm or less. For special cables requirements in the standards given under may be used:

a. IEC Standard 60331-23: Procedures and requirements – Electric data cables.
b. IEC Standard 60331-25: Procedures and requirements – Optical fiber cables.

Cables conforming to alternative national standards and appropriate for use in a marine environment may be considered. Fire resistant type cables are to be easily discernible, for e.g. by way of color code.

3.1.5. The over-sheath is to be of an enhanced oil resistance grade, where cables are installed in an area likely to be contaminated by oil.

3.1.6. Electric cables are to be constructed such that they are capable of withstanding the thermal and mechanical effects of the maximum short circuit current which can flow in any part of the circuit in which they are installed taking into consideration not only the time/current characteristics of the circuit protective device but also the peak value of the prospective short circuit current. Where electric cables are to be used in circuits with a maximum short circuit current in excess of 70 kA, evidence is to be submitted for consideration when required demonstrating that the cable construction can bear the effects of the short circuit current.

3.1.7. All high voltage electric cables are to be suitably marked so that they are readily identified.

3.2. Insulating materials

3.2.1. The materials used for insulation are to conform to IEC Publication 60092-351 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.

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

All electrical cables for power and lighting circuits are to have insulation suitable for a conductor temperature of not less than 60°C.

3.2.3. 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 surpass the values stated in Table 6.3.1 of this section. Special consideration will be given to other insulating materials.

Table 6.3.1: Maximum rated conductor temperature

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature (°C)	
		Normal operation	Short-circuit
a) Thermoplastic:			
- based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC/A	60	150
b) Elastomeric or thermosetting:			
- based upon ethylene-propylene rubber or similar (EPM or EPDM)	EPR	85	250
- based upon high modulus or hard grade ethylene propylene rubber	HEPR	85	250
- based upon cross-linked polyethylene	XLPE	85	250
- based upon rubber silicon	S 95	95	350
- based upon ethylene-propylene rubber or similar (EPM or EPDM) halogen free	HF EPR	85	250

Table 6.3.1: Maximum rated conductor temperature

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature (°C)	
		Normal operation	Short-circuit
- based upon high modulus or hard grade halogen free ethylene propylene rubber	HF HEPR	85	250
- based upon cross-linked polyethylene halogen free	HF XLPE	85	250
- based upon rubber silicon halogen free	HF S 95	95	350
- based upon cross-linked polyolefin material for halogen free cable (Refer 1)	HF 85	85	250
(1) Used on sheathed cable only			

3.2.4. PVC insulated cables are not put to use either in refrigerated spaces or on decks exposed to the weather of ships classed under unrestricted service.

3.2.5. Where a rubber-like material rather rubber itself is used with maximum conductor temperature of more than 60°C, it is to be easily identifiable.

3.2.6. Other insulating materials are taken into consideration.

3.3. Inner covering, fillers and binders

3.3.1. The cores of a multi-core cable are to be laid up and the spaces between them are to be filled so as to make an assembly with essentially circular cross-section. In multi-core cables having a conductor cross-sectional area not above 4 mm^2, the filling may be omitted. When over the inner covering a non-metallic sheath is applied directly or over the fillers, it may replace partially with the inner covering or fillers.

3.3.2. The materials used the binders and the thicknesses of the inner coverings are generally to be as per the IEC Publications of the series 60092-3 with respect to the type of cable.

3.4. Protective covering

3.4.1 Cables fitted in the following locations are to have an impervious sheath. In permanently wet situations, metallic sheaths are to be used for cables with hydroscopic insulation.

a. Decks exposed to weather;
b. Bathrooms;
c. Refrigerated spaces;
d. Machinery spaces; and
e. Any other location where water condensation or harmful vapor (e.g. oil vapor) may be present.

3.4.2 Where cables are provided with armor or metallic braid (e.g. for cables installed in areas which are risky), an overall impervious sheath or other means to shield the metallic elements against corrosion is to be provided.

a. Metallic armor (if not otherwise protected against corrosion) is to be secured by help of protective paint coating. The paint is to be non-flammable and of requisite viscosity. When dry, it is not to flake off.
b. The materials and construction used for (metal) armor are to be as per the guidelines of IEC Publication 60092-350 and their dimensions are to be those specified for each type of cable in the relevant standard.
c. The materials used for sheaths are to be as per the IEC Publication 60092-359 and are to have the thicknesses specified for each type of cable in the relevant standard. The quality of the materials is to be adequate to the service temperature of the cable.

3.4.3 All cables are to be of flame-retardant type (Refer [3.1.2.] of this section) or fire-resisting type (Refer [3.1.4.] of this section), except that non flame-retardant cables may be accepted for final circuits only in the cases mentioned below:

a. Where cables are installed in metallic conduits with internal diameter not surpassing 25 mm and provided the conduits are electrically and mechanically continuous.
b. Bare lead sheathed cable having conductor sections not surpassing 4.5 mm^2.

3.4.4 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.

3.4.5 Single-core cables for A.C. circuits with rated current exceeding 20 A are to be either non-armored or armored with non-magnetic material.

3.5. Cable junction boxes

Electrical equipment is to be constructed of flame-retardant, moisture resistant materials which are durable, and not subject to deterioration in the marine environment and at the temperatures to which it is likely to be exposed. Cable junction box is to be designed in such a manner that current-carrying parts with potential to earth are safeguarded against accidental contact. Live parts within the box are to be given the right kind of clearances and creepage distances or shielding by flame retarding insulation material. As per the rated voltage, each compartment within the junction boxes having different voltage levels is to appropriately identify. So that they do not put stress on the cable contacts, cables within the junction boxes are to be well supported. In general, junction boxes are to conform to a recognized standard or type approved.

3.6. Identification

3.6.1. To clearly identify and determine the manufacturer, each cable is to have clear means of identification.

3.6.2. Fire non-propagating cables are to be noticeably labeled with sign of the standard as per which this characteristic has been validated and, if applicable, of the category to which they correspond.

3.7. Propulsion cables

3.7.1. The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, are to consist of not less than seven strands and have a cross-sectional area of not less than 1.5 mm^2.

3.7.2. Silicone rubber insulated cables or ethylene-propylene rubber cross-linked polyethylene cables are to be used for propulsion power cables except where the polyvinyl chloride insulated cables may be used and the normal ambient temperature will not surpass 50°C (122°F).

3.7.3. Impervious metallic sheaths will be considered but are not to be used with single-conductor alternating-current cables.

3.7.4. In the main control gear, the insulation of internal wiring including switchboard wiring shall be of flame-retardant quality.

3.7.5. In the presence of the Surveyor, all the propulsion cables other than internal wiring in control gears and switchboards are to be subjected to dielectric and insulation tests.

3.8. Fiber optic cables

Fiber optic cables are to comply with a standard acceptable to INTLREG. The flame-retardant standard (Refer [3.1.2.] of this section) for electrical cables is also applicable to fiber optic cables.

The installation of fiber optic cables is to be in accordance with the manufacturer's recommendations to prevent sharp bends where the fiber optic cables enter the equipment enclosure. Consideration is to be given to the use of angled stuffing tubes. The cables are to be installed so as to avoid abrading, crushing, twisting, kinking or pulling around sharp edges.

3.9. Mineral insulated metal sheathed cables

Mineral-insulated cable provided with approved fittings for terminating and connecting to boxes, outlets and other equipment may be used for any service up to 600 V. At all points where a metal-sheathed and mineral-insulated cable terminates, an approved seal is to be instantly provided after stripping to prevent moisture from entering into the mineral insulation and in addition, the conductors going beyond the sheath are to be insulated with an approved insulating material. When a mineral-insulated cable is connected to equipment or boxes, the fittings are to be approved for the conditions of service. The connections are to be as per the recommendation of the manufacturer's installation.

3.10. Cable splices

Cable splice is to be made of fire resistant replacement insulation that is equivalent in thermal and electrical properties to the original insulation. The replacement jacket is to be at least equivalent to the original impervious sheath so as to guarantee a watertight splice. Splices are to be made using the splice kit which is to comprise of the following:

a. Replacement jacket;
b. Connector of correct size and number;
c. Replacement insulation;
d. Instructions for use.

All cable splices require type-testing and approval.

SECTION 4 INSTALLATION OF CABLES

Contents

4.1. General requirements

4.1.1. Cable runs are to be, as far as possible, straight and accessible and far above the bilges.

4.1.2. The installation of cables across expansion joints in any structure is to be avoided. Where such installation is unavoidable a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least twelve times the external diameter of the cable.

4.1.3. Where a duplicate supply is required and provided for any particular service the two cables are to follow different routes which are separated throughout their length as widely as is practicable to minimize the probability of simultaneous damage to the two circuits. The provision is also applicable to control circuits.

4.1.4. Generator cables, as far as possible, are to be divided between two or more cable runs. These cable runs are to be separated as far apart as practicable.

4.1.5. Cables supplying essential or important consumers are generally not to be installed in rooms where there is an excessive fire hazard such as paint stores, galleys etc.

4.1.6. Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together or where this is not practicable the cables are to be operated so that no cable reaches temperature higher than that permitted for the lowest temperature-rated cable in the group.

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

4.1.8. The minimum internal radius of cable bends which are not subjected to movements by expansion when installed is to be generally as per Table 6.4.1 of this section.

Table 6.4.1: Bending radii

Cable construction		Overall diameter of cable (D)	Minimum internal radius of bend
Insulation	**Outer covering**		
Thermoplastic or thermosetting with circular copper conductors	Unarmored or unbraided	<= 25 mm	4 D
		> 25 mm	6 D
	Metal braid screened or armored	Any	6 D
	Metal wire armored Metal tape armored or metal-sheathed	Any	6 D
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with shaped copper conductors	Any	Any	8 D
Mineral	Hard metal-sheathed	Any	6 D

4.1.9. Electric cables are not to be coated or painted with materials which may adversely affect their sheath or their fire protection.

4.1.10. Where electric cables are installed in refrigerated spaces they are not to be covered with thermal insulation but may be placed directly on the face of the refrigeration chamber provided that precautions are taken to prevent the electric cables being used as casual means of suspension. Refer also [4.9.] of this section.

4.1.11. Cable runs are normally not to include joints. However if a joint is necessary it is to be carried out with prior approval and with due consideration to methods of splicing that retain the original mechanical and electrical properties of the cable and which ensure that all conductors are adequately secured insulated and protected from atmospheric action. Terminals and busbars are to be of dimensions adequate for the cable rating.

4.1.12. Where electric cables are installed in bunches, provision is to be made to limit the spread of fire, which may be accomplished by either of the following:

a. Cables which have been tested as per IEC 60332-3 Category A or a test procedure for cables installed in bunches equivalent thereto.
b. Refer to Fig.6.4.1, 6.4.2, 6.4.3 and 6.2.4 of this section for Installation of cables.

   i. Fire stops having at least B0 penetrations fitted as follows:

      - Cable entries at the main and emergency switchboard.
      - Cable entries at centralized control panels for propulsion machinery and essential auxiliaries.
      - Where cable enter engine control rooms; and
      - At each end of an absolutely enclosed cable trunk.

   ii. In enclosed and semi enclosed spaces, cable runs are to conform to the following:

      - To entire length of vertical runs or fitted with fire stops having at least B0 penetrations, every second deck or approx. 6 m for vertical runs and at every 14 m for horizontal runs.
      - To have fire protection coating applied to minimum 1 m in every 14 m.

4.1.13. Cables having an exposed metallic screen braid or armor are to be installed in such a manner that galvanic corrosion by contact with other metals is prevented. Sufficient measures are also to be taken to prevent damage to exposed galvanized coatings during installation.

4.1.14. Protection is to be provided for cable over sheaths in areas where cables are likely to be exposed to damaging substances under normal circumstances or areas where the spillage or release of harmful substances is likely.

4.1.15. Electric cables are to be as far as practicable installed remote from sources of heat. Where installation of cables near sources of heat cannot be avoided and where there is consequently a risk of damage to the cables by heat. Suitable shields insulation or other precautions are to be installed between the cables and the heat source. The free air circulation around the cables is not to be impaired.

4.1.16. High voltage cables may be installed as mentioned below:

a. In the open (e.g. on carrier plating) when they are to be provided with a continuous metallic sheath or armor which is effectively bonded to earth to reduce danger to personnel. The metallic sheath or armor may be omitted provided that the cable sheathing material has a longitudinal electric resistance high enough to prevent sheath currents which may be hazardous to personnel;

b. Contained in earthed metallic protective casings when the cables may be as in [4.1.16. a.] of this section or the armor or metal sheath may be omitted. In the latter case care is to be taken to ensure that protective casings are electrically continuous and that short lengths of cable are not left unprotected;

c. For high voltage cable installation Refer also Ch 2, Sec 5, [5.1.5.] of this part.

4.1.17. Electric cables are to be, so far as reasonably practicable, installed remote from sources of mechanical damage. Where practicable, the cables are to be protected as per the requirements of [4.2.] of this section.

4.1.18. Where electric cables penetrate bulkheads and decks, the requirements of [4.5.] of this section are to be conformed to.

4.1.19. Where electric cables are installed in protective casings, the requirements of [4.7.] of this section are to be conformed to.

4.1.20. A.C. wiring is to be done with help of the multi-core cables, wherever reasonably practicable. Where it is mandatory to install single core electric cables for alternating current circuits in excess of 20 amperes, the requirements of [4.10.] of this section are to be fulfilled.

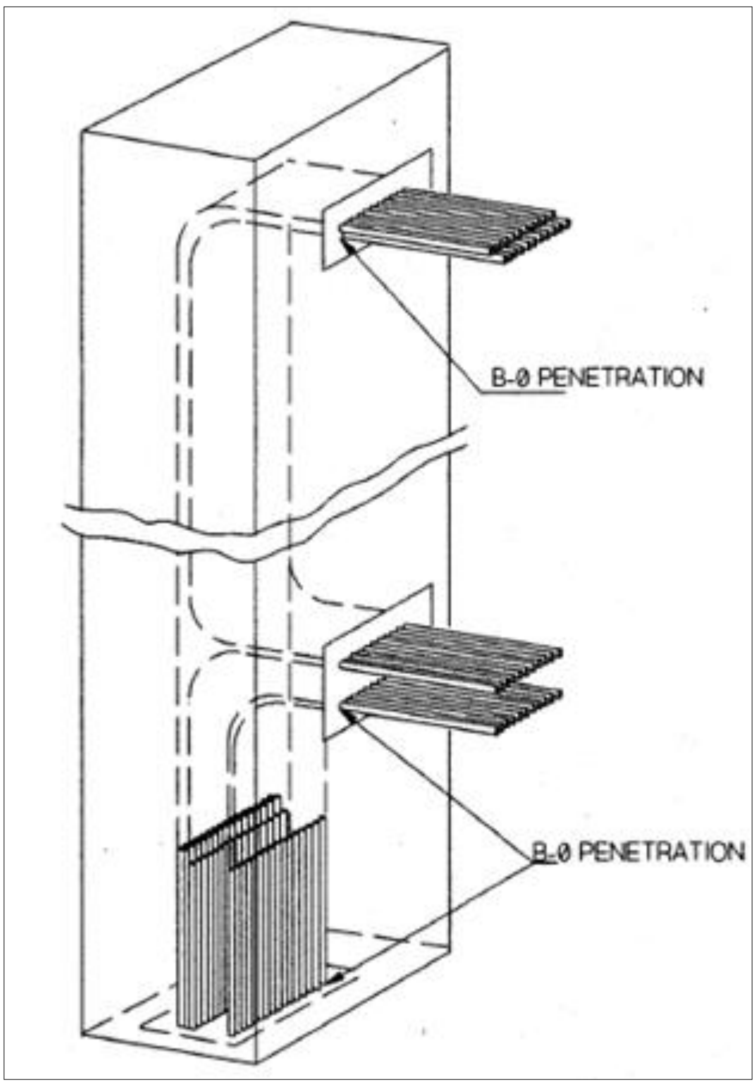


Figure 6.4.1: Totally enclosed trunks

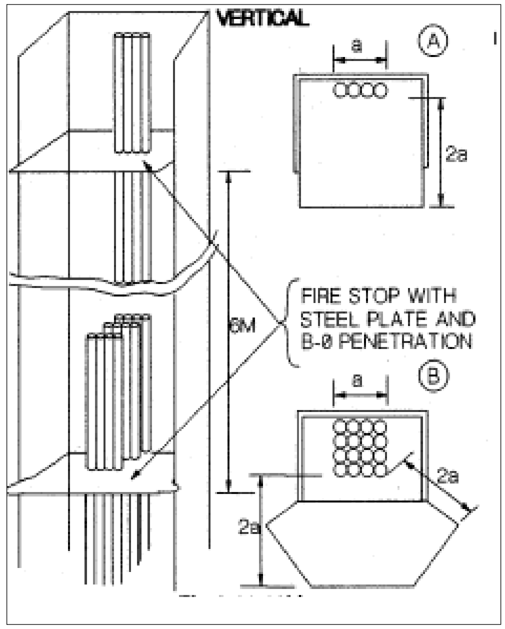
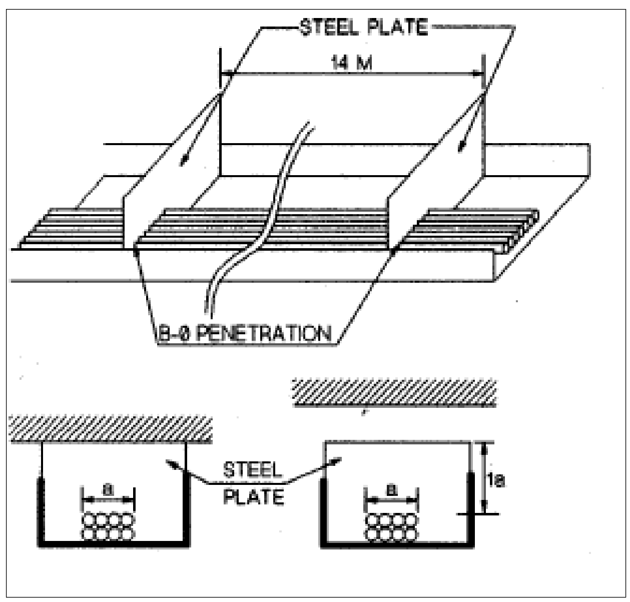


Figure 6.4.2: Non totally enclosed trunks – vertical



REMARK: THE LENGTH OF THE FIRE STOPS FOR HORIZONTAL CABLE RUNS SHOULD BE ATLEAST ONCE OF THE LARGER DIMENSION OF THE CABLE BUNCH OR UP TO THE DECK

Figure 6.4.3: Non totally enclosed trunks – horizontal

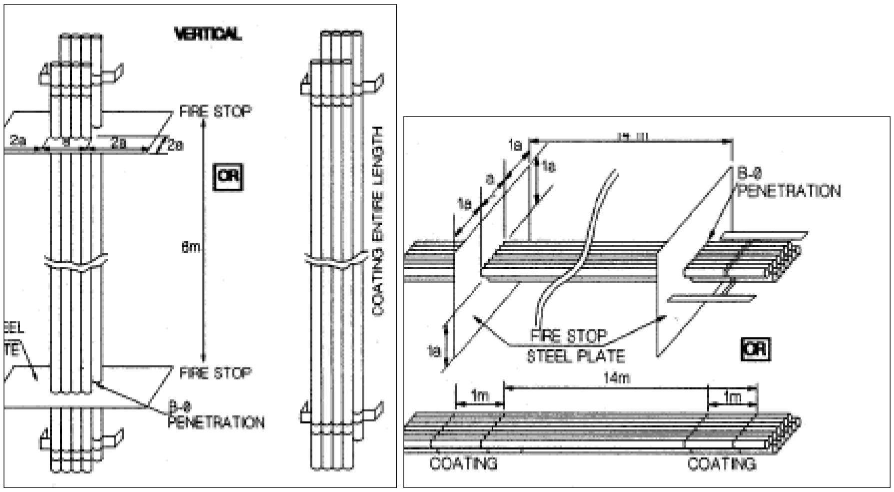


Figure 6.4.4: Open cable runs
(Note: All fire stops steel plates 3 mm thick)

Figures 6.4.1 to Figure 6.4.2: Installation of cables

4.2. Mechanical protection of cables

4.2.1. Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g. armor or metallic sheath, Refer Sec. 3, [3.4.] of this chapter) is adequate to withstand the possible damage.

4.2.2. Cables installed in locations such as within cargo holds, in way of cargo hatch openings, open decks subjected to seas, etc., even of the armored type, are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means, which are to be of sufficient strength to provide effective protection to the cables.

4.2.3. Metallic protections are to be electrically continuous and earthed to the hull. Expansion bellows or similar, where fitted, are to be accessible for maintenance.

4.2.4. Cable protective casings, pipes and similar fixtures are to be provided with drainage.

4.2.5. Metal casings for mechanical protection of cables are to be adequately protected against corrosion.

4.2.6. Non-metallic protective casings and fixings are to be flame retardant type as per the requirements of IEC Publication 92-101.

4.2.7. If cable trays/protective casings are made of plastic materials, then they are to conform to the requirements in [4.7.7.] of this section.

4.3. Earthing of metal coverings

4.3.1. Metal coverings of cables are to be effectively earthed at both ends of the cable except its final sub-circuits other than those installed in hazardous zones or spaces. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

4.3.2. The electrical continuity of all metal coverings of cables throughout the length of the cable particularly at joints and tapping is to be ascertained.

4.3.3. The lead sheath of lead-sheathed cables is not to be used as the only means of earthing the non-current carrying parts of items of equipment.

4.4. Cable support systems

4.4.1. Electric cables are installed , effectively supported and secured without being damaged to the ship's structure either indirectly by a cable support system or directly by means of clips saddles or straps to bulkheads etc.

4.4.2. Cable support systems which may be in the form of trays or plates separate support brackets, hangers or ladder racks together with their fixings and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection. The cable support system is to be effectively secured to the ship's structure the spacing of the fixings taking account of the probability of vibration and any heavy external forces e.g. where located in areas subject to impact by sea-water.

4.4.3. The distances between the points at which the cable is supported (e.g. distances between ladder rungs, support brackets, hangers. etc.) are to be chosen as per the construction of cable (i.e. size and rigidity) and the probability of vibration and are to be generally as per those given in Table 6.4.2 of this section.

Table 6.4.2: Distance between supports

External diameter of cable			
Exceeding (mm)	**Not exceeding (mm)**	**Non-armored cables (mm)**	**Armored cables (mm)**
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

4.4.4. Where the cables are laid on top of their support system, the spacing of fixings may be increased beyond those given in Table 6.4.2 of this section but should take into account the probability of movement and vibration and in general is not to exceed 900 mm. This relaxation is not to be applied where cables are subjected to heavy external forces e.g. where they are run on or above open deck or in areas subject to impact by sea-water.

4.4.5. Single core electric cables are to be firmly fixed using supports of strength that are adequate to withstand forces corresponding to the values of the peak prospective short circuit current.

4.4.6. Alternatively, cable support systems complying with a recognized standard other than IEC 60092-352 may be used where the installed cables also comply with that standard. Specifically, cable support systems meeting the requirements of IEEE 45 may be used where IEEE 45 cables are installed.

4.5. Penetration of bulkheads and decks by cables

4.5.1. Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. In either case the watertight integrity and strength of the bulkheads and decks are to be maintained. Where cables with polyvinyl chloride insulation are being installed particular care is to be taken to avoid damage to the sheathing during the fitting of watertight bulkhead glands.

4.5.2. Where fire-resisting or fire-retarding bulkheads or decks are drilled for the passage of cables all arrangements are to be such that this fire resisting or fire retarding property and strength are not diminished.

4.5.3. Where cables pass through gastight bulkheads or decks separating hazardous zones or spaces arrangements are to be such that the gastight integrity and strength of the bulkhead or deck are not impaired.

4.5.4. Where cables pass through non-watertight bulkheads or structural steel the holes are to be bushed in order to protect the cables with lead or other approved material which will prevent damage to the cables by abrasion. If the steel is 6 mm thick adequately rounded edges may be accepted as the equivalent of bushing.

4.5.5. No cable is allowed to penetrate the collision bulkhead.

4.5.6. Cables passing through decks are to be protected by deck tubes or ducts.

4.5.7. Materials used for glands and bushings are to be such that there is no risk of corrosion.

4.5.8. Where rectangular holes are cut in bulkheads or structural steel the corners are to be adequately rounded.

4.5.9. The distance from cable penetrations to flanges of steam pipes or hot oil pipes is to be not less than 500 mm.

4.5.10. Where cables pass through thermal insulation they are to do so at right angles in tubes sealed at both ends.

4.5.11. For penetration through insulated, refrigerated space bulkheads, cables are to be installed in phenolic pipes or similar heat-insulating material. The pipe may be inserted through the bulkhead stuffing tube or joined directly to the bulkhead penetration piece.

4.6. Installation of cable junction boxes

Junction boxes may be employed to connect cables provided they are of approved design Refer Sec. 3, [3.5.] of this chapter. Junction boxes are not to be used in propulsion cables. The following installation details are to be conformed to:

a. The junction box enclosures are to be apt for the installation sites.
b. Junction boxes are to be in sites accessible for inspection.
c. For low voltage systems (50 V, 110 V. etc. or up to 1 kV AC), each voltage level is to be given its own junction box or divided by physical barriers within the same junction box. For high voltage systems (> 1 kV), a distinct junction box is to be used for each of the voltage levels.
d. Normal and emergency circuits are not supposed to share the same junction box.
e. Armored cables are to have their armoring made electrically continuous.
f. Cables arranged for connection at a junction box are to be well-supported and so fastened that conductor contacts are not subjected to excessive stress.

4.7. Non-metallic cable support systems, protective casings and fixings

4.7.1. Non-metallic cable support systems and protective casings are to be installed in accordance with the manufacturer’s recommendations. The support systems and protective casings are to have been tested in accordance with an acceptable test procedure for:

a. Flame retardancy;
b. Safe working load;
c. Ambient operating temperatures;
d. Impact resistance;
e. Smoke and toxicity; and

f. Use in explosive gas atmospheres or in the presence of combustible dusts, electrical conductivity; with satisfactory results.

4.7.2. Non-metallic cable support systems protective casings and fixings installed on the open deck are to be protected from degradation caused by exposure to solar radiation.

4.7.3. Where the cable support system protective casing or fixings are manufactured from a material other than metal suitable supplementary metallic fixings or straps spaced at regular distances are to be provided such that in the event of a fire or failure the cable support system protective casing and the affixed cables are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route. Alternatively the cables may be routed away from such areas.

4.7.4. The load on non-metallic cable support systems or protective casings is not to exceed the tested safe working load.

4.7.5. When a cable support system or protective casing is secured by means of clips or straps manufactured from a material other than metal the fixings are to be supplemented by suitable metal clips or straps spaced at regular distances each not exceeding 2 m and for non-metallic cable support systems or protective casings that used during safe working load testing.

4.7.6. Non-metallic fixings are to be flame retardant type as per the requirements of IEC 60092-101 or an alternative relevant National or International Standard.

4.7.7. If cable trays/protective casings are made of plastic materials, then they are to conform to the following requirements:

a. They are to be of approved type and 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 an injury to personnel and/or an obstruction to any escape route. The spacing of their metallic fixing and straps is generally not to exceed 2 m.
b. When used on open deck they are additionally to be safeguarded against ultra-violet light.
c. The load on the plastics cable trays/protective casings is to be enclosed in the Safe Working Load (SWL) and the spacing of support, in general is not to exceed 2 m.
d. The sum of the total cross-sectional area of the cables based on their external diameter is not to exceed 40% of the internal cross-sectional area of the protective casing. However, this does not apply to a single cable in a protective casing.

4.8. Installation of cables in pipes and conduits

4.8.1. Installation of cables in pipes and conduits is to be conducted in such a manner that there is no damage to the cable covering.

4.8.2. Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit do not need earthing.

4.8.3. The internal radius of bend of pipes and conduit is to be not less than that laid down for cables provided that for pipes exceeding 64 mm diameter the internal radius of bend is not less than twice the diameter of the pipe.

4.8.4. The drawing-in factor (ratio of the sum of the cross-sectional areas of the cables. based on their external diameter. to the internal cross-section area of the pipe) is not to exceed 0.4.

4.8.5. Expansion joints are to be provided, where necessary.

4.8.6. Cable pipes and conduits are to be adequately and effectively protected against corrosion. Where necessary openings are to be provided at the highest and lowest points to permit air circulation and to prevent accumulation of water.

4.8.7. Cable pipes are to be effectively supported, particularly in sites where they are likely to be subject to heavy vibrations.

4.8.8. Cables in a conduit should belong to the same temperature class.

4.8.9. Where cables are laid in trunks the trunks are to be so constructed as not to afford passage for fire from one deck or compartment to another.

4.8.10. Cables used for cold cathode luminous discharge lamps are not to be installed in metal conduit unless protected by metal sheath or screen.

4.9. Installation of cables in refrigerated spaces

4.9.1. The installation of cables in refrigerated spaces is to be avoided as far as possible.

4.9.2. In refrigerated spaces, PVC insulated cables are not to be installed.

4.9.3. Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be shielded against mechanical damage. If an armored cable is used, the armor unless galvanized or of non-corrosive material is to be protected against corrosion with help of an additional moisture-resisting covering.

4.9.4. Cables are not to be embedded in or covered by the thermal insulation. They may be fixed to galvanized perforated plates with a space left between the back of the plate and the wall of the room.

4.9.5. Where cables entering a refrigerated space have to pass through the thermal insulation they are to be installed at right angle to such insulation and are to be protected by a pipe sealed at each end. Alternatively the cables may be passed through solid door frames the necessary holes being sealed at each end.

4.9.6. Precautions are to be taken to prevent the placing of hooks around the cable as a casual means of suspension.

4.9.7. Plating, supporting strips or hangers used for securing the cables is to be galvanized or otherwise protected against corrosion.

4.10. Installation of cables for alternating currents

4.10.1. Generally, multi-core cables are to be used in A.C. installations. Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 A the requirements of [4.10.2.] to [4.10.11.] of this section are to be complied with.

4.10.2. The cable is to be supported on non-fragile insulators

4.10.3. Cables are to be either armored with non- magnetic material or non-armored.

4.10.4. The cable armoring or any metallic protection is to be earthed at mid span or supply end only.

4.10.5. If installed in pipe or conduit cables belonging to the same circuit are to be installed in the same conduit unless the conduit or pipe is of non-magnetic material.

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

4.10.7. When installing two, three or four single-core cables forming respectively single-phase circuits and 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 case the distance between the external coverings of two adjacent cables is not to be greater than one diameter.

4.10.8. In the case of circuits using two or more parallel connected cables per phase all cables are to have the same length and cross sectional area.

4.10.9. Where single core cables of rating exceeding 50 A and over 30 m in length are used the phases are to be transposed at regular intervals of approximately 15 m in order to obtain the same degree of impedance of circuits.

4.10.10. Where single core cables of rating exceeding 50 A are used magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates all cables of the same circuit are to pass through the plate or gland so constructed that there is no magnetic material between the cables and suitable clearance is provided between the cable core and magnetic material. This clearance wherever practicable is not to be less than 75 mm when the current exceeds 300 A. For currents between 50 A and 300 A the clearance may be proportionately reduced.

4.10.11. If single-core cables of 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 A.C. circuit are installed in trefoil formation.

4.11. Installation of cables in the vicinity of radio equipment

All cables between transmitters and antennas are to be routed separately of any other cable. Where it is necessary to use single-core cables, the arrangement of conductors is to be such as to avoid complete or partial loops.

4.12. Installation of cables for submerged bilge pumps

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 and 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.

4.13. Internal wiring of switchboards and other enclosures for equipment

For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath). Other types of flame-retardant switchboard wiring may be accepted at the discretion of INTLREG. For internal wiring of switchboard Refer Ch 2, Sec 4, [4.2.10.4.] of this part.

4.14. Installation of cables for emergency and essential services

4.14.1. As far as practicable, cables and wiring for emergency and essential services (Refer Ch 1, Sec. 2, [2.2.] of this part), including electrical services required to be operable under fire condition (Refer Ch 1, Sec 2, [2.16.] of this part), are not to be subjected to high fire risk areas listed in Ch 1, Sec 2, [2.17.] of this part. These cables and wiring are to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space. In those cases when it is not possible for the cables and wiring to be routed clear of high fire risk areas, the methods applicable to passenger vessels in [4.14.2.] of this section may be considered.

4.14.2. Where cables for services required to be operable under a fire condition (Refer Ch 1, Sec 2, [2.16.] of this part) including their power supplies pass through high fire risk areas (Refer Ch. 1, Sec. 2, [2.17.] of this part) or main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be accomplished by adopting any of the following measures:

a. Fire resistant cables are installed and run continuous to keep the fire integrity within the high fire risk area.

b. 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.

c. Cables used in systems that are self-monitoring, fail safe or duplicated with cable runs separated as widely as practicable, may be exempted.

4.14.3. The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their sources of prime movers and power. They are to be of a fire resistant type (Refer Sec. 3, [3.1.4.] of this chapter), where they pass through other high fire risk areas.

4.15. Installation of cable splices

All splices are to be made with an approved splice kit, Refer Sec. 3, [3.10.] of this chapter. No splice is allowed in risk areas, except for cables with intrinsically safe circuits and neither is splice allowed in propulsion cables. Where permitted the following installation details are to be complied with:

4.15.1. All splices are to be made after the cables are in order and in sites accessible for inspection.

4.15.2. The conductor splice is to be made using a pressure type butt connector via a one-cycle compression tool.

4.15.3. Armored cables having splices are not required to have the armor replaced provided that the armor is made electrically continuous.

4.15.4. Splices are to be so arranged that mechanical stresses are not carried by the splice. Splicing of fiber optic cables is to be by means of mechanical or fusion methods as recommended by the manufacturer.

4.16. Installation of cable in hazardous area

For electric cables installed in hazardous spaces Refer Ch 3, Sec 6, [6.4.] of this part.

4.17. Cable ends

4.17.1. Soldered lugs are permitted for conductors up to 2.5 mm^2 only.

4.17.2. Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture. Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

4.17.3. Where screw-clamp or spring-clamp type terminations are used in electrical apparatus for external cable connections, cable conductors of the solid or stranded type may be put in directly in the terminals. Where flexible conductors are used, a suitable termination is to be fitted to the cable conductor to prevent ‘whispering’ of the strands.

4.17.4. If compression type conductor terminations are used on the cable ends they are to be of a size to match the conductor and to be made with a compression type tool with the dies selected to suit the termination and conductor sizes and having a ratchet action to ensure completion of the compression action.

4.17.5. Soldered sockets may be used along with non-corrosive fluxes, provided that the maximum conductor temperature at the joint under short-circuit conditions does not exceed a temperature of 160°C.

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

4.17.7. Cable terminations are to be of such a design and dimensions that the maximum current likely to flow through them will not result in degradation of the contacts or damage to insulation as the result of overheating.

4.17.8. The fixing of conductors in terminals at joints and at tapping is to be capable of withstanding the thermal and mechanical effects of short-circuit currents.

4.18. Joints and branch circuits in cable systems

4.18.1. It is vital to adequately secure, insulate and protect all the conductors in the joints from atmospheric action, if a joint is necessary. 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.

4.18.2. Tapping (branch circuits) are to be made in suitable boxes of such a design that the conductors remain suitably insulated protected from atmospheric action and fitted with terminals or busbars of dimensions appropriate to the current rating.

4.18.3. Cables of a fire-resistant type (Refer Sec. 3, [3.1.4.] of this chapter) are to be installed, so that they are continuous throughout the entire length without any joints or tapping.

SECTION 5 TESTING

Contents

5.1.Testing

Electrical cables are to be tested by the manufacturers in accordance with the standards of compliance. Records of test are to be maintained and are to be submitted upon request by INTLREG.

5.1.1. Type test

Type tests are to be as per the relevant IEC 60092-3 Series Publications and IEC 60332-1, IEC 60332-3 Category A and IEC 60331, where applicable.

5.1.2. Routine test

5.1.2.1. The following routine tests are to be carried out on every length of finished cable:

a. High voltage test;
b. Visual inspection;
c. Check of conductor cross-sectional area by measuring electrical resistance;
d. Insulation resistance measurement;
e. Dimensional checks (as necessary).

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

5.1.2.2. Power cables for electrical propulsion systems, other than internal wiring in switchboards, are to be type approved and tested for acceptance in the presence of the Surveyor.
Acceptance tests are to include at least:
a. A high voltage test
b. Insulation resistance measurement.
Where an alternative scheme, e.g. a certified quality assurance system, is recognized by the INTLREG, attendance of the Surveyor may not be required.

5.1.3. Shipboard test

5.1.3.1. Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor.

5.1.3.2. Voltage drop along power and lighting cables is to be measured. Voltage drop at any part of the installation is not to exceed the limits specified in Sec. 2, [2.4.] of this chapter.

5.1.3.3. Insulation Resistance of power and lighting cables are to be carried out as follows:
Insulation resistance of power and lighting cables is to be measured. Appliances connected to the circuits may be disconnected for this test. Each power and each lighting circuit is to have an insulation resistance between conductors and between each conductor and earth of not less than the values in Table 6.5.1 of this section.

Table 6.5.1: Insulation resistance value for power & lighting cable	
Load(A)	Insulation Resistance (MΩ)
≤ 5	2
≤ 10	1
≤ 25	0.4
≤ 50	0.25
≤ 100	0.10
≤ 200	0.05
> 200	0.025

SECTION 6 BUSBAR TRUNKING SYSTEM

Contents

6.1. Busbar trunking system

Where busbar trunking systems are used in place of electric cables, they are to conform to the requirements of [6.1.1] to [6.1.5] of this section.

6.1.1. The busbar trunking or enclosure system is to have a minimum ingress protection of IP54, as per IEC 60529: Degrees of protection provided by enclosures (IP Code).

6.1.2. The internal and external arrangements of the busbar trunking or enclosure system are to ensure that the fire and/or watertight integrity of any structure through which it passes is not impaired.

6.1.3. In places where the busbar trunking system is employed for circuits on and below the bulkhead deck, arrangements are to be made to ascertain that circuits on other decks are not adversely affected in the event of partial flooding under the normal angles of inclination.

6.1.4. Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection. The support system is to effectively secure the busbar trunking system to the ship's structure.

When accessories are fixed to the busbar system by means of clips or straps manufactured from a material other than metal the fixings are to be supplemented by suitable metal clips or straps such that in the event of a fire or failure, the accessories are prevented from failing and causing injury to personnel and/or an obstruction to any escape route. Alternatively, the busbar system may be routed away from such areas.

CHAPTER 7 SHIP SAFETY SYSTEMS

CONTENTS

SECTION 1 EMERGENCY LIGHT

Contents

1.1. Emergency lighting

1.1.1. In regard to this section on emergency lighting, transitional emergency lighting and supplementary emergency lighting are referred to under the generic term ‘emergency lighting’.

1.1.2. Emergency lighting is to be arranged so that a fire or other casualty in the spaces containing the emergency source of electrical power associated transforming equipment and the emergency lighting switchboard does not render the main lighting system inoperative.

1.1.3. The level of illumination provided by the emergency lighting should be sufficient for permitting safe evacuation in an emergency, having regard to the possible presence of smoke.

1.1.4. The exit (s) of all the main compartments occupied by passengers or crew should be continuously illuminated with the help of an emergency lighting fitting.

1.1.5. Switches are not to be installed in the final sub-circuits to emergency light fittings unless the light fittings are serving normally unmanned spaces, i.e. storage-rooms, cold rooms, etc. Where switches are fitted they are to be accessible only to ship’s crew with provision made to ensure that the emergency lighting is energized when such spaces are manned.

1.1.6. Where emergency lighting fittings are connected to dimmers, provision is to be made, upon the loss of the main lighting, to automatically restore them to their normal level of illumination.

1.1.7. Fittings are to be specially marked to indicate that they form part of the emergency lighting system.

SECTION 2 GENERAL ALARM

Contents

2.1. General Emergency Alarm Systems

2.1.1. The system is to be capable of sounding the general emergency alarm signal consisting of seven or more short blasts followed by one long blast on the vessel's whistle or siren and, additionally, on an electrically operated bell or klaxon or other equivalent system, which is to be powered from the vessel's main supply and the emergency source of power.

2.1.2. The system is to be capable of operation from at least the navigating bridge and from at least one other strategic location from which emergency situations are intended to be controlled. Fire control station, muster station, or cargo control station, etc. are examples of spaces that may be regarded as strategic locations, provided they are fitted with the means of operating the general alarm system. Attention is drawn to the Flag Administration, which may require additional stations.

2.1.3. There are to be not less than two sources of power supply for the electrical equipment used in the operation of the general emergency alarm system, one of which is to be from the emergency switchboard and the other from the main switchboard. The supply is to be provided by separate feeders reserved solely for that purpose. Such feeders are to run to an automatic changeover switch situated in, or adjacent to, the main general emergency alarm control panel.

2.1.4. An alarm is to be provided to indicate when there is a loss of power in any one of the Feeders required by [2.1.3.] of this section.

2.1.5. As an alternative to the two feeders as outlined in [2.1.3.] of this section, a battery may be considered as one of the required sources, provided the battery has the capacity of at least 30 minutes of continuous operation for alarming and 18 hours in standby. A low voltage alarm for the battery and the battery charger output is to be provided. The battery charger is to be supplied from the emergency switchboard.

2.1.6. The minimum sound pressure level for the emergency alarm tone in interior spaces is to be 80 dB(A) and 10 dB(A) above ambient noise level existing during normal equipment operation with the vessel under way in moderate weather. In cabins without a loudspeaker, an electric alarm transducer is to be installed. 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 level. Reference is to be made to IMO Resolutions A. 830(19) Codes on Alarms and Indicators.

2.1.7. Except the bells, the alarm should have a signal frequency between 200 Hz and 2.5 kHz.

2.1.8. An engineers' alarm operable at the centralized propulsion machinery control station or the propulsion machinery local control position is to be provided. It should be clearly audible in each engineer's cabin, and the sound pressure level should be in compliance with [2.1.6.] of this section.

2.1.9. Each refrigerated space is to be fitted with means to activate an alarm in a normally manned control station, operable from within such spaces for the protection of personnel.

2.1.10. Each elevator car should be fitted with means for activating an alarm in a normally manned control station or via voice communication with that station.

2.1.11. Where the special alarm fitted for summoning the crew from the navigation bridge, of fire control station forms part of the ship's general alarm system, it should be capable of being sounded independently of the alarm to the passenger spaces.

2.1.12. The general emergency alarm system should be supplemented by either a public address system which is in compliance with the requirements stated in Sec 3, [3.1.] of this chapter or other suitable means of communication.

2.1.13. The entertainment sound system is to be automatically turned off when the general alarm system is activated.

2.1.14. The system is to be audible throughout all of the accommodation and normal crew working spaces. 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.

2.1.15. In cabins without a loudspeaker installation, an electronic alarm transducer, e.g. a buzzer or similar, is to be installed.

2.1.16. The sound pressure levels are to be measured during a practical test and documented.

2.1.17. On completion of the general emergency alarm system and the public address system tests, the Surveyor is to be provided with two copies of the test schedule, detailing the measured sound pressure levels. Such schedules are to be signed by the Surveyor and the Builder.

SECTION 3 COMMUNICATION & PUBLIC ADDRESS SYSTEM

Contents

3.1. Public address systems

3.1.1. Public address systems on passenger ships and public address systems used on cargo ships to sound the general emergency alarm or the fire-alarm are to comply with the International Life-Saving Appliances (LSA) Code and the requirements of this Section.

3.1.2. The system is to have loudspeakers to broadcast messages to muster stations and to all spaces where crew is normally present.

3.1.3. The public address system is to be designed for broadcasting from the navigation bridge and at least one other emergency alarm control station situated in at least one other location for use when the navigation bridge is rendered inaccessible due to the emergency. The broadcasting stations are to be provided with an override function so that emergency messages can be broadcast even if any loudspeaker has been switched off, its volume has been turned down, or the public address system is used for other purposes.

3.1.4. The public address system is to be provided with an emergency source of electrical power as per the requirements of Ch 2, Sec 3, [3.3.] or [3.4.] of this part and also connected to the main source of electrical power with automatic changeover facilities located adjacent to the public address system. Failure of any power supply is to operate an audible and visual alarm, Refer also Sec. 2 of this chapter and Ch 8, Sec 2, [2.7.] and [2.9.] of this part.

3.1.5. The public address distribution system is to be so arranged that a fire or casualty in any one main vertical zone, as defined by SOLAS 1974 as amended Reg II-2/A, 3.32, other than the zone in which the public address control station is located, will not interfere with the distribution in any other such zone. There are to be at least two cable routes, sufficiently separated throughout their length, to public rooms, alleyways, stairways and control stations so arranged that any single electrical fault, fire or casualty will not cause the loss of the facility to broadcast emergency announcements in any public rooms, alleyways, stairways and control stations, albeit at a reduced capacity.

3.1.6. Amplifiers are to be continuously rated for the maximum power that they are required to deliver into the system for audio and, where alarms are to be sounded through the public address system, for tone signals.

3.1.7. Loudspeakers are to be rated continuously for their proportionate share of amplifier output and protected against short-circuits.

3.1.8. Amplifiers and loudspeakers are to be selected and arranged for preventing feedback and other interference. There are also to be means to automatically override any volume controls, so as to ensure the specified sound pressure levels are met.

3.1.9. Where the public address system does not form part of the internal communication equipment required in an emergency, provision is to be made, at a position adjacent to the emergency system control panel, to silence the public address system.

3.1.10. Where the public address system is used for sounding the general emergency alarm and the fire-alarm, the following requirements are to be met in addition to those specified in Sec 2 of this chapter:

a. The emergency system is the sound signals for the emergency alarms.
b. More than one device is provided for generating the sound signals for the emergency alarms.

3.1.11. Where more than one alarm is to be sounded through the public address system they are to have recognizably different characteristics and additionally be arranged so that any single electrical failure which prevents the sounding of any one alarm will not affect the sounding of the remaining alarms.

3.1.12. The following needs to be satisfied where the public address system is the only means for sounding the general emergency alarm signal and the fire alarm; in addition to the requirements of Sec 2 and Sec 3 of this chapter :

a. The system automatically overrides any other input system, when an emergency alarm is required.
b. The system automatically overrides any volume control provided to give the required output for the emergency mode when an emergency alarm is required.
c. The system is arranged to prevent feedback or other interference.
d. 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:

    i. Multiple amplifiers;
    ii. Segregated cable routes to public rooms, alleyways, stairways and control stations;
    iii. More than one device for generating electronic sound signal;
    iv. Electrical protection for individual loudspeakers against short-circuits.

e. For cargo vessels, the coverage provided by the arrangement of the system loops and speakers is to be such that after a single failure, the announcements and alarms are still audible in all spaces. Duplication of system loops and speakers in each room or space is not required provided the announcements and alarms are still audible in all spaces.
f. For passenger vessels, a single system serving for both public address and general emergency alarm functions would still be required to have at least two loops sufficiently separated throughout their length with two separate and independent amplifiers.

3.1.13. With the vessel under way, the minimum sound pressure level for broadcasting messages in interior spaces is to be 75 dB(A) and at least 20 dB(A) above the corresponding speech interference level, which is to be maintained without action from addressees.

3.1.14. The system is to be protected against unauthorized use.

3.1.15. The sound pressure levels are to be measured during a practical test using speech and, where applicable, tone signals and documented. Refer also Sec 2, [2.1.17.] of this chapter.

3.2. Internal communication systems

3.2.1. General

Means of communication should be provided between the navigation bridge and the following interior locations:

a. Centralized propulsion machinery control station, if fitted;
b. Propulsion machinery local control position;
c. Radio room, if separated from the navigation bridge;
d. Steering gear compartment;
e. For ships intended to be operated with unattended propulsion machinery spaces, each engineer's cabin and at least one public space where the alarm monitoring station is provided. Refer to [3.2.3.c.] of this section;
f. Any other positions where the speed and direction of thrust of the propellers may be controlled, if fitted.

3.2.2. Engine order telegraph

An engine order telegraph system which provides visual indication of the orders and responses both in the machinery space (the centralized control station, if fitted, otherwise propulsion machinery local control position) and on the navigation bridge is to be provided. A means of communication is to be provided between the centralized propulsion machinery control station, if fitted, and the propulsion machinery local control position. This can be a common talking means of voice communication and calling or an engine order telegraph repeater at the propulsion machinery local control position.

3.2.3. Voice communication

Means of voice communication should be provided as follows. A common system capable of serving all of the following will be acceptable:

a. A common talking means of voice communication and calling is to be provided among the navigation bridge, centralized control station, if fitted (otherwise the propulsion machinery local control position), and any other position where the speed and direction of thrust of the propellers may be controlled. Simultaneous talking among these positions is to be possible at all times and the calling to these positions is to be always possible, even if the line is busy.
b. A means of voice communication is to be provided between the navigation bridge and the steering gear compartment.
c. The engineers’ accommodation is to be included in the communication system in [3.2.3.a.] of this section, for ships intended to be operated with an unattended propulsion machinery space.

3.2.4. Power Supply

The above communication systems and system described in [3.1.] of this section are to be supplied with power (not applicable to sound powered telephones) from the emergency switchboard. The final power supply branch circuits to these systems are to be independent of other electrical systems.

For sound powered telephone systems where the calling device or any peripheral devices are electrically powered, the above requirements are applicable to the electrically powered devices.

3.3. Shipboard Tests of Internal Communications System

Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor. Satisfactory operation of the internal communications system, as required by [3.1.], [3.2.] of this section, is to be demonstrated. Particular attention is to be paid to the voice communication system for its audibility while the vessel is under way.

SECTION 4 FIRE & OTHER SAFETY SYSTEM

Contents

4.1. Fire detection and alarm systems

4.1.1. Fire detection and alarm systems are to be provided with an emergency source of electrical power required by Ch 2, Sec 3, [3.3.] or [3.4.] of this part and are also to be connected to the main source of electrical power. Separate feeders, reserved solely for this purpose, with automatic changeover facilities located in, or adjacent to, the main fire control panel are to be provided. Failure of any power supply is to operate an audible and visual alarm. Refer also Ch 8, Sec 2, [2.7.] & [2.9.] of this part.

4.1.2. Detectors and manually operated call points are to be grouped into sections. The activation of any detector or manually operated call point is to initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes an audible alarm is to be automatically sounded throughout the crew accommodation and service spaces, machinery spaces of Category A (Refer Ch 1, Sec 2, [2.12.] of this part) and control stations. This alarm sounder system need not be an integral part of the detection system.

4.1.3. Indicating units are to denote the section in which a detector or manually operated call point has operated. At least one unit is to be so located that it is easily accessible to responsible members of the crew. One indicating unit is to be located in the main fire-control station.

4.1.4. Clear information should be displayed on or adjacent to each indicating unit about the spaces covered and the location of the section and, for passenger ships, each detector and manually operated call point.

4.1.5. No section covering more than one deck within accommodation, service spaces and control stations is normally to be permitted except a section which covers an enclosed stairway. The numbers of enclosed spaces in each section are to be limited to the minimum considered necessary in order to avoid delay in identifying the source of fire. In no case are more than fifty spaces permitted in any section.

4.1.6. In passenger ships, if there is no fire detection system capable of remotely and individually identifying each detector, a section of detectors shall not serve spaces on both sides of the ship nor on more than one deck and neither shall it be situated in more than one main vertical zone except that INTLREG, if it is satisfied that the protection of the ship against fire will not thereby be reduced, may permit such a section of detectors to serve both sides of the ship and more than one deck.

In passenger ships where there are individually identifiable fire detectors, a section might serve spaces on both sides of the ship and on several decks but might not be situated in more than one main vertical zone.

4.1.7. A section of fire detectors which covers a control station, a service space or an accommodation space is not to include a machinery space of Category A.

4.1.8. The fire detection system is not to be used for any other purpose, except for closing the fire doors and similar functions may be permitted at the control panel.

4.1.9. A loop circuit of an addressable fire detection system, capable of interrogating from either end of the loop any detector served by the circuit, may comprise more than one section of detectors. Such sections are to be separated by devices which will ensure that if a short circuit occurs anywhere in the loop only the attached section of detectors will be isolated from the control panel. No section of detectors between these devices is in general to include more than 50 detectors.

4.1.10. A loop circuit of an addressable fire detection system, capable of remotely identifying from either end of the loop each detector and manually operated call point served by the circuit, may serve spaces on both sides of the ship and on several decks, but is not to be situated in more than one main vertical or horizontal fire zone, nor is a loop circuit which covers an accommodation space, service space and/or control station to include a machinery space of Category A.

4.1.11. Detectors fitted in cabins in passenger ships, when activated, should be capable of emitting or cause to be emitted, an audible alarm within the space where they are located.

4.1.12. A section of fire detectors and manually operated call points is not to be situated in more than one main vertical zone.

4.1.13. The wiring for each section of detectors and manually operated call points in an addressable fire detector system is to be separated as widely as practicable from that of all other sections on the same loop. Where practicable no loop is to pass through a space twice. When this is not practical, such as in large public spaces, the part of the loop which by necessity passes through the space for a second time is to be installed at the maximum possible distance from other parts of the loop.

4.1.14. Where it is intended that detectors be installed in external locations, e.g. cabin balconies, in addition to meeting the requirements for an environmental category suitable for open decks, Ch 8, Sec 2, [2.9.] of this part, they are also to be tested for sun irradiation and ultraviolet exposure along with satisfactory results.

4.1.15. The location of the fire control panel should be on the navigating bridge or in a central fire control station and may form of the panel specified in Ch 8, Sec 2, [2.9.] of this part. For passenger ships carrying more than 36 passengers, the fire control panel is to be located in the continuously manned central control station. If located in the firefighting station, a repeater panel is to be fitted on the navigation bridge.

4.2. Automatic sprinkler system

For automatic sprinkler system Refer Pt 5A .

4.2.1. Each section of sprinklers is to be provided with means for giving an alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems are to be constructed so as to indicate if any fault occurs in the system and with provision for testing the alarm and the indicators for each section of sprinklers.

4.2.2. In passenger ships such units are to give an indication of any fire and their locations in any space served by the system and are to be centralized on the navigating bridge or in the main fire control station, so as to ensure that any alarm from the system is immediately received by a responsible member of the crew.

4.2.3. In cargo ships such units are to indicate in which section served by the system fire has occurred and are to be centralized on the navigating bridge and in addition, alarms from the unit are to be placed in positions other than on the navigating bridge, so as to ensure that the indication of fire is immediately received by the crew.

4.2.4. Any electrically driven power pump, provided solely for the purpose of continuing automatically the discharge of water from the sprinklers, is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

4.2.5. For passenger ships, electrically driven sea-water pumps for automatic sprinkler systems are to be served by not less than two circuits reserved solely for this purpose, one fed from the main source of electrical power and one from the emergency source of electrical power. Such feeders are to be connected to an automatic change-over switch situated near the sprinkler pump and the switch is to be normally closed to the feeder from the main source of electrical power. The switches on the main and emergency switchboards are to be clearly labeled and normally kept closed.

4.2.6. The automatic alarm and detection system is to be fed by exclusive feeders from two sources of electrical power, one of which is to be an emergency source, with automatic changer-over facilities located in, or adjacent to, the main alarm and detection panel.

4.2.7. Feeders for the sea-water pump and the automatic alarm and detection system are to be arranged so as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk, except in so far as it is necessary to reach the appropriate switch boards. The cables are to be of a fire resistant type where they pass through such high risk areas.

4.3. Fire pumps

4.3.1. When the emergency fire pump is electrically driven, the power is to be supplied by a source other than that supplying the main fire pumps. This source is to be located outside the machinery spaces containing the main fire pumps and their source of power and drive units.

4.3.2. As far as is reasonably practicable the electrical cables to the emergency fire pumps are not to pass through the machinery spaces containing the main fire pumps and their source of power and/or prime mover(s). Where the ship arrangements are such that the cables have to pass through these spaces the cables are to be of a fire resistant type and specially protected against mechanical damage, e.g. run in heavy gauge pipe. The cables are to be of a fire resistant type where they pass through other high fire risk areas.

4.4. Fire doors

4.4.1. The electrical power required for the control, indication and alarm circuits of fire doors should be provided by an emergency source of electrical power as per the requirements in Ch 2, Sec 3, [3.3.] of this part. Passenger ships carrying more than 36 passengers should have an alternative supply fed from the main source of electrical power with automatic changeover facilities provided at the central control station. Failure of any power supply is to operate an audible and visual alarm, refer to Ch 8, Sec 2, [2.7.] and [2.9.] of this part.

4.4.2. The control and indication systems for the fire doors are to be designed on the fail-safe principle with the release system having a manual reset.

4.5. Fire dampers

4.5.1. The electrical power required for the control and indication circuits of fire dampers should be supplied from the emergency source of electrical power.

4.5.2. For the fire dampers, the control and indication systems are to be designed on the fail-safe principle with the release system having a manual reset.

4.5.3. In passenger ships carrying 36 passengers or more, where electrically operated fire dampers are fitted at the lower end of exhaust ducts from main laundries, they are to be capable of automatic and remote operation.

4.6. Fixed water-based local application firefighting systems

4.6.1. Where fixed water-based local application firefighting system pressure sources are reliant on external power they need only be supplied by the main source of electrical power.

4.6.2. The fire detection, control and alarm systems are to be provided with an emergency source of electrical power as per the requirements of Ch 2, Sec 3, [3.3.] or [3.4.] of this part. They are also to be connected to the main source of electrical power. Separate feeders, reserved solely for this purpose, with automatic changeover facilities located in, or adjacent to the main control panel should be provided.

4.6.3. Failure of any power supply is to operate an audible and visual alarm. Refer also to Ch 8, Sec 2, [2.7.] and [2.9.] of this part.

4.6.4. Means to activate a system are to be located at easily accessible positions inside and outside the protected space. Arrangements inside the space are to be situated such that they will not be cut off by a fire in the protected areas and are suitable for activation in the event of escape. Where it is proposed to install local activation means outside of the protected space, details are to be submitted for consideration.

4.6.5. For the sake of electrical safety of electrical and electronic equipment in areas protected by fixed water-based local application, fire-fighting systems and adjacent areas where water may extend, the requirements of [4.6.6.] to [4.6.10.] of this section are applicable.

4.6.6. As far as is practicable, electrical and electronic equipment is not to be located within protected areas or adjacent areas. The system pump, its electrical motor and the sea valve if any, may be in a protected space provided that they are outside areas where water or spray may extend.

4.6.7. High voltage equipment and their enclosures are not to be installed in protected areas or adjacent areas. For high voltage generators enclosures which cannot be fully located outside of adjacent areas due to close proximity, a technical justification, including proposed degree of protection ratings that are normally not to be lower that IP54, may be submitted for consideration that demonstrates the overall safety of the installation in the event of system operation.

4.6.8. Electrical and electronic equipment enclosures located within protected areas and within adjacent areas should provide adequate protection in the event of system operation.

4.6.9. To demonstrate compliance with [4.6.8.] of this section, evidence of the suitability of electrical and electronic equipment for use in protected areas and adjacent areas is to be submitted. The evidence is to demonstrate that additional precautions have been taken, where necessary, in respect of:

a. Satisfying [4.6.6.] and [4.6.7.] of this section;
b. Personnel protection against electric shock;
c. Cooling airflow, where necessary, for equipment required to operate during system operation; and
d. Maintenance requirements for equipment before return to operation following system activation.

Any test evidence submitted is to consider the overall installation, including equipment types, system configuration and nozzles and the potential effects of airflows in the protected space.

4.6.10. The evidence required by [4.6.9.] of this section is to demonstrate the safe and effective operation of the overall arrangements in the event of system operation. This evidence is to demonstrate that exposure to system spray and/or water:

a. Cannot result in loss of essential services (e.g. unintended activation of automatic machinery shut-down);
b. Cannot result in loss of availability of emergency services;
c. Will not affect the continued safe and effective operation of electrical and electronic equipment required to operate during the required period of system operation;
d. Does not present additional electrical or fire hazards; and
e. Would require only identified readily replaceable components to be repaired or replaced.

The installation of electrical and electronic equipment required for providing essential or emergency services in enclosures with a degree of protection less than IP44 within areas exposed to direct spray should be acceptable to INTLREG. At the same time, evidence of suitability is to be submitted accordingly.

4.6.11. Fixed water-based local application fire-fighting system electrically-driven pumps may be shared with:

a. Equivalent automatic sprinkler systems;
b. Equivalent main machinery space fire-fighting systems; or
c. Local fire-fighting systems for deep-fat cooking equipment; on the condition that the shared use is accepted by the National Administration as complying with applicable statutory regulations and the arrangements comply with the requirements of [4.6.12.] to [4.6.14.] of this section.

4.6.12. Shared electrically-driven sea-water pumps are to be served by not less than two circuits reserved solely for this purpose, one fed from the main source of electrical power and one from the emergency source of electrical power. Such feeders are to be connected to an automatic changeover switch situated near the pumps and the switch is to be normally closed to the feeder from the main source of electrical power. No other switches are permitted in the feeders. The switches on the main and emergency switchboards are to be clearly labeled and normally kept closed.

4.6.13. Failure of a component in the power and control system is not to result in a reduction of the total available pump capacity below that required by any of the areas which the system is required to protect. For equivalent automatic sprinkler systems, a failure is not to prevent automatic release or reduce sprinkler pump capacity by more than 50 per cent.

4.6.14. Where fire-fighting systems share fire-fighting pumps, failure of one system is not to prevent activation of the pumps by any other system.

4.7. Fire safety stops

4.7.1. In order to limit the fire growth potential in every space of the ship, means for controlling the air supply from Ventilation Systems to the spaces and flammable liquids within the spaces are to be provided.

4.7.2. To control air supply, a means of stopping all forced and induced draught fans, and all ventilation fans serving accommodation spaces, service spaces, control stations and machinery spaces from an easily accessible position outside of the space being served are to be provided. The position is not to be readily cut off in the event of a fire in the spaces served by the fans.

4.7.3. In passenger ships carrying more than 36 passengers, there should be a second means of stopping ventilation fans intended for accommodation spaces, service spaces and control stations is to be provided at a position as far apart from the position required by [4.7.2.] of this section as is practicable. At both positions, the controls are to be grouped so that all fans can be stopped from either of the two positions.

4.7.4. A second means of stopping ventilation fans serving machinery spaces is to be provided at a position as far apart from the position required by [4.7.2.] of this section as is practicable. At both positions the controls are to be grouped so that all fans are operable from either of the two positions. The means for stopping machinery space ventilation fans are to be entirely separate from the means for stopping fans serving all other spaces.

4.7.5. In passenger ships, the means of stopping machinery ventilation fans as required by [4.7.2.] of this section is to be located at the central control station which is to have safe access from the open deck. The central control station is to be provided with ventilation fan OFF status indications together with a means for restarting the ventilation fans.

4.7.6. In passenger ships carrying 36 passengers or more, exhaust ducts from main laundries are to be fitted with additional remote-control arrangements for shutting off the exhaust fans and supply fans from within the space and for operating electrically operated fire dampers fitted at the lower end of the duct.

4.7.7. To control flammable liquids, a means of stopping all fuel oil, lubricating oil, hydraulic oil, cargo oil and thermal oil pumps, oil purifiers from outside the spaces being served is to be provided. The position is not to be cut off in the event of a fire.

4.7.8. Means of cutting off power to the galley, in the event of a fire, is to be provided outside the galley exits, at positions which will not readily be rendered inaccessible by such a fire.

4.7.9. Following activation of any fire safety stops, a manual reset is to be provided in order to restart the associated equipment.

4.7.10. Fire safety stop systems are to be designed on the failsafe principle or alternatively the power supplies to, and the circuits of, the fire safety stop systems are to be continuously monitored and an alarm initiated in the event of a fault. Cables are to be of a fire-resistant type, Refer Ch 6, Sec 3, [3.1.4.] of this part.

4.8. Safety center on passenger ships

4.8.1. Passenger ship safety centers required by SOLAS Ch. II/2, Reg. 23 to provide a control station dedicated to assist with the management of emergency situations are to satisfy the requirements of this Section.

4.8.2. The safety center is to be either a part of the navigation bridge or to be located in a separate adjacent space having direct access to the navigation bridge.

4.8.3. Except where located in the same space, means of communication between the safety center, the central control station, the navigation bridge, the engine control room, the storage room(s) for fire extinguishing system(s) and fire equipment lockers is to be provided.

4.8.4. The operation, control and monitoring of the following arrangements, where they are required to be installed by the statutory authority, is to be additionally available from the safety center:

a. Fire doors;
b. All powered ventilation systems;
c. Public address system;
d. Watertight and semi-watertight doors;
e. General emergency alarm system;
f. Fire detection and alarm systems;
g. Fixed water based local application fire-fighting systems;
h. Automatic sprinkler systems or equivalents;
i. Water based fixed fire extinguishing systems for machinery spaces;
j. Alarm to summon the crew;
k. Flooding detection systems;
l. Fire pumps and emergency fire pumps;
m. Atrium smoke extraction system;
n. Indicators for bow and inner doors and stern and side shell doors and their closing appliances;
o. Electrically powered escape route lighting or low location lighting for evacuation guidance;
p. Remote surveillance systems for bow and inner doors and stern and side shell doors;
q. Water ingress detection for bow and inner doors and stern and side shell doors.

Operation, control and/or monitoring facilities available at the safety center are additional to any dedicated facilities required at other locations by the Rules or the Statutory Authority.

4.8.5. Where arrangements are operated, controlled and/or monitored from the safety center in accordance with [4.8.4.] of this section, they are to be in compliance with the relevant requirements of Ch 8, Sec 2, [2.6.], [2.7.], [2.9.], and [2.10.] of this part in respect of control, alarm and programmable electronic systems.

4.9. Electrically powered air compressors for breathing air cylinders

In passenger ships carrying more than 36 passengers where electrically powered air compressors are installed as part of the means required by SOLAS 1974 as amended, Chapter II-2/C, for recharging breathing apparatus air cylinders for fire-fighter's outfits, the compressors are to be supplied by the main and emergency sources of electrical power. Details of the emergency supply electrical load, supply changeover arrangements and operation under fire conditions are to be submitted for consideration. The arrangements are to be to the satisfaction of the National Administration with which the ship is registered.

4.10. Safety systems for doors & Bilge pumps

4.10.1. General - electrical power supply

4.10.1.1 The electrical power required for power-operated sliding watertight doors is to be separate from any other power circuit and supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits are to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck and for passenger ships be capable of being automatically supplied by the transitional source of emergency electrical power required by Ch. 2, Sec 3, [3.3.2.] of this part in the event of failure of either the main or emergency source of electrical power.

4.10.1.2 Availability of the power supply is to be continuously monitored at a point in the electrical circuit adjacent to the door operating equipment. Loss of any such power supply is to activate an audible and visual alarm at the central operating console at the navigating bridge.

4.10.1.3 Electrical power, control, indication and alarm circuits are to be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit. Short circuits or other faults in the alarm or indicator circuits of a door are not to result in a loss of power operation of the door. Arrangements are to be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

4.10.1.4 A single failure in the power operating or control system of power-operated sliding watertight doors is not to result in a closed door opening or prevent the hand operation of any door.

4.10.2. Watertight doors

4.10.2.1. For passenger ships, where the sources for opening and closing the watertight doors have electric motors, unless an independent temporary source of stored energy is provided, the electric motors are to be capable of being automatically supplied from the transitional source of emergency electrical power.

4.10.2.2. The enclosures of electrical components necessarily situated below the bulkhead deck are to provide suitable protection against the ingress of water with ratings as defined in IEC 60529: Degrees of protection provided by enclosures (IP Code) or an acceptable and relevant National Standard, as follows:

a. Electrical motors, associated circuits and control components, protected to IPX7 Standard.
b. Door position indicators and associated circuit components protected to IPX8 Standard, where the water pressure testing of the enclosures is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours.
c. Door movement warning signals, protected to IPX6 Standard.

4.10.2.3. On passenger ships, a central operating console is to be fitted on the navigating bridge and is to be provided with a 'master-mode' switch having:

a. A 'local control' mode for normal use which is to allow any door to be locally opened and locally closed after use without automatic closure, and;
b. a 'doors closed' mode for emergency use which is to allow any door that is opened to be automatically closed whilst still permitting any doors to be locally opened but with automatic re-closure upon release of the local control mechanism.

4.10.2.4. On passenger ships, the 'master mode' switch is to be arranged to be normally in the 'local control' mode position; be clearly marked as to its emergency function and be Type Approved

4.10.2.5. On passenger ships, the central operating console at the navigating bridge is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate a door is fully open and a green light, a door fully closed. When the door is closed remotely a red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

4.10.2.6. The arrangements are to be such that it is not possible to remotely open any door from the central operating console.

4.10.3. Stern and side shell doors

4.10.3.1. The indication system is to be arranged such that it functions independently of any system for door operation, securing and locking.

4.10.3.2. The electrical power supply for the indication system is to be independent of any electrical power supply for operating, securing and locking the doors.

4.10.3.3. The indication system is to be fed from two exclusive circuits, one from the main source of electrical power and one from the emergency source of electrical power with automatic changeover facilities located adjacent to the panel. Loss of either active or standby power supply is to initiate an audible and visual alarm on the navigation bridge.

4.10.3.4. Means are to be provided to prevent unauthorized operation of the doors and associated securing and locking devices.

4.10.3.5. Detection of door position and securing and locking device status is to be by direct sensing of proximity, contact or equivalent, not inferred from actuator positions. Sensors are to be protected against ice formation, mechanical damage and water ingress to be not less than IPX6 Standard as defined in IEC 60529, or an acceptable and relevant National Standard.

4.10.3.6. Where a strong back or equivalent independent secondary means of securing an inwardly opening door is required, these need not be monitored by the indication system providing their correct positioning can be easily observed from the control position.

4.10.3.7. For monitoring of Stern and side shell doors, Refer Ch 8, sec 4, [4.2.3.3.] of this part.

4.10.4. Bow and inner doors

4.10.4.1. For remote control of Bow and inner doors, Refer Ch 8, sec 4, [4.2.3.2.] of this part.

4.10.4.2. Means are to be provided to prevent unauthorized operation of the doors and associated securing and locking devices

4.10.4.3. For monitoring of Bow and inner doors, Refer Ch 8, sec 4, [4.2.3.3.] of this part.

4.10.4.4. The indication system is to be arranged such that it functions independently of any system for door operation.

4.10.4.5. The electrical power supply for the indication system is to be independent of any electrical power supply for operating, securing and locking the doors.

4.10.4.6. The indication system is to be fed from two exclusive circuits, one from the main source of electrical power and one from the emergency source of electrical power with automatic changeover facilities located adjacent to the panel. Loss of either active or standby power supply is to initiate an audible and visual alarm on the navigation bridge.

4.10.4.7. Detection of door position and securing and locking device status is to be by direct sensing of proximity, contact or equivalent, not inferred from actuator positions. Sensors are to be protected against ice formation, mechanical damage and water ingress to be not less than IPX6 Standard as defined in IEC 60529, or an acceptable and relevant National Standard.

4.10.4.8. For leakage monitoring of Bow and inner doors, Refer Ch 8, sec 4, [4.2.3.4.a.] of this part.

4.10.4.9. The electrical power supply for surveillance lighting is to be independent of any electrical power supply for operating, securing and locking the doors.

4.10.5. Subdivision doors on vehicle decks

Where subdivision doors are provided on passenger ship vehicle decks etc, the control and monitoring arrangements for these doors are to generally comply with [4.10.4.] of this section.

4.10.6. Bilge pumps

Where the bilge pumps for the holds of open-top container ships are electrically driven one pump is to be supplied from the emergency switchboard, the remaining pumps are to be supplied from the main source of electrical power, independent of the emergency switchboard.

4.11. Fire-extinguishing media release

4.11.1. Where it is required that alarms be provided to warn of the release of a fire-extinguishing medium, and these are electrically-operated, they are to be provided with an emergency source of electrical power, as required by Ch 2, Sec 3, [3.3.] or [3.4.] of this part, and also connected to the main source of electrical power, with automatic changeover facilities located in, or adjacent to, the fire-extinguishing media release panel, Refer also Ch 8, Sec 2, [2.7.] of this part. Failure of any power supply is to operate an audible and visual alarm, Refer also Ch 8, Sec 2, [2.7.] and [2.9.] of this part.

4.11.2. The opening of the fire-extinguishing media control cabinet door, or panel, for any purpose, other than for the release of the fire-extinguishing media, is not to cause the loss of any essential services, Refer Ch 1, Sec 2, [2.2.] of this part.

4.12. Refrigerated liquid carbon dioxide systems

4.12.1. Where there are electrically driven refrigeration units for carbon dioxide fire-extinguishing systems, one unit is to be supplied by the main source of electrical power and the other unit from the emergency source of electrical power.

4.12.2. Each electrically driven carbon dioxide refrigerating unit is to be arranged for automatic operation in the event of loss of the alternative unit.

4.13. Operation under flooding conditions

4.13.1. Flooding of spaces along the ship bottom that are not fitted with a double bottom is not to result in the loss of the ability to provide electrically operated fire, ship, crew and passenger emergency safety systems outside of the spaces.

4.13.2. Installation of electrical equipment necessary to provide fire, ship, crew and passenger emergency safety systems in spaces along the ship bottom not fitted with a double bottom is to be avoided, wherever practical. Where it is proposed to install electrical equipment, including cabling, necessary to provide fire, ship, crew and passenger emergency safety systems in such spaces, evidence is to be submitted to demonstrate that required emergency services will be available in other spaces in the event of flooding of the space not fitted with a double bottom.

4.14. Operation under fire conditions

4.14.1. As a minimum, the emergency services mentioned in Ch 1, Sec. 2, [2.16.] of this part and their emergency power supplies, are required to be capable of being operated under fire conditions.

4.14.2. Where cables for the emergency services listed in [4.14.1.] of this section pass through high fire risk areas, main vertical or horizontal fire zones other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the emergency service in any other area or zone. Refer also Ch 6, Sec 4, [4.14.2.] of this part.

4.14.3. Where the cables for the power supplies for the emergency services listed in [4.14.1.] of this section pass through high fire risk areas, main vertical or horizontal fire zones other than those which they serve, they are to be of a fire resistant type complying with Ch 6, Sec 3, [3.1.4.] of this part, extending at least to the local distribution panel serving the relevant area or zone.

4.14.4. Fire resistant electrical cables for the emergency services listed in [4.14.1.] of this section, including their power supplies, are to be run as directly as is practicable, having regard to any special installation requirements, for example those concerning minimum bend radii.

4.14.5. Materials used for electrical equipment, cables and accessories within passenger accommodation areas are not to be capable of producing excessive quantities of smoke and toxic products.

NOTE: Compliance with IEC 60695: Fire hazard testing, or an alternative and acceptable Standard, will satisfy this requirement.

4.15. Trials

It is to be demonstrated by practical tests that the Rules have been complied with in respect of fire, crew and passenger emergency and ship safety systems.

SECTION 5 EMERGENCY SHUTDOWN SYSTEM

Contents

5.1. Ventilation Systems

Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside of the spaces served. This position is not to be readily cut off in the event of a fire in the spaces served. The means for stopping the power ventilation of machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

5.1.1. Machinery spaces

Power ventilation systems serving machinery spaces are to be fitted with means for stopping the ventilation fan motors in the event of fire. The means for stopping the power ventilation serving machinery spaces is to be entirely separate from the means for stopping the ventilation of other spaces. This stopping means is to be grouped so as to be operable from two positions, one of which is to be located in the passageway leading to, but outside of, the space or at the firefighting station, if fitted. Refer Pt 5A ..

5.1.2. Cargo spaces

Electrical ventilation systems installed in cargo spaces are to be fitted with remote means of control so that the ventilation fan motors can be stopped in the event of a fire in the cargo space. These means are to be outside the cargo spaces and in a location not likely to be cut off in the event of a fire in the cargo spaces. Particular attention is to be directed to specific requirements applicable to the ventilation systems of cargo spaces of each vessel type ..

5.1.3. Other than machinery and cargo spaces

A control station for all other ventilation systems is to be located on the navigation bridge, in firefighting station, if fitted, or in an accessible position leading to, but outside of, the space ventilated.

5.2. Fuel Oil, Lubricating Oil and Thermal Oil Systems

Fuel oil transfer pumps, fuel oil unit pumps and other similar fuel pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers, but not including oily water separators) are to be fitted with remote means of stopping. These means are to be located outside the space where these pumps and separators are installed or at the firefighting station, if fitted, so that they may be stopped in the event of a fire arising in that space.

5.3. Forced-draft Fans

Forced- or induced-draft fans for boilers, incinerators, thermal oil heaters and similar fired equipment are to be fitted with remote means of stopping. These means are to be located outside the space in which this equipment is located or at the firefighting station, if fitted, so that the fans may be stopped manually in the event of a fire arising in that space.

5.4. Unattended Machinery Spaces

For vessels intended to be operated with an unattended propulsion machinery space, the emergency shutdowns of equipment in [5.1.] through [5.3.] of this section, associated with the propulsion machinery space, are to be located in the fire-fighting station, as required by Ch 8, Sec 2, [2.8.] of this part.

SECTION 6 ESCAPE ROUTE OR LOW LOCATION LIGHTING

Contents

6.1. Escape route or low location lighting (LLL)

6.1.1. The escape route or low location lighting (LLL) required by SOLAS 1974 as amended Pt D, Ch II-2, Reg. 13, 3.2.5.1, where satisfied by electric illumination, is to comply with the requirements of this Section.

6.1.2. The LLL system is to be provided with an emergency source of electrical power as required by Ch 2 , Sec 3, [3.3.] of this part and also be connected to the main source of electrical power, with automatic changeover facilities located adjacent to the control panel, Refer also Sec 4, [4.14.] of this chapter.

6.1.3. The power supply arrangements to the LLL are to be arranged so that a single fault or a fire in any one fire zone or deck does not result in loss of the lighting in any other zone or deck. This requirement may be satisfied by the power supply circuit configuration, use of fire-resistant cables complying with Ch 6, Sec 3, [3.1.4.] of this part, and/or the provision of suitably located power supply units having integral batteries adequately rated to supply the connected LLL for a minimum period of 60 minutes.

6.1.4. The performance and installation of lights and lighting assemblies are to comply with ISO Standard 15370: Ships and marine technology – Low location lighting on passenger ships.

CHAPTER 8 CONTROL SYSTEMS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1. General

1.1.1. This chapter applies to self-propelled vessels of 500 gross tons and over.

When installed, the requirements of this chapter are applicable to the following:

a. Remote control systems for propulsion machinery, controllable pitch propeller, and steering gear where it is intended that the propulsion machinery be directly controlled from the navigation bridge or from any remote propulsion control station within or outside the propulsion machinery space;
b. Where, it is intended to control and monitor the propulsion and auxiliary machinery from a continuously manned centralized control station; or
c. Where it is intended that the propulsion machinery space be periodically unmanned.
d. Safety systems for emergency diesel engines;
e. Safety systems for electric power generating plants and propulsion plants;
f. Instrumentation equipment of boiler plants.

1.1.2. For ships intended to operate with unattended machinery spaces, refer to sec 4 of this chapter.

1.1.3. Provisions for remote control of steering gears and of athwart ship or positioning thrusters are given in Ch 5, Sec 3 and sec. 4 of this part.

1.1.4. Alarm systems should satisfy the environmental requirements (Refer Ch 1, Sec 2, [2.32.] of this part).

1.2. Class notations

1.2.1. CCS notation

Where it is proposed that the propulsion and auxiliary machinery is to operate with the continuous supervision from a centralized control station, it is mandatory that the provisions of [2.13.] in sec. 2 of this chapter should be complied with and only after the verification of compliance will the class notation CCS be assigned.

1.2.2. UMS notation

Where it is being intended that the propulsion machinery space is to be periodically unmanned and that the propulsion machinery is to be controlled mainly from the navigation bridge, it is mandatory that the provisions of [4.1.] in sec. 4 of this chapter should be complied with and only after the verification of compliance will the class notation UMS be assigned.

1.2.3. ICC notation

This notation may be assigned when the arrangements are such that the control and supervision of ship operational function is computer based. It denotes that the control engineering equipment has been arranged, installed and tested in accordance with INTLREG Rules, or is equivalent thereto. Refer Sec. 5 of this chapter.

The continuance of validity of these notations is subject to periodical survey of the propulsion remote control and automation systems.

1.3. Definitions

1.3.1. General terms

1.3.1.1. Alarm indicator

It is an indicator which gives a visible and/or audible warning upon the appearance of one or more faults to advise the operator that his attention is required.

1.3.1.2. Alarm system

It is a system intended to give a signal in the event of abnormal running condition.

1.3.1.3. Automatic control

It is the control of an operation without direct or indirect human intervention, in response to the occurrence of predetermined conditions.

1.3.1.4. Automation systems

This system includes control and monitoring systems.

1.3.1.5. Unmanned propulsion machinery space

The propulsion machinery space that is operable without continuous attendance by the crew locally either in the machinery space or in a centralized control station.

1.3.1.6. Safety system

It is an automatic control system designed to automatically lead machinery being controlled to a predetermined less critical condition in response to a fault which may endanger the machinery or the safety of personnel and which may develop too fast to allow manual intervention. To protect an operating machine in the event of a detected fault, the automatic control system may be designed to automatically:

a. Start a standby support service so that normal operation is resumed by the machine.
b. Slow down the machine or reduce its demand.
c. Shut down the machine.

For the purpose of this Chapter, automatic shutdown, automatic slowdown and automatic start of standby pump are all safety system functions. Where “safety system” is stated hereinafter, it means any or all three automatic control systems.

1.3.1.7. Centralized control station

It is a propulsion control station fitted with instrumentation, control systems and actuators for enabling propulsion and auxiliary machinery be controlled and monitored, and the state of propulsion machinery space be monitored, without requiring regular local attendance in the propulsion machinery space.

1.3.1.8. Control system

A system by which an intentional action is exerted on an apparatus to attain given purposes.

1.3.1.9. Fail safe

A designed failure state which has the least critical consequence. A system or a machine is fail safe when, upon the failure of a component or subsystem or its functions, the system or the machine automatically reverts to a designed state of least critical consequence.

1.3.1.10. Full redundant

Used for describing an automation system comprising two (identical or non-identical) independent systems performing the same function and operating simultaneously.

1.3.1.11. Integrated system

It is a system consisting of two or more subsystems having independent functions connected by a data transmission network and operated from one or more workstations.

1.3.1.12. Monitoring system

A system designed for observing the correct operation of the equipment by the detection of incorrect functioning (measures of variables compared with specified value).

1.3.1.13. Systems independence

Systems performing different functions (e.g., monitoring systems, control systems, and safety systems) are to be, as much as practicable, independent of each other such that a single failure in one will not render the others inoperative. Specifically, the shutdown function of the safety system is to be independent of control and monitoring systems. However, except for the shutdown functions and automatic start/changeover of the required pumps common sensors will be acceptable for all other functions.

1.3.1.14. Failure mode and effect analysis (FMEA)

It is a failure analysis methodology used during design to postulate every failure mode and the corresponding effect or consequences. Generally, the analysis is to begin by selecting the lowest level of interest (part, circuit, or module level). The various failure modes that can occur for each item at this level are identified and enumerated. The effect for each failure mode, taken singly and in turn, is to be interpreted as a failure mode for the next higher functional level. Successive interpretations will result in the identification of the effect at the highest function level, or the final consequence. A tabular format is normally used to record the results of such a study.

1.3.1.15. Redundancy

This is the existence of more than one means for performing a required function.

1.3.1.16. Remote control

It is the control from a distance of apparatus by means of an electrical or other link.

1.3.1.17. Equipment under control (EUC)

It is the mechanical equipment (pumps, valves, machinery etc.) or environment (fire, waves, smoke etc.) monitored and/or controlled by a monitoring and control system.

1.3.1.18. Engineers’ alarm

It is an alarm system, which shall be provided to operate from the engine control room or the maneuvering platform, as appropriate, and shall be clearly audible in the engineers' accommodation.

1.3.2. Terms related to computer based system

1.3.2.1. Computer–based system

Computer–based system is defined as a system comprising of one or more microprocessors, associated software, peripherals and interfaces.

1.3.2.2. Integrated system

A combination of computer-based systems interconnected for allowing communication between computer systems; between computer systems and monitoring, control and ship management systems; and for allowing centralized access to information and/or command/control.

For example, an integrated system may consist of systems capable of performing passage execution (e.g., steering, speed control, traffic surveillance, voyage planning); machinery management and control (e.g., power management, machinery monitoring, fuel oil/lubrication oil transfer); cargo operations (e.g., cargo monitoring, inert gas generation, loading/discharging); etc.

1.3.2.3. Visual display unit (VDU)

It is normally a computer monitor, but may also be any area where information is displayed including indicator lamps or panels, instruments, mimic diagrams, light emitting diode (LED) display, cathode ray tube (CRT), and liquid crystal display (LCD).

1.3.2.4. User input device (UID)

A device from which a user may issue an input including handles, switches, buttons, keyboard, joystick, pointing device, voice sensor and other control actuators.

1.3.2.5. Software module

This is an assembly of code and data with a defined set of input and output, intended for accomplishing a function and where verification of intended operation is possible through documentation and tests.

1.3.2.6. Basic software

It is the software necessary for the hardware for supporting the application software.

1.3.2.7. Application software

This is ship specific computer software performing general tasks related to the EUC being controlled or monitored, rather than to the functioning of the computer itself.

1.3.2.8. Data communication links

It includes point to point links, instrument net and local area networks, normally used for inter-computer communication. A data communication link includes all software and hardware necessary for supporting the data communication.

1.3.2.9. Node

In a network, a node is a processing location and can be a computer or other device, say for example a printer. There is a unique network address for every node.

1.3.2.10. Interface

Interface is a transfer point where usually information is exchanged. Examples of interfaces include: input/output interface (for interconnection with sensors and actuators);communications interface (for enabling serial communications /networking with other computers or peripherals).

1.3.2.11. Peripheral

It is a device performing an auxiliary function in the system (e.g., printer, data storage device).

1.4. Documentation

1.4.1. General

Before the actual construction is commenced, the Manufacturer, Designer or Shipbuilder is to submit to the INTLREG the documents (plans, diagrams, specifications and calculations) requested in this Section. The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles. The INTLREG reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components. Plans are to include all the data necessary for their interpretation, verification and approval. Unless otherwise agreed with the INTLREG, documents for approval are to be sent in triplicate if submitted by the Shipyard and in four copies if submitted by the equipment supplier. Documents requested for information are to be sent in duplicate. In any case, the INTLREG reserves the rights to require additional copies, when deemed necessary.

1.4.2. Documents to be submitted

The documents listed in Table 8.1.1 of this section are to be submitted.

Table 8.1.1: Documentation to be submitted

No.	I/A (Refer 1)	Documentation
1	I	A general description of the operation of the system is to be given. This is to include a list of monitoring points, their alarm settings and their normal ranges.
2	A	The detailed specification of the essential service systems
3	A	The list of components used in the automation circuits, and references (Manufacturer, type, etc.)
4	I	Instruction manuals
5	I	Test procedures for control, alarm and safety systems
6	A	A general diagram showing the monitoring and/or control positions for the various installations, with an indication of the means of access and the means of communication between the positions as well as with the engineers
7	A	The diagrams of the supply circuits of automation systems, identifying the power source
8	A	The list of monitored parameters for alarm/monitoring and safety systems
9	A	Diagram of the engineers' alarm system

(1) A = to be submitted for approval; I = to be submitted for information.

1.4.3. Documents for type approval of equipment

Documents to be submitted for type approval of equipment are listed hereafter:

a. A request for type approval from the manufacturer or his authorized representative;
b. The technical specification and drawings depicting the system, its components, characteristics, working principle, installation and conditions of use and, when there is a programmable electronic system, the documents listed in table 8.1.2 of this section;
c. Any test reports previously prepared by specialized laboratories.

Table 8.1.2: Documents to be submitted for programmable electronic system

No.	I/A (Refer 1)	Documentation (Refer 2)
1	A	System block diagram, showing the arrangement of individual parts, input and output devices and interconnection
2	A	Wiring connection diagrams, including details of electrical power supplies and of input & output devices
3	A	System functional description
4	I	Software system description and documentation
5	I	User interface description
6	I	Test programs

(1) A = To be submitted for approval; I = To be submitted for information.

(2) Refer as guidance IEC 60092-504 clause 10.11

1.4.4. Plans

1.4.4.1. Plans for the control, alarm and safety systems of the following are to be submitted:

a. Air compressors;
b. Bilge and ballast systems;
c. Cargo pumping systems for tankers;
d. Cargo and ballast pumps in hazardous areas;
e. Controllable pitch propellers;
f. Electric generating plant;
g. Fixed water based local application fire-fighting systems;
h. Incinerators;
i. Inert gas generators;
j. Main propelling machinery including essential auxiliaries;
k. Miscellaneous machinery or equipment (where control, alarm and safety systems are specified by other Sections of the Rules);
l. Oil fuel transfer and storage systems;
m. Steam raising plant. (Boilers and their ancillary equipment);
n. Steering gear;

o. Thermal fluid heaters;
p. Transverse thrust units;
q. Valve position indicating systems;
r. Waste-heat boiler;
s. Water-jets for propulsion purposes;
t. Cargo tank, ballast tank and void space instrumentation where such arrangements are specified by other sections of the Rules (e.g. water ingress detection, gas detection).

1.4.4.2. Where control, alarm and safety systems are intended for the machinery or equipment the following are to be submitted:

a. Description of operation with explanatory diagrams;
b. Line diagrams of control circuits;
c. List of monitored points;
d. List of control points;
e. List of alarm points;
f. Test schedules (for both works testing and sea trials) which should include methods of testing and test facilities provide;
g. Failure Mode and Effects Analysis (FMEA) where required by other sections of the Rules;
h. List of safety functions and details of any overrides.

1.4.4.3. Details of the overall alarm system linking the main control station, subsidiary control stations, the bridge area and accommodation are to be submitted.

1.4.4.4. In addition to the documentation required by Sec 5, [5.9.] of this chapter the following is to be submitted for programmable electronic systems:

a. System requirements specification;
b. System integration plan;
c. Failure Mode and Effects Analysis (FMEA);
d. Details of the hardware configuration in the form of a system block diagram, including input/output schedules;
e. Hardware certification details;
f. Software quality plans, including applicable procedures;
g. Factory acceptance, integration and sea trial test schedules for hardware and software;
h. Details of data storage arrangements.

1.4.4.5. Schematic diagrams and operational descriptions for the following items of propulsion remote control system are to be submitted:

a. Propulsion control (e.g., from Navigation Bridge, centralized control station, etc.);
b. Control transfer;
c. Independent local manual control;
d. Starting of propulsion machinery;
e. Critical speeds;
f. Shaft turning gear;
g. Propulsion manual emergency shutdown;
h. Navigation bridge instrumentation;
i. Communications systems.

1.4.4.6. Operational descriptions for the following items of propulsion machinery control from the centralized control station are to be submitted:

a. Propulsion steam turbines;
b. Propulsion gas turbines;
c. Propulsion diesel engines;
d. Electric propulsion.

1.4.4.7. Operational descriptions for the following items of propulsion machinery safety system are to be submitted:

a. Initiation of automatic shutdown;
b. Initiation of automatic slowdown;
c. Initiation of automatic starting of standby units;
d. Override of automatic shutdown;
e. Override of automatic slowdown;
f. Re-start of propulsion machinery.

1.4.4.8. Description of monitoring systems including a list of alarms and displays including preset parameters for the following items:

a. Centralized control station alarm and instrumentation;
b. Monitoring station in the engineers accommodation;
c. Navigation bridge instrumentation.

1.4.4.9. Schematic diagrams and operational descriptions of the propulsion boiler the following are to be submitted:

a. Prevention of excessive steam;
b. Automatic shutdown;
c. Automatic ignition;
d. Trial-for-ignition period;
e. Automatic burner light off;
f. Burner primary-air or atomizing steam;
g. Post purge;
h. Boiler limit systems;
i. Modulated air-fuel ratio.

1.4.4.10. Schematic diagrams and operational descriptions for the remote control, monitoring and safety systems of generator prime movers including, but not limited to, the list of alarms and displays, initiation of automatic shutdown, automatic changeover of prime mover auxiliaries, preset parameter, etc., at each of the following control stations, as applicable:

a. Centralized control station;
b. Navigation bridge;
c. Monitoring station in engineer’s accommodation.

1.4.4.11. Schematic diagrams and operational descriptions for the following auxiliary machinery controls:

a. Controls from the centralized control station;

b. Control of the electric generators, including the automatic starting of the generators; and
c. The electric power management system;
d. Control of auxiliary machinery;
e. Automatic starting of vital auxiliary pumps.

1.4.4.12. For Failure modes and effect analysis (FMEA) information containing at least the following:

a. System block diagrams showing system breakdown and components of interests.
b. A tabulation of the following:

i. Systems and components of interests;
ii. Potential failures;
iii. Failure detection;
iv. Responses of the system to the failures;
v. Possible consequences of the failures;
vi. Conclusions, comments or recommendations.

1.4.4.13. Schematic diagrams and arrangements of the internal communication systems.

1.4.4.14. Schematic diagrams and operational descriptions of power supply to the control, monitoring and safety systems.

1.4.4.15. Schematic diagrams, parts list (including manufacturer’s names and model names), function descriptions, construction plans and outline view for the control console plan of the following equipment:

a. Navigation bridge console;
b. Centralized control and monitoring console.

1.4.4.16. Plans showing the system operation and the type and location of all machinery space fire detector heads, manual call points and the fire detector indicator panel(s) are to be submitted. The plans are to indicate the position of the fire detectors in relation to significant items of machinery, ventilation and extraction openings.

1.4.4.17. Where it is intended to employ a standard system which has been previously approved, plans are not required to be submitted, on the condition that there have been no changes in the applicable Rule requirements. The building port, where applicable, and date of the previous approval is to be advised.

1.4.4.18. Type, size and protection of cables between control and monitoring equipment. For details of instrumentation and control system cabling requirements, Refer Sec. 6, [6.3.] of this chapter.

1.4.4.19. Locations of centralized control station and remote control stations on the navigation bridge; arrangements of the centralized control station containing control consoles and other equipment, including glass windows, doors, and ventilation fitting, as applicable.

1.4.5. Operational guidance manual

For reference, an operational guidance manual is to be provided on board the ship and it should contain the necessary system technical information and give operating instructions for normal and emergency operations.

1.5. Alterations and additions

1.5.1. It is mandatory to submit plans for approval in case any alteration or addition to the approved system(s) is proposed. The alterations and additions are to be carried out under survey and the installation and testing should be to the satisfaction of the Surveyor.

1.5.2. Details of proposed software modifications are to be submitted for consideration. Where the modification may affect compliance with these Rules, proposals for verification and validation are also to be submitted.

1.5.3. Software versions are to be uniquely identified by number, date or other appropriate means. Modifications are not to be made without also changing the version identifier. A record of changes to the system since the original issue (and their identification) is to be maintained and made available to the INTLREG on request.

1.6. Location of controls

1.6.1. Ship motion and anticipated structural vibrations requires to be considered while selecting the locations of main and associated secondary control locations.

1.6.2. The control locations are to be well ventilated and air conditioning is to be provided for the control consoles when required by the operational characteristics of the components within the consoles. There is to be an alarm for failure of the console integral air conditioning.

1.6.3. Enclosed main control location located within the machinery spaces are to have two means of access located as remote from each other as practicable.

1.6.4. The leading of pipes in the vicinity of control console is to be avoided as far as possible. When such leads are necessary, care is to be taken to fit no flanges or joints over or near the console unless provision is made to prevent any leakage from injuring the equipment.

1.6.5. Glass in a control room located within or adjacent to the machinery space is to be of the shatter resistant type.

1.6.6. When the main control for the propulsion plant is to be situated in a location remote from the propulsion machinery space, details of special arrangements are to be submitted to show that the operation of the propulsion plant would be as effective as with the main control located within or adjacent to the machinery space.

1.6.7. The main control location is to provide control of the propulsion plant and associated ship's service system including starting, stopping, and for changeover of vital pumps and motors, and is to provide effective means for monitoring temperatures, pressures, the electrical system, fluid and gas flows, liquid levels and other variables which are essential for the propulsion plant operation.

The main control location is to be fitted with alarms and emergency trips as required together with indicators and is to have means for the assessment of the operational status of all machinery and systems vital to the propulsion of the vessel.

Control functions from the console may be designed for either 'remote manual' or 'automatic control'. Means are to be provided for independent manual control, at or near the machinery concerned, in the event of failure of a particular control in the centralized control system.

1.6.8. In general, secondary control locations for the control of propulsion machinery from the bridge or other locations on board are to be kept as simple as possible and provided with only those indicators and controls necessary for the effective control of speed and direction of the propulsion engines, and of the controllable-pitch propeller where fitted, for normal operation.

1.6.9. Control consoles should be preferably self-supported with the sides and backs suitably protected. Where necessary, protection is to be provided for consoles which might be subject to damage by leaks or falling objects.

SECTION 2 SYSTEM REQUIREMENTS

Contents

2.1. General

2.1.1. All control systems essential for the propulsion, should be designed in such a manner that failure of one system does not degrade the performance of another system. Safety functions should be independent of control and monitoring functions. Specifically, the shutdown function of the safety system is to be independent of control and monitoring systems.

2.1.2. Local manual controls are to be fitted for enabling safe operation during commissioning and maintenance and allowing effective control in the event of an emergency or failure of remote control. The fitting of remote controls should not compromise the level of safety and operability of the local controls.

2.1.3. Automation systems (Refer Sec. 1, [1.3.1.4.] of this chapter) are to be constructed as:

a. To have necessary facilities for maintenance work;
b. To withstand environmental conditions;
c. Easy identification of failures;
d. Easy installation and safe handling in the event of replacement of parts (plug and play principle) without impairing the operational capability of the system, as far as practicable.
e. Facility for adjustment of calibration;
f. Test point facilities, to verify the proper operation of components.

2.1.4. Control, monitoring and safety systems should have self-check facilities. An alarm is to be activated in the event of a failure.

2.1.5. A fail-safe concept (Refer Sec. 1, [1.3.1.9.] of this chapter) is to be applied to the design of all remote control systems, manual emergency control systems and safety systems. In consideration of its application, due regard is to be given to the safety of individual machinery, the system of which the machinery forms a part and the vessel as a whole.

2.1.6. FMEA (Refer Sec. 1, [1.3.1.14.] of this chapter) may be carried out during system design to investigate if any single failure in control systems would lead to undesirable consequences such as loss of propulsion, loss of propulsion control, etc. The analysis may be qualitative or quantitative. In particular, failure of the power supply of the automation system is to generate an alarm.

2.2. Materials

Explosive materials and materials which may develop toxic gases shall not be used. Covers, termination boards, printed circuit cards, constructive elements and other parts that may contribute to spreading fire shall be of flame-retardant material.

The equipment that are components of the control, monitoring and safety systems of propulsion machinery, propulsion boilers, vital auxiliary pumps and the electrical power generating plant including its prime mover for vessels to be assigned with CCS or UMS notation.

Control, safety and monitoring equipment is to be designed such that it will successfully withstand the test conditions stipulated in Sec. 7, Table 8.7.3 of this chapter, as applicable. Upon request by the manufacturer, equipment designed to environmental conditions in excess of those in Sec. 7, Table 8.7.3 of this chapter may be tested to such conditions and certified accordingly. For equipment test Refer Sec. 7, [7.2.5.] of this chapter.

Where equipment is designed to operate only in a temperature-regulated environment, the temperature regulating system (such as air-conditioner) is to be backed up by a stand-by unit. Failure of the system is to be alarmed.

Electric and electronic equipment that are components of control, safety and monitoring systems are to be designed and constructed in accordance with the applicable requirements of Ch 1 to Ch 7 of this part.

Hydraulic equipment is to be suitable for the intended service, compatible with the working fluid. The hydraulic fluid is to be non-flammable or have a flash point above 157°C (315°F).

Pneumatic equipment is to be suitable for the intended service.

2.3. Marking

All units and test points are to be clearly and permanently marked. Transducers, actuators and controllers shall be marked with their system function for being easily and clearly identified in instrument lists and plans.

2.4. Power supply

2.4.1. Power source for control, monitoring and safety systems may be electric, hydraulic or pneumatic or a combination thereof. Each power supply is to be monitored and its failure is to be alarmed.

2.4.2. Where power supply is electric, each of the control, monitoring and safety systems is to be supplied by a separate circuit. The control systems are to be served by two feeders from the main switchboard. One of the feeders may be from the emergency switchboard, if provided. Transfer may be by manual or automatic switch installed in or adjacent to the control console. The feeder from the transfer switch to the control console may be through a single cable. These feeders are not to supply power for any other machinery. This applies to both single and redundant control and monitoring systems. Each of these circuits is to be protected for short circuit and monitored for voltage failure.

2.4.3. Redundant control and monitoring systems for important services, and control and monitoring systems required to be independent, shall be supplied by independent power supplies. Redundant units in an integrated control and monitoring systems shall be provided with independent power supplies.

2.4.4. For control and monitoring systems where both un-interruptible and independent power supplies are required, at least one of the supplies shall be provided with stored energy. If the user interface is required to be duplicated, the requirement for independent power supplies also applies to the user interface. If uninterruptible power supply is required for the control system, this also applies at least one user interface at the dedicated work stations.

2.4.5. The following categories of control and monitoring systems shall be provided with uninterruptible power supply:

a. Control and monitoring systems required to be operable during black-out (Refer Ch 1, Sec 2, [2.14.] of this part).
b. Control and monitoring systems required to restore normal conditions after black-out.
c. Control and monitoring systems serving functions with redundancy type R0.

d. Control and monitoring systems serving functions with redundancy type R1 - unless the control and monitoring system will be immediately available upon restoration of main power supply (i.e. no booting process).
e. Control and monitoring systems for services with other redundancy types if the restoration time of the control and monitoring system exceeds the corresponding allowed unavailable time.
f. Certain control and monitoring systems where specific requirements for stand-by power supply are given.

The capacity of the stored energy providing the un-interruptible power shall be at least 30 minutes, unless otherwise specified.

2.4.6. The feeders supplying power to the control console are to be provided with short-circuit protection at the main switchboard and emergency switchboards, if provided. Where circuits within the control consoles are protected by fuses or circuit breakers, the control-system protection is to be subdivided and arranged so that failure of one set of fuses or circuit breakers will not cause failure of another circuit or system and it is to be possible to isolate the defective system.

2.4.7. The power for monitoring, alarms and emergency action is to be supplied automatically from an emergency source upon failure of ship's service power supply. An audio/visual alarm is to be provided at the main control location to indicate failure of power supply.

2.4.8. Cables and console wiring for control and monitoring should be of the flame-retarding type (Refer Ch 6, Sec 3, [3.1.2.] of this part) and should be stranded except that solid conductors might be used in low energy circuits, where they are properly supported and not subject to undue vibration or movements.

2.4.9. Conductors for monitoring circuits which carry low-level or information-level signals are to be installed in such a manner or provided with shields so as to minimize the introduction of spurious signals from outside sources. Wiring within consoles is to be arranged to provide maximum accessibility and protection from steam, water or oil piping.

2.5. Maintenance, checking

2.5.1. The self-check facilities are to cover at least power failures.

2.5.1.1. Additionally for essential systems:

a. Loop failures, both command and feedback loops (normally short circuit and broken connections);
b. Earth faults.

2.5.1.2. Additionally for computer based systems:

a. Communication errors;
b. Computer hardware failures.

2.5.2. Maintenance, repair and performance tests of systems and components are as far as practicable to be possible without affecting the operation of other systems or components.

2.5.3. Provisions for testing shall be arranged in pipes connecting pressure switches/transducers to EUC (Equipment Under Control) normally in operation at sea.

2.6. Electrical and electronic devices

2.6.1. All electrical and electronic devices should be suitable to be used in marine atmosphere, corrosion resistant, not affected by shipboard vibration and motion and should be capable of performing their intended functions at compartment ambient temperature (Refer Ch 1, Sec 2, [2.32.] of this part).

2.6.2. Electronic and electrical devices should be applied on the basis of 50^0C ambient when located in machinery spaces or 40^0C ambient when located in other spaces with the inclusion of those cases when the component is located in an air-conditioned console.

2.6.3. Electromagnetic interferences are to be taken into account at the time of constructing electronic systems. Special precautions should be taken for:

a. Measuring elements such as the analogue amplifier or analog/digital converter; and
b. Connecting different systems having different ground references.

2.6.4. Semiconductor devices are to be selected on the basis of expected shipboard ambient air-temperature ranges of 0°C-50°C for interior compartments and 0°C-60°C inside of consoles. Silicon and selenium semiconductor devices are to be used in preference to germanium which may be used, where its characteristics are favored for a circuit provided care is taken to ensure satisfactory operation under shipboard conditions.

2.6.5. Steady-state voltage variations of 10 per cent and frequency variations of ± 5 per cent from the nominal console feeder rating are not to affect the intended functioning of the electrically operated control and monitoring devices. Where close tolerances on voltage and frequency are required, special regulated supplies are to be provided. Voltage transients are not to cause any dangerous malfunctioning or damage to the control and monitoring devices and the control equipment is to be fitted with transient voltage suppressors.

2.6.6. The design and arrangement of all devices is to provide ready accessibility to parts requiring inspection, adjustment or periodic replacement. Where devices are parts of sub-circuits assembled in physically-identical modular units for easy mounting on and removal from the console, suitable arrangements such as matched plug-in modules with coded plugs are to be provided to facilitate correct replacement of modules in the console.

2.6.7. Built-in circuitry is to be provided for use in the testing of module functions.

2.6.8. Consideration is to be given to minimize, as far as practicable, the probability that failure of any one component or device in the control circuitry will cause unsafe operation of the plant.

2.6.9. Control levers or wheels are to be readily identifiable as to function and position and are to be arranged for a logical sequence of operations. Suitable interlocks are to be provided to prevent incorrect operation.

2.6.10. When logic circuits are used for sequential start-up or for operating individual plant, components, indicators are to be provided at the control console to show the successful completion of the sequence of operations by the logic circuit and start-up and operation of the component. If some particular step is not carried out during the sequence, the sequence is to stop at this point. Manual override is to be fitted in vital functions to permit control in case of failure of a logical circuit.

2.6.11. Electrically-powered actuators for the execution of control commands are to be suitable for shipboard use, and have working and other parts which would not be damaged or rendered ineffective by corrosion. The windings are to be treated to resist oil and water and the enclosures are to be suitable for the location. The ratings of coils are to be based on ambient air temperature of 50°C when located in the machinery spaces and 40°C when located outside such spaces. The power supply for electrical actuators is to be from the same source as the power to the control systems.

2.7. Alarm systems, general requirements

2.7.1. The alarm system is to be designed as far as practicable to function independently of control and safety systems such that a failure or malfunction in these systems will not prevent the alarm system from operating.

2.7.2. Audible alarms associated with machinery are to be distinct from other alarms such as the fire alarm, general alarm etc., and are to be of sufficient loudness to attract the attention of duty personnel. For spaces of unusually high noise level, a beacon light or similar, installed in a conspicuous place, may supplement the audible alarm. However, red light beacons are only to be used for fire alarms.

Visual alarms are to be a flashing signal when first activated. The flashing display is to change to a steady display upon acknowledgment. The steady display is to remain activated, either individually or in the summarized fashion, until the fault condition is rectified. Other arrangements capable of attracting the operator's attention to an alarm condition in an effective manner will be considered.

Alarms are to be visual and audible and are to be clearly distinguishable, in the ambient noise and lighting in the normal position of the personnel, from any other signals.

2.7.3. Where alarms are displayed as group alarms provision is to be made to identify individual alarms at the main control station (if fitted) or alternatively at subsidiary control stations.

2.7.4. Sufficient information is to be provided for proper handling of alarms.

2.7.5. Alarms are to be activated when abnormal conditions appear in the machinery, which need the intervention of personnel on duty, and on the automatic change-over, when standby machines are installed. An existing alarm is not to prevent the indication of any further fault.

2.7.6. It is to be possible to delay alarm activation in order to avoid false alarms due to normal transient conditions (e.g. during start-up or trimming).

2.7.7. The acknowledgment of an alarm consists in manually silencing the audible signal and additional visual signals (e.g. rotating light signals) while leaving the visual signal on the active control station. Acknowledgement of alarms at positions outside a machinery space is not to silence the audible alarm or extinguish the visual alarm in that machinery space.

2.7.8. Acknowledged alarms are to be clearly distinguishable from unacknowledged alarms. Acknowledgement should not prevent the audible signal to operate for new alarm.

2.7.9. Manual locking of separate alarms is acceptable when this is clearly indicated. Locking of alarm and safety functions in certain operating modes (e.g. during start-up or trimming) should be automatically disabled in other modes.

2.7.10. Alarm circuits may be temporarily disabled, for example, for maintenance purposes, provided that such action is clearly indicated at the associated station in control and at the centralized control station, if fitted.

2.7.11. The alarm system is to be arranged with automatic changeover to a standby power supply in the event of a failure of the normal power supply. Where an alarm system could be adversely affected by an interruption in power supply, changeover to the stand-by power supply is to be achieved without a break. Failure of any power supply to the alarm system is to operate an audible and visual alarm.

2.7.12. The alarm system is to be of the self-check type; failure within the alarm system, including the outside connection, is to activate an alarm. The alarm circuits are to be independent from each other. All alarm circuits are to be protected so as not to endanger each other.

2.7.13. The alarm system should be capable of being tested during normal machinery operation.

2.7.14. At least one alarm monitoring station is to be provided in the engineers' public space, such as the officers' lounge or officers' mess room. Where the engineer on-duty is assigned to work in a specific space, such as the ship's office or engineers' office, then such a space is also to be provided with an alarm monitoring station. In addition, an alarm monitoring station is to be provided in each engineer's cabin through a selector switch so arranged as to ensure connection to at least one of these cabins. Each station is to be provided with:

a. An alarm for fire in the propulsion machinery space
b. An alarm for high bilge water level in the propulsion machinery space
c. A summary-alarm to be activated by any of the alarm conditions listed in Table 8.2.1 through Table 8.2.10 of this section

The fire alarm is to have a separate visual display and a distinct sound from the summary alarm, and other alarms, where fitted. Selector switch is not to be provided for fire alarm.

All engineers' alarm is to be silenced only at the centralized control station. Alternatively, arrangements may be made to silence the summary and the bilge alarms at the alarm monitoring stations in the engineers' public space or at a selected engineer's cabin, provided the associated visual alarm is not extinguished. The arrangements are to be such that if the audible alarm is not also silenced manually at the centralized control station in a preset period of time (e.g., 2 minutes), the system is to activate the engineer's alarm.

The communication system required by Ch 7, Sec 3, [3.2.1.] of this part is to include the engineer's accommodation area.

2.8. Controls at firefighting station

2.8.1. A fire-fighting station should be provided and located outside the propulsion machinery space. However the installation of the fire-fighting control station within the room housing the centralized control station can be considered on the condition that the room's boundary common with the propulsion machinery space, including the glass windows and doors is insulated to A-60 standard. The doors opening into the propulsion machinery space should be self-closing. The ventilation system of the room should be separate from other systems serving the propulsion machinery space and the inlet for ventilation should be from a safe space outside the propulsion machinery space. There is to be a protected access, insulated to A-60 standard, from the room to the open deck.

2.8.2. The fire-fighting station should be provided with remote manual controls for the operations detailed in the following list:

a. Shutdown of fuel oil, lubricating oil and thermal oil system pumps.
b. Shutdown of ventilation fans serving the machinery space.

c. Shutdown of forced and induced draft fans of boilers, inert gas generators and incinerators, and of auxiliary blowers of propulsion diesel engines.
d. Shutdown of fixed local application firefighting systems, before activating a high-expansion foam fire extinguishing system, to avoid adverse water action on the foam.
e. Closing of propulsion machinery space fuel oil tanks suction valves. This is to include other forms of fuel supply, such as gas supply valves in LNG carriers.
f. Closing of propulsion machinery space skylights, ventilator dampers, openings in funnels and other openings. Where the propulsion machinery space is protected by a high-expansion foam fire extinguishing system, the remote means of closing the upper level ventilation openings is not required from the fire-fighting station.
g. Closing of propulsion machinery space watertight and fire-resistant doors. Doors normally closed and self-closing doors may be excluded.
h. Starting of emergency generator where it is not arranged for automatic starting.
i. Starting of a fire pump located outside of the propulsion machinery space, including operation of all necessary valves, to pressurize the fire main. However, valves located near the pump need not be provided with remote operation from the firefighting station, if they are kept locked open (LO), or closed (LC), as appropriate, to provide immediate water supply to the fire main. The position of the valves (open or closed) is to be clearly marked. Where the sea chest valve is located in the same compartment as the fire pump and the sea chest valve is kept locked open, a high-level bilge alarm is to be fitted in the fire pump space. If the sea chest is located in a different space than the compartment containing the fire pump, then a high-level bilge alarm is to be fitted in the fire pump space, as well as the compartment containing the sea chest, in order to detect possible flooding in each of these spaces. The high-level bilge alarm is to sound in the centralized control station. Starting of one of the main fire pumps is also to be provided on the navigation bridge.
j. Actuation of the fixed fire extinguishing system for the propulsion machinery space.

2.9. Fire detection alarm systems

Where an automatic fire detection system is to be fitted in a machinery space, the requirements specified in [2.9.1.] to [2.9.12.] of this section should be satisfied. Refer also Ch 7, Sec 4, [4.1.] of this part and SOLAS 1974 as amended Reg. II-2/C, 7 as applicable.

2.9.1. A fire detection control unit should be located in the navigating bridge area, the fire control station or in some position such that in the event of a fire in the machinery spaces, it will not render it inoperable. For controls at firefighting station Refer [2.8.] of this section.

2.9.2. Fire detection indicating panels should denote the section in which a detector or manually operated call point has operated. At least one indicating panel is to be located such that it can easily be accessed by responsible members of the crew at all times. An indicating panel should be located on the navigating bridge.

2.9.3. An audible fire-alarm is to be provided having a characteristic tone which distinguishes it from the alarm system required by [2.7.] of this section or any other alarm system. The audible fire-alarm is to be immediately audible on all parts of the navigating bridge, the fire-control station, the crew accommodation areas and the machinery spaces.

2.9.4. Facilities are to be provided in the fire detection system to manually initiate the fire alarm from the following locations:

a. Positions adjacent to all exits from machinery spaces;
b. Navigating bridge;
c. Control station in engine room;
d. Fire control station.

2.9.5. The alarm system should be designed with self-monitoring properties. An audible alarm distinguishable from the fire alarm is to be initiated in case of power or system failures. This alarm may be incorporated in the machinery alarm system as required by [2.7.] of this section.

2.9.6. Detector heads should be located in the machinery spaces so that all potential fire breakout points are guarded. A combination of detectors should be provided in order that the system will react to all possible fire characteristics.

2.9.7. When fire detectors are provided with means for adjusting their sensitivity, the arrangements should be such that the set point can be fixed and readily identified.

2.9.8. When it is intended to temporarily switch off a particular loop, the state is to be indicated clearly at the fire detection indicating panels.

2.9.9. When it is intended that a particular detector(s) is (are) to be temporarily switched off locally, this state is to be clearly indicated at the local position. After a preset time, reactivation of the detector(s) is to be performed automatically.

2.9.10. The fire detector heads are to be of such a type that they can be tested and reset without the renewal of any component. Facilities are to be provided on the fire-control panel for functional testing and reset of the system.

2.9.11. It is to be demonstrated to the Surveyor's satisfaction that detector heads are located such that air currents will not render the system ineffective at sea and in port.

2.9.12. In addition to the portable fire extinguishers located in the machinery space and the spare charges, an equal number of portable extinguishers, are to be provided. These extinguishers are to be stored in or in the vicinity of the fire-fighting station, or at the entrance to the propulsion machinery space.

2.10. Safety systems, general requirements

2.10.1. A safety system is to be designed such that it limits the consequence of failures. It is to be constructed on the fail-safe principle. The safety system should be of the self-check type; as a rule, failure within the safety system, including the outside connection, is to activate an alarm. The requirements of [2.10.2.] to [2.10.10.] of this section need to be satisfied where safety systems are provided.

2.10.2. Safety systems should operate automatically in the event of serious faults endangering the machinery, so that:

a. Normal operating conditions are restored, e.g. by the starting of standing machinery, or
b. The operation of the machinery is temporarily adjusted to the prevailing conditions, e.g. by reducing the output of the machinery, or
c. The machinery is protected from critical conditions by shutting the fuel or power supplies off thereby stopping the machinery.

2.10.3. The safety system requirement of [2.10.2.c.] of this section is to be designed as far as practicable to operate independently of the control and alarm systems, so that in the event of a failure or malfunction in the control and alarm systems does not prevent the safety system from operating. For safety systems required by [2.10.2. a. and b.] of this section complete independence from other control systems is not necessary.

2.10.4. The safety system is to be designed to ‘fail-safe’. The characteristics of the ‘fail-safe’ operation are to be evaluated on the basis not only of the safety system and its associated machinery, but also the complete installation. Failure of a safety system is to initiate an audible and visual alarm.

2.10.5. safety systems are comply with the following:

a. Means are to be provided to indicate the cause of the safety action.
b. Alarms are to be given on the navigation bridge, at the centralized control station and at local manual control position, as applicable, upon the activation of a safety system.
c. Propulsion machinery shut down by a safety system is not to be designed to restart automatically, unless first actuated by a manual reset.
b. A safety system for the protection of one machine unit is to be independent of that of the other units.

2.10.6. Where arrangements are provided for overriding a safety system, they are to be such that inadvertent operation is prevented. Visual indication is to be given at the relevant control station(s) when a safety override is operated. The consequences of overriding a safety system are to be established and documented. Refer also Sec. 3, [3.4.] of this chapter.

2.10.7. The safety system is to be arranged with automatic changeover to a standby power supply in the event of a failure of the normal power supply. Failure of any power supply to a safety system is to operate an audible and visual alarm.

2.10.8. When safety systems are provided with means to adjust their set point, the arrangements are to be such that the final settings can be readily identified.

2.10.9. As far as practicable, the safety system required by [2.10.2. b.] of this section is to be arranged to effect a rapid reduction in speed or power.

2.10.10. To avert rapid deterioration of propulsion and auxiliary machinery, the following automatic shutdowns are to be provided, regardless of the mode of control (manual, remote or automatic). These shutdowns are not to be fitted with manual override:

a. For all diesel engines:

- Over speed.

b. For all gas turbines:

- Failure of lubricating oil system;
- Failure of flame or ignition;
- High exhaust gas temperature;
- High compressor vacuum;
- Over speed;
- Excessive vibration;
- Excessive axial displacement of rotors.

c. For all steam turbines:

- Failure of lubricating oil system;
- Over speed;
- Back-pressure for auxiliary turbines.

d. For all boilers:

- Failure of flame;
- Failure of flame scanner;
- Low water level;
- Failure of forced draft pressure;
- Failure of control power.

e. For propulsion reduction gears:

- Shutdown prime movers upon failure of reduction gear lubricating oil system.
- For manned operation, where prime movers are diesel engines, shutdown is mandatory only for multiple high speed or medium speed diesel engines coupled to a reduction gear.

f. For generators:

- For generators fitted with forced lubrication system only: shutdown prime movers upon failure of generator lubricating oil system.

g. For propulsion DC motor:

- Over speed.

2.11. Fixed water-based local application fire-fighting systems

Where fixed water-based local application fire-fighting systems are installed, in accordance with SOLAS as amended Ch. II-2/C, Reg. 10.5.6, arrangements are to be in accordance with this sub-section.

2.11.1. Systems are to be available for immediate use and arranged for manual activation from inside and outside the protected space. Refer also Ch 7, Sec 4, [4.6.] of this part.

2.11.2. The activation of a system is not to result in loss of electrical power or reduction of the maneuverability of the ship and is not to require confirmation of space evacuation or sealing. Refer also Ch 7, Sec 4, [4.6.] of this part.

2.11.3. System zones and protected areas are to be arranged to allow essential services to be provided by machinery and/or equipment located outside areas affected by direct spray or extended water in the event of a system activation, where the machinery and/or equipment is duplicated or otherwise replicated to provide redundancy.

2.11.4. A control panel is to be provided for managing actions such as opening of valves, starting of pumps and sounding of alarms and processing information from detectors. This panel is to be independent of the fire detection control unit required by [2.9.] of this section.

2.11.5. A fire detection alarm system panel in accordance with [2.9.] of this section may be used for receiving fire detection signals. Separate loops are not required on the condition that the address of the initiating device can be identified at the control panel. The signals received are then to be sent to the control panel required by [2.11.4.] of this section for processing and action.

2.11.6. Alarms are to be initiated upon activation of a system and are to indicate the specific zone activated at the control panel. Alarms are to be provided in each protected space, at an attended machinery control station and in the wheelhouse. The audible alarm is to be distinguishable from other safety system alarms.

2.11.7. A failure in a manual system activation switch circuit is not to prevent system activation using other installed manual system activation switches or, where installed, automatic activation. The means of activation are to be provided with self-monitoring facilities which will activate an alarm at an attended control station in the event of failure detection.

2.11.8. Where SOLAS requires the system to, additionally, be capable of automatic release, the arrangements are to be in accordance with [2.11.5.] & [2.11.9.] to [2.11.11.] of this section.

2.11.9. A minimum of two fire detectors are to be provided for each protected area. One is to be a flame detector and the other is to be a smoke or heat detector, as considered appropriate to the nature of the risk and ambient conditions. The system is to be activated upon detection by two of the detectors. A fault in one detector is to initiate an alarm at an attended control station and is not to inhibit activation of the system under the control of the other detector or manually.

2.11.10. The fire detectors are to be arranged (located, oriented, guarded, etc.) to ensure that a fire in one protected area will not result in the inadvertent automatic activation of a system for another protected area. Guards or barriers provided to comply with this requirement are not to reduce the ability to detect a fire in the protected area.

2.11.11. The system's fire detection systems and control units should meet the performance criteria of SOLAS CH II/C, Reg.7 and should be Type Approved.

2.12. Control systems, general requirements

Where control systems are provided, the requirements of [2.12.1.] to [2.12.7.] of this section should be satisfied:

2.12.1. Control systems for machinery operations are to be stable throughout their operating range.

2.12.2. Failure of any power supply to a control system is to operate an audible and visual alarm.

2.12.3. Control systems should be designed to 'fail-safe'. The evaluation of the characteristics of the 'fail-safe' operation should be on the basis of not only the control system and its associated machinery, but also the complete installation.

2.12.4. The control system is to be designed such that normal operation of the controls cannot induce detrimental mechanical or thermal overloads in the machinery.

2.12.5. Remote or automatic controls are to be provided with sufficient instrumentation at the relevant control stations to ensure effective control and indicate that the system is functioning correctly.

2.12.6. When control systems are provided with means to adjust their sensitivity or set point, the arrangements are to be such that the final settings can be readily identified.

2.12.7. Failure of a control system is not to result in the loss of ability to provide essential services by alternative means. This may be achieved by manual control or redundancy within the control system or redundancy in machinery and equipment. Instrumentation is to be provided at local manual control stations to ensure effective operation of the machinery.

2.13. Centralized control stations for machinery (CCS)

2.13.1. Where, in lieu of manning the propulsion machinery space locally, it is intended to monitor the propulsion machinery space and to control and monitor the propulsion and auxiliary machinery from a continuously manned centralized control station. These provisions cover propulsion machinery during start-up, navigating and maneuvering, and do not cover operations in port or at mooring or anchorage.

The notation CCS will be assigned upon verification of compliance and upon satisfactory tests and trials carried out in the presence of a Surveyor.

For purposes of assigning CCS, remote propulsion control from the navigation bridge is not mandatory.

The centralized control station is to be:

a. As effective as a propulsion machinery space under local supervision and operation;
b. Provided with remote control of propulsion machinery;
c. Provided with means to monitor the states of the propulsion machinery space, the propulsion, auxiliary and other machinery, as appropriate; and
d. Provided with means to effect, manually or automatically, corrective actions, such as starting of a standby pump, in the event of a fault in the machinery plant.

2.13.2. FMEA is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in the loss of propulsion control, the loss of propulsion or other undesirable consequences.

2.13.3. System power supply should be in compliance with sec 3, [3.2.] of this chapter.

2.13.4. The centralized control station is to be located within, or adjacent to, the propulsion machinery space. Consideration will be given to this station being located away from the propulsion machinery space, provided its operation and monitoring of the propulsion machinery and propulsion machinery space is to be as effective as if it were located either within or adjacent to the propulsion machinery space.

Where this station is in an enclosure located in or adjacent to machinery space, at least two means of access, separated as remote from each other as practicable, are to be provided. Where fitted, glass windows forming parts of the boundaries, are to be of shatter-resistance type.

2.13.5. Necessary controls to operate the propulsion machinery and its associated auxiliary systems are to be provided in the centralized control station. This includes the following control functions.

a. Remote propulsion control, as provided in Section 3 of this chapter
b. Put on-line a standby generator
c. Start, stop and transfer auxiliaries necessary for the operation of propulsion and power generation machinery

All required controls are shown in the “C” column of Table 8.2.1. of this section.

2.13.6. Alarms and displays for monitoring propulsion and auxiliary machinery and for propulsion machinery space are to be provided in the centralized control station, as specified in Table 8.2.1 to Table 8.2.10 of this section, as applicable. Refer also Sec. 4, [4.1.] of this chapter.

Safety system functions (Auto start, Auto shutdown, and Auto slowdown columns) in these tables are not mandatory for assigning CCS notation, except for automatic shutdowns required in [2.10.10.] of this section.

Propulsion machinery space is to be provided with fixed fire detection and alarm system. Propulsion machinery space fire is to be alarmed in the centralized control station. Refer also [2.9.] of this section.

2.13.7. Where a computer is used as the operator interface to display monitoring information, the centralized control station is to be provided with at least two computers, including keyboards and monitors, unless other means of display are provided capable of displaying the same information.

2.13.8. Where alarms are not acknowledged at the centralized control station in a pre-set period of time (e.g., 2 minutes), the system is to activate the engineers’ alarm audible in the engineers’ accommodations.

2.13.9. Safety system functions are to be in accordance with Sec. 3, [3.4.] of this chapter. As a minimum, safety shutdowns specified in [2.10.10.] of this section are to be provided. Where desired, safety system functions specified in “Auto start”, “Auto slowdown” and “Auto shutdown” columns in Table 8.2.2 through Table 8.2.10 of this section may be provided. Override of safety system functions is to be as in Sec. 3, [3.4.3.].

2.13.10. The centralized control station is to be provided with means to remotely start and stop auxiliary pumps associated with the operation of the following:

a. Propulsion engine
b. Electrical power generators
c. Controllable pitch propellers
d. Propulsion boilers and boilers supporting propulsion (including power generation)
e. Fuel oil transfer system

Automatic transferring of vital auxiliary pumps, where fitted, is to be alarmed at the centralized control station

2.13.11. A system of alarm displays and controls is to be provided which readily ensures identification of faults in the machinery and satisfactory supervision of related equipment. This may be provided at a main control station or, alternatively at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

2.13.12. Indication of all essential parameters necessary for the safe and effective operation of the machinery is to be provided for example pressures, tank levels, temperatures, powers, speeds etc.

Indication of the operational status of running and standby machinery is to be provided.

2.13.13. At the centralized control station, means of communication with the bridge area, the accommodation for engineering personnel and, if necessary, the machinery space are to be provided.

In addition, a second means of communication is to be provided between the bridge and the centralized control station. One of these means is to be independent of the main electrical power supply.

2.13.14. Arrangements are to be provided in the centralized control station so that the normal supply of electrical power may be restored in the event of failure.

2.13.15. Components, equipment, subsystems, etc. used in control, monitoring and safety systems of propulsion machinery, propulsion boilers and vital auxiliary pumps are to be designed and tested in accordance with the provisions in [2.2.] of this section.

2.14. Valve control systems

Where cargo, bilge, ballast, oil fuel transfer and sea valves for engine services are operated by remote or automatic control, the requirements of [2.14.1.] to [2.14.4.] of this section should be satisfied.

2.14.1. Failure of control system power or actuator power is not to permit a valve to move to an unsafe condition.

2.14.2. Positive indication is to be provided at the remote control station for the service to show the actual valve position or alternatively that the valve is fully open or closed.

2.14.3. Equipment located in places which may be flooded is to be capable of operating when submerged.

2.14.4. A secondary means of operating the valves, which may be by local manual control, is to be provided.

2.15. Hydraulic controls

2.15.1. Hydraulic pumps, actuators, motors and accessories are to be suitable for the intended duty, compatible with the working fluid and are to be designed to operate safely at full-power conditions. In general, the hydraulic fluid is to be non-flammable or have a flash point above 157°C.

2.15.2. All control piping is to be readily accessible and supported so as to protect the piping and associated accessories from mechanical damage, vibration and shock. The control piping is to be suitably marked to indicate the character of its service.

2.15.3. The hydraulic pumps are to be fitted in duplicate and have pressure relief protection on the discharge side. The pump suctions are to be from a reservoir of sufficient capacity to contain all the fluid when drained from the system, maintain the fluid level at an effective working height and allow air and foreign matter to separate out. The pump suctions are to be sized and positioned to prevent cavitation or starvation of a pump. A duplex filter which can be cleaned without interrupting the oil supply is to be fitted on the discharge side of the pumps.

2.16. Pneumatic controls

2.16.1. Air compressors, actuators, motors and accessories are to be suitable for the intended duty and have working and other parts which will not be damaged or rendered ineffective by corrosion.

2.16.2. All control piping is to be readily accessible and supported so as to protect the piping and associated accessories from mechanical damage, vibration and shock. The control piping is to be suitably marked to indicate the character of its service.

2.16.3. Compressed air for pneumatic control is to be available from at least two air compressors. The starting air system may be used as a source of control air. The air pressure to the pneumatic control system is to be automatically maintained at the level required for the operation of the installation and low air pressure is to set off an alarm at the main control location. Means are to be provided in the delivery from the compressors to assure clean, dry and oil-free air to the pneumatic controls.

2.17. Automation consoles

2.17.1. General

Automation consoles are to be designed on ergonomic principles. Handrails should be fitted for safe operation of the console.

2.17.2. Indicating instruments

2.17.2.1. The operator is to receive feed-back information on the effects of his orders.

2.17.2.2. Indicating instruments and controls are to be arranged according to the logic of the system in control. In addition, the operating movement and the resulting movement of the indicating instrument are to be consistent with each other.

2.17.2.3. The instruments should be clearly labeled. When installed in the wheelhouse, all lighted instruments of consoles are to be dimmable, where necessary.

2.17.3. VDU’s and keyboards

2.17.3.1. VDU’s in consoles are to be located so as to be easily readable from the normal position of the operator. The environmental lighting should not create any reflection which makes reading difficult.

2.17.3.2. The keyboard is to be so located that it gives easy access from the normal position of the operator. Special precautions are to be taken for avoiding inadvertent operation of the keyboard.

Table 8.2.1: Instrumentation and controllers in centralized control station – All propulsion and auxiliary machinery

System	Monitored/controlled parameter		A	D	C	Note (Refer also bottom of table) [A= Alarm; D= Display; C= Controller/Actuator]
Propulsion control and monitoring	A1	As in Sec. 3, Table 8.3.1 of this chapter items A1 through C2, with follow additional features	x	x	x	Following items of Sec. 3, Table 8.3.1 of this chapter are to be modified: - Item A4: additional telegraph is not required for centralized control station. - Item A6: starting of propulsion engine is required for all engine types - Item C1: acknowledgement switch for transfer of control station is not required in centralized control station
	A2	System power supply main and emergency feeders: failure, status and transfer	x	x	x	
	A3	Propulsion engine auxiliaries and boiler auxiliaries – status and start/stop		x	x	Automatic start/stop, if fitted, is to be alarmed. Applicable to propulsion boilers and boilers supporting propulsion.
	A4	Controllable pitch propeller (CPP) hydraulic power unit start/stop		x	x	
	A5	CPP hydraulic oil pressure – low and high	x			High-pressure alarm is required only if required by design.
	A6	CPP hydraulic oil temperature – high	x			If it is a system design feature
	A7	CPP hydraulic oil tank level – low	x			

	A8	Steam turbine shaft stopped – excess of set period	x			
	A9	Steam turbine shaft rollover – activated		x	x	To be activated automatically for UMS
Electric Power Generating Plant	B1	Starting, paralleling & putting generator on line			x	Not required if main switchboard is located in the centralized control station
	B2	Generator running		x		
	B3	Voltage – high and low	x	x		
	B4	Current – high	x	x		
	B5	Frequency – high and low	x	x		
	B6	Failure of on-line generator	x			
	B7	Generator engine auxiliaries start/stop		x	x	Automatic start/stop, if fitted, is to be alarmed
	B8	Bearing lub. oil inlet pressure – low	x	x		Automatic shutdown prime mover.
	B9	Generator cooling inlet pump or fan motor – fails	x			
	B10	Generator cooling medium temp. – high	x	x		
High voltage rotating machine	C1	Stationary windings temperature – high	x			
Fuel oil system	D1	Settling and service tank level – low and high	x			High level alarm required only if automatic filling is provided, or if UMS
	D2	Overflow tank and drain tank level – high	x			
	D3	Transfer pump start/stop		x	x	Start/stop may be automatic.
	D4	Heated fuel oil in settling and service tank, fuel oil temperature – high	x	x		
	D5	Fuel oil tank heating medium temperature – high	x			

	D6	Fuel oil heater, fuel oil temperature – high (or viscosity – low) or flow	x			
	D7	Fuel oil heater, heating medium temperature – high	x			
Stern tube lub. oil	E1	Tank level – low	x			
Boiler, thermal oil heater, incinerator, etc.	F1	Automatic shutdown	x			Propulsion boilers and auxiliary boilers supporting propulsion are to meet Table 8.2.8 and Table 8.2.9 of this section
Propulsion machinery space	G1	Bilge level – high	x			
	G2	Bilge pump status	x	x		Alarm applicable to automatically started bilge pump that starts/stops excessively or running unduly long
	G3	Fire detected	x			
	G4	Air condition system – fails	x			If necessary for equipment environmental control
Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.						

Table 8.2.2: Instrumentation and safety system functions in centralized control station – slow speed (crosshead) diesel engines

System	Monitored parameter		A	D	Auto slow down	Auto start	Auto shut down	Notes (Refer also bottom of table)
Sensors	Common or separate		c	c	c	s	s	c = common; s = separate
Fuel oil	A1	Fuel oil after filter (engine inlet), pressure – low	x	x		x		
	A2	Fuel oil before injection pumps, temp. – high (or viscosity – low)	x					
	A3	Fuel oil before injection pumps, temp. – low (or viscosity – high)	x					
	A4	Leakage from high pressure pipes	x					
	A5	Fuel oil service tank, level – low	x					High level alarm is also required if without suitable overflow arrangements.
	A6	Common rail fuel oil pressure – low	x					
Lubricating oil	B1	Lub. oil to main bearing and thrust bearing, pressure – low	x	x	x	x	x	
	B2	Lub. oil to crosshead bearing, pressure – low	x	x	x	x	x	If of a different system.
	B3	Lub. oil to camshaft, pressure – low	x			x	x	If of a different system.

	B4	Lub. oil to camshaft, temp. – high	x					If of a different system.
	B5	Lub. oil inlet, temp. – high	x					
	B6	Thrust bearing pads temp. or bearing outlet temp. – high	x		x		x	
	B7	Oil mist in crankcase, mist concentration - high; or Bearing temperature - high; or Alternative arrangements	x		x			For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 inch.).
	B8	Each cylinder lubricator, flow rate – low	x		x			
	B9	Lub. oil tanks, level – low	x					Where separate lubricating oil systems are installed (e.g. camshaft, rocker arms, etc.), individual level alarms are required for all the tanks.
	B10	Common rail servo oil pressure – low	x					
Turbocharger	C1	Lub. oil inlet, pressure – low	x					Unless provided with a self-contained lubricating oil system integrated with the turbocharger

	C2	Lub. oil outlet (each bearing), temp. – high	x					Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
	C3	Speed		x				
Piston cooling	D1	Coolant inlet, pressure – low	x		x	x		The slowdown is not required if the coolant is oil taken from the main cooling system of the engine.
	D2	Coolant outlet (each cylinder), temp. – high	x		x			
	D3	Coolant outlet (each cylinder), flow – low	x		x			Where outlet flow cannot be monitored due to engine design, alternative arrangements may be accepted.
	D4	Coolant in expansion tank, level – low	x					
Sea water cooling	E1	Sea water cooling, pressure – low	x			x		
Cylinder fresh water cooling	F1	Water inlet, pressure – low	x		x	x		
	F2	Water outlet from each cylinder, temp. – high; or common water outlet, temp. – high	x		x			Sensing at common water outlet is permitted for cylinder jackets fitted with common cooling space without intervening stop valves.

	F3	Oily contamination of engine cooling water system.	x					Where engine cooling water is used in fuel and lubricating oil heat exchangers.
	F4	Cooling water expansion tank, level – low	x					
Compressed air	G1	Starting air before main shutoff valve, pressure – low	x	x				
	G2	Control air, pressure – low	x					
	G3	Safety air, pressure – low	x					
Scavenge air	H1	Scavenge air receiver, pressure		x				
	H2	Scavenge air box, temp. – high (fire)	x		x			
	H3	Scavenge air receiver water level – high	x					
Exhaust gas	I1	Exhaust gas after each cylinder, temp. – high	x	x	x			
	I2	Exhaust gas after each cylinder, deviation from average, temp. – high	x					
	I3	Exhaust gas before each turbocharger, temp. – high	x	x				
	I4	Exhaust gas after each turbocharger, temp. – high	x	x				
Fuel valve coolant	J1	Coolant, pressure – low	x			x		
	J2	Coolant, temp. – high	x					

	J3	Coolant expansion tank, level – low	x					
Engine	K1	Speed/direction of rotation		x				
	K2	Rotation – wrong way	x					
	K3	Engine over speed	x				x	
Power	L1	Control, alarm or safety system, power supply failure	x					

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto slowdown = automatic slowdown of diesel engine, along with activation of suitable alarm.

Auto start = automatic starting of a standby pump, along with activation of suitable alarm

Auto shutdown = automatic stopping of the diesel engines, along with activation of suitable alarm

Table 8.2.3: Instrumentation and safety system functions in centralized control station – medium and high speed (trunk piston) diesel engines

System	Monitored parameter		A	D	Auto slow down	Auto start	Auto shut down	Notes (Refer also bottom of table) [A = alarm. D = display.
Sensors		Common or separate	c	c	c	s	s	c = common; s = separate
Fuel oil	A1	Fuel oil after filter (engine inlet), pressure – low	x	x		x		
	A2	Fuel oil before injection pumps, temp. – high (or viscosity – low)	x					For heavy fuel oil burning engines only.

	A3	Fuel oil before injection pumps, temp. – low (or viscosity – high)	x					For heavy fuel oil burning engines only.
	A4	Leakage from high pressure pipes	x					
	A5	Fuel oil service tank, level – low	x					High level alarm is also required if without suitable overflow
	A6	Common rail fuel oil pressure – low	x					
Lubricating oil (diesel engine)	B1	Lub. oil to main bearing and thrust bearing, pressure – low	x	x		x	x	
	B2	Lub. oil filter differential, pressure – high	x	x				
	B3	Lub. oil inlet, temp. – high	x	x				
	B4	Oil mist in crankcase, mist concentration – high; or Bearing temperature - high; or Alternative arrangements	x				x	For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 inch.). Single sensor having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown.
	B5	Each cylinder lubricator, flow rate – low	x		x			If necessary for the safe operation of the engine.
	B6	Common rail servo oil pressure – low	x					
Lubricating oil (other than diesel engine)	B7	Reduction gear lub. oil inlet pressure – low	x	x	x	x	x	Shutdown is to affect all power input to gear

Sea water cooling	C1	Sea water cooling system pressure – low	x	x		x		
Cylinder fresh water cooling	D1	Water inlet, pressure – low or flow – low	x	x	x	x		
	D2	Water outlet (general), temp. – high	x	x	x			Two separate sensors are required for alarm and slowdown.
	D3	Cooling water expansion tank, level – low	x					
Compressed air	E1	Starting air before shutoff valve, pressure – low	x	x				
	E2	Control air pressure – low	x	x				
Scavenge air	F1	Scavenge air receiver temp. – high	x					
Exhaust gas	G1	Exhaust gas after each cylinder, temp. – high	x	x	x			For engine power > 500 kW/cylinder
	G2	Exhaust gas after each cylinder, deviation from average, temp. – high	x					For engine power > 500 kW/cylinder
Engine	H1	Speed		x				
	H2	Over speed	x				x	
Power	J1	Control, alarm or safety system, power supply failure	x					
Turbocharger	K1	Turbocharger lub. oil inlet pressure – low	x					Unless provided with a self-contained lubricating oil system integrated with the turbocharger

	K2	Turbocharger lub. oil temp., each bearing – high	x					Where outlet temperature from each bearing cannot be monitored due to the engine/ turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto slowdown = automatic slowdown of diesel engine, along with activation of suitable alarm.

Auto start= automatic starting of a standby pump, along with activation of suitable alarm.

Auto shutdown = automatic stopping of the diesel engines, along with activation of suitable alarm.

Table 8.2.4: Instrumentation and safety system functions in centralized control station – propulsion steam turbines

System	Monitored Parameter		A	D	Auto slow down	Auto start	Auto shut down	Notes (Refer also bottom of table) [A = alarm. D = display. x = apply.]
Sensors	Common or separate		c	c	c	s	s	c = common; s = separate
Lubricating oil	A1	Pressure at bearing inlets – low	x	x		x	x	For turbines, gears and thrust bearings.
	A2	Temp. at bearing inlet – high	x	x				For turbines, gears and thrust bearings.
	A3	Bearing temp. or bearing oil outlet temp. – high	x	x				For turbines, gears and thrust bearings.
	A4	Filter differential pressure – high	x					

	A5	Gravity tank and sump levels – low	x	x				
Lubricating oil cooling medium	B1	Pressure or flow – low	x	x		x		
	B2	Temp. at outlet – high	x					
	B3	Expansion tank level – low	x	x				
Sea water	C1	Pressure or flow – low	x	x		x		
	C2	Pump – auto starting and running		x				For vessels fitted with sea inlet scoops
	C3	Scoop valve – open/close		x				For vessels fitted with sea inlet scoops.
Steam	D1	Pressure at throttle – low	x				x	
	D2	Pressure, ahead chest		x				
	D3	Pressure, astern chest		x				
	D4	Pressure, gland seal		x				
	D5	Gland seal exhaust fan – failure	x					
	D6	Astern guardian valve – position		x				
	D7	Astern guardian valve – fail to open	x					In response to throttle trip or maneuvering signal.
Condensate	E1	Condenser level – high	x	x			x	
	E2	Condenser level – low	x	x				
	E3	Condensate pump pressure – low	x			x		
	E4	Condenser vacuum – low	x	x			x	
	E5	Salinity – high	x	x				
Turbine	F1	Vibration Level – high	x		x			
	F2	Axial Displacement – large	x				x	
	F3	Speed		x				
	F4	Over speed	x				x	

	F5	Shaft rollover – activated		x				
	F6	Shaft stopped – excess of set period	x					Shaft rollover to be activated manually or automatically
Power	G1	Throttle control system power failure	x					

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto slowdown = automatic slowdown of turbine, with activation of suitable alarm.

Auto start = automatic starting of standby pump in the system, with activation of suitable alarm.

Auto shutdown = automatic closing of ahead steam throttle valve, with activation of suitable alarm; but to allow admission of steam to astern turbine for braking purposes.

Table 8.2.5: Instrumentation and safety system functions in centralized control station – propulsion gas turbines

System	Monitored parameter		A	D	Auto start	Auto shut down	Notes (Refer also bottom of table) [A = alarm. D = display. x = apply.]
Sensors		Common/separate	c	c	s	s	c = common sensor; s = separate sensor
Fuel oil	A1	Pressure or flow – low	x	x			
	A2	Temperature – high and low(or viscosity – low and high)	x	x			For heavy fuel oil.
Lubricating oil	B1	Inlet pressure – low	x	x	x	x	For turbines, reduction gears and thrust bearings
	B2	Inlet temperature – high	x	x			For turbines, reduction gears and thrust bearings
	B3	Main bearing temp. or main bearing oil outlet temp. – high	x	x			For turbines, reduction gears and thrust bearings
	B4	Filter differential pressure – high	x				
	B5	Tank level – low	x	x			
Cooling medium	C1	Pressure or flow – low	x				
	C2	Temperature – high	x				

Starting	D1	Stored starting energy level – low	x				
	D2	Automatic starting failure	x				
Combustion	E1	Combustion or flame failure	x			x	
Exhaust	F1	Temperature – high	x	x		x	
Turbine	G1	Vibration level – high	x			x	
	G2	Rotor axial displacement – large	x			x	Auto shutdown may be omitted for rotors fitted with roller bearings
	G3	Over speed	x			x	
	G4	Vacuum at compressor inlet – high	x			x	

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto start = automatic starting of standby pump in the system, with activation of suitable alarm.

Auto shutdown = automatic closing of main fuel valve, with activation of suitable alarm.

Table 8.2.6: Instrumentation and safety system functions in centralized control station – electric propulsion

System	Monitored parameter		A	D	Auto shut down	Notes (Refer also bottom of table) [A = Alarm; D =
Propulsion Generator	A1	Bearing lub. oil inlet pressure – low	x	x	x	Prime mover automatic shutdown
	A2	Voltage – off-limits	x	x		To read all phases and at least one bus
	A3	Frequency – off-limits	x	x		
	A4	Current		x		To read all phases
	A5	Stationary windings temperature – high	x	x		To read all phases; for generators >500 kW
	A6	Main generator circuit breakers –		x		

	A7	Generator running		x		
	A8	Failure of on-line generator	x			
	A9	Transfer of standby generator	x			
	A10	Generator cooling medium temperature – high	x	x		If applicable
	A11	Failure of generator cooling pump or fan motor	x			If applicable
	A12	Field voltage and current		x		For DC generator
	A13	Inter-pole winding temperature – high	x	x		For DC generator
Propulsion Motor - AC	B1	Bearing, lub. oil inlet pressure – low	x	x	x	
	B2	Armature voltage – off-limits	x	x		To read all phases and at least one bus
	B3	Field voltage		x		
	B4	Frequency – off-limits	x	x		
	B5	Armature current		x		To read all phases
	B6	Field current		x		For synchronous motors
	B7	Ground lights or similar		x		
	B8	Stationary windings temperature – high	x	x		To read all phases; for motors > 500 kW
	B9	Motor circuit breakers – open/close		x		
	B10	Motor running		x		
	B11	Failure of on-line motor	x			

	B12	Transfer of standby motor	x			
	B13	Motor cooling medium temperature – high	x	x		If applicable
	B14	Failure of cooling pump or fan motor	x			If applicable
Propulsion Motor - DC	C1	Bearing lub. oil inlet pressure – low	x	x	x	
	C2	Armature voltage – off-limits	x	x		
	C3	Field voltage		x		
	C4	Armature current		x		
	C5	Field current		x		
	C6	Ground lights or similar		x		
	C7	Motor circuit breakers - open/close		x		
	C8	Motor running		x		
	C9	Motor over speed	x		x	
	C10	Failure of on-line motor	x			
	C11	Transfer of standby motor	x			
	C12	Motor cooling medium temperature – high	x	x		If applicable
	C13	Failure of cooling pump or fan motor	x			If applicable
Propulsion SCR	D1	Voltage		x		
	D2	Current		x		
	D3	Overload (high current)	x			Alarms before protective device is activated

	D4	Open/close position for assignment switches		x		
	D5	SCR cooling medium temperature – high	x	x		If applicable
	D6	Failure of SCR cooling pump or fan motor	x			If applicable
	D7	Inter-phase reactor temperature, high	x	x		
Transformer	E1	Transformer winding temperature – high	x	x		For each phase
Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.						

Table 8.2.7: Instrumentation and safety system functions in centralized control station – generator prime mover for electric propulsion

Systems	Monitored parameters		A	D	Auto start	Auto shut down	Notes (Refer also bottom of table) [A = alarm. D = display. x = apply.]
Trunk Piston Type Diesel							
Fuel oil	F1	Fuel oil after filter (engine inlet), Pressure – low	x	x	x		
	F2	Fuel oil before injection pumps, temp. – high (or viscosity – low)	x				For heavy fuel oil burning engines only.
	F3	Fuel oil before injection pumps, temp. – low (or viscosity – high)	x				For heavy fuel oil burning engines only.
	F4	Leakage from high pressure pipes	x				
	F5	Fuel oil service tank, level – low	x				High level alarm is also required if without suitable overflow
	F6	Common rail fuel oil pressure – low	x				
Lubricating oil	G1	Lub. oil to main bearing, pressure – low	x	x	x	x	
	G2	Lub. oil filter differential, pressure – high	x	x			
	G3	Lub. oil inlet, temp. – high	x	x			

	G4	Oil mist in crankcase, mist concentration – high; or Bearing temperature – high; or Alternative arrangement	x			x	For engines having a power of 2250 kW (3000 hp) and above or cylinder bore of more than 300 mm (11.8 in.). Single sensor having two independent
	G5	Each cylinder lubricator, flow rate – low	x				If necessary for the safe operation of the engine.
	G6	Common rail servo oil pressure – low	x				
Sea cooling water	H1	Sea water cooling system pressure – low	x	x	x		
Cylinder fresh water cooling	J1	Water inlet, pressure – low or flow – low	x	x	x		
	J2	Water outlet (general), temp. – high	x	x			
	J3	Cooling water expansion tank, level – low	x				
Compressed air	K1	Starting air before shutoff valve, pressure – low	x	x			
	K2	Control air pressure – low	x	x			
Exhaust gas	L1	Exhaust gas after each cylinder, temp. – high	x	x			For engine power > 500 kW/cylinder

Turbocharger	M1	Turbocharger oil inlet pressure – low	x				Unless provided with a self-contained lubricating oil system integrated with the
	M2	Turbocharger oil temp., each bearing – high	x				Where outlet temperature from each bearing cannot be monitored due to the engine/ turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger
Engine	N1	Over speed	x			x	
Power Supply	P1	Main	x	x			
	P2	Emergency	x				
Gas Turbines							
Fuel oil	Q1	Pressure or flow – low	x	x			
	Q2	Temperature – high and low (or viscosity – low and high)	x	x			For heavy fuel oil.
Lubricating oil	R1	Inlet pressure – low	x	x	x	x	
	R2	Inlet temperature – high	x	x			
	R3	Bearing temp. or bearing oil outlet temp. – high	x	x			
	R4	Filter differential pressure – high	x				
	R5	Tank level – low	x	x			
Cooling medium	S1	Pressure or flow – low	x	x			

	S2	Temperature – high	x				
Starting	T1	Stored starting energy level – low	x				
	T2	Ignition failure	x			x	
Combustion	U1	Combustion or flame failure	x			x	
Exhaust gas	V1	Temperature – high	x	x		x	
Turbine	W1	Vibration level – high	x			x	
	W2	Rotor axial displacement – large	x			x	Auto shutdown may be omitted for rotors fitted with roller bearings
	W3	Over speed	x			x	
	W4	Vacuum at compressor inlet – high	x			x	
Power Supply	Z1	Main	x	x			
	Z2	Emergency	x				

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto start = automatic starting of a standby pump, along with activation of suitable alarm.

Auto shutdown = automatic stopping of the diesel engines and gas turbine, along with activation of suitable alarm.

Table 8.2.8: Instrumentation and safety system functions in centralized control station – propulsion boiler

System		Monitored parameters	A	D	Auto start	Auto shut down	Notes (Refer also bottom of table) [A = alarm. D = display.
Sensors		Common/separate	c	c	s	s	c = common sensor; s = separate
Feed water	A1	Atmospheric drain tank level – high and low	x	x			
	A2	Deaerator level – high and low	x	x			
	A3	Deaerator pressure – high and low	x	x			
	A4	Feed water pump pressure – low	x	x	x		
	A5	Feed water temperature – high	x	x			
	A6	Feed water outlet salinity – high	x	x			
Boiler Drum	B1	Water level – high and low	x	x			
	B2	Water level – low-low	x			x	
Steam	C1	Pressure – high and low	x	x			
	C2	Super heater outlet temperature – high	x	x			
Air	D1	Forced draft pressure – failure	x			x	
	D2	Rotating air heater motor – failure	x				If provided
	D3	Air register – open/close		x			
	D4	Fire in boiler casing	x	x			
Fuel oil	E1	Pump pressure at outlet – low	x	x	x		
	E2	Heavy fuel oil temperature – high (or viscosity – low)	x	x			
	E3	Heavy fuel oil temperature – low (or viscosity – high)	x	x			
	E4	Master fuel oil valve – open/close		x			
Burner	F1	Burner valve – open/close		x			Individual
	F2	Atomizing medium pressure – off- limits	x	x			
	F3	Ignition or flame of burners – fails	x	x		x	For multiple burners, flame failure of a single burner is to shut down the corresponding burner fuel valves. Shutdown is to be achieved within 6 seconds following flame extinguishment.

	F4	Flame scanner – fails	x			x	For multiple burners fitted with Individual flame scanner, failure of flame scanner is to shut down the corresponding burner fuel
	F5	Uptake gas temperature – high	x				For fire detection
Power	G1	Control system power supply – fails	x	x		x	Automatic closing of fuel valve(s)

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Auto start = automatic starting of standby pump in the system, with activation of suitable alarm.

Auto shutdown = automatic closing of fuel valve, with activation of suitable alarm.

Table 8.2.9: Instrumentation and safety system functions in centralized control station – auxiliary boiler

System	**Monitored parameters**		**A**	**D**	**Auto shut down**	**Notes (Refer also bottom of table)** **[A = alarm. D = display. x = apply.]**
Feed water	A1	Feed water outlet salinity – high	x	x		
Boiler drum	A2	Water level – high	x			
	A3	Water level – low	x	x	x	
Steam	A4	Pressure – high and low	x	x		
	A5	Super heater outlet temperature – high	x	x		
Air	A6	Supply air pressure – failure	x		x	Refer [2.10.10. d.] of this section, Alarm for draft fan failure is acceptable
	A7	Fire in boiler air supply casing	x			Excessive high temperature alarm at boiler air supply casing is acceptable
Fuel oil	A8	Pump outlet pressure – low	x	x		
	A9	Temperature – high and low (or viscosity – low and high)	x	x		For heavy fuel oil only
Burner	A10	Fuel oil valves – open/close		x		Individual valves (Refer Note 1)
	A11	Ignition or flame – fails	x	x	x	Individual; Refer Table 8.2.8 of this section
	A12	Flame scanner – fails	x		x	Individual; Refer Table 8.2.8 of this section

	A13	Uptake gas temp. – high	x			
Power	A14	Control system power supply – fails	x		x	

Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.

Notes:

1 Applicable only to auxiliary boilers with multiple burners.

Table 8.2.10: Instrumentation and safety system functions in centralized control station – auxiliary turbines and diesel engines

System	Monitored system & parameters			A	D	Auto shut down	Notes (Refer also bottom of table)
Diesel Engine	Lubricating oil	A1	Bearing oil inlet pressure – low	x	x	x	
		A2	Bearing inlet oil temperature – high	x	x		
		A3	Oil mist in crankcase, mist concentration – high; or bearing temperature – high; or alternative arrangements	x		x	For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore more than 300 mm (11.8 inch.). Single sensor having two independent outputs for initiating alarm and for shutdown will satisfy independence of alarm and shutdown.
		A4	Common rail servo oil pressure – low	x			
	Cooling medium	A5	Pressure or flow – low	x	x		
		A6	Temperature at outlet – high	x	x		
		A7	Expansion tank level – low	x			
	Fuel oil	A8	Fuel oil leakage from injection pipe	x			
		A9	Fuel oil temp. – high and low	x			For heavy fuel oil only
		A10	Service tank level – low	x			
		A11	Common rail fuel oil pressure - low	x			

	Starting medium	A12	Energy level – low	x	x		
	Exhaust	A13	Exhaust gas temperature after each cylinder – high	x			For engines having a power of more than 500 kW/cycle.
	Speed	A14	Over speed	x		x	
Steam Turbine	Lubricating oil	B1	Bearing oil inlet pressure – low	x	x	x	
		B2	Bearing oil inlet temperature – high	x	x		
		B3	Bearing temperature or bearing oil outlet temperature – high	x	x		
	Lub. oil cooling medium	B4	Pressure or flow – low	x	x		
		B5	Temperature at outlet – high	x			
		B6	Expansion tank level – low	x			
	Sea water	B7	Pressure or flow – low	x	x		
	Steam	B8	Pressure at inlet – low	x	x		
	Condensate	B9	Condenser vacuum – low	x	x	x	
		B10	Condensate pump pressure – low	x	x		
	Rotor	B11	Axial displacement – large	x		x	
		B12	Overspeed	x		x	
Gas Turbine	Lubricating oil	C1	Inlet pressure inlet – low	x	x	x	
		C2	Inlet temperature – high	x	x		
		C3	Bearing temp. or oil outlet temp. – high	x	x		
		C4	Filter differential pressure	x			
	Cooling medium	C5	Pressure or flow – low	x	x		
		C6	Temperature – high	x			
	Fuel oil	C7	Pressure, inlet – low	x	x		
		C8	Temp. – high and low (or viscosity – low and high)	x			For heavy fuel oil only
	Exhaust gas	C9	Temperature – high	x			
	Combustion	C10	Combustion or flame failure	x		x	
	Starting	C11	Ignition failure	x		x	
		C12	Stored starting energy level – low	x			
	Turbine	C13	Vibration level – high	x		x	

		C14	Axial displacement – high	x		x	Auto shutdown may be omitted for rotors fitted with roller bearings
		C15	Over speed	x		x	
		C16	Vacuum at compressor inlet – high	x		x	
Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness may be considered.							

SECTION 3 REMOTE PROPULSION CONTROLS

Contents

3.1. General

3.1.1. The provisions of Section apply whenever remote control of propulsion machinery is provided.

3.1.2. The remote propulsion control station is to be:

a. As effective as local control;
b. Provided with control of speed and direction of thrust of the propeller.
c. Provided with sufficient instrumentation so that the operator has adequate information about the state of the propulsion machinery and the control system itself.

3.1.3. In general, system requirements in Sec. 2 of this chapter are to be applied. Further requirements are provided in [3.3.] and [3.4.] of this section hereunder.

3.1.4. Equipments for Remote propulsion controls fitted on vessels not receiving notations are to be in accordance with the following requirements:

a. For electrical, hydraulic and pneumatic equipment the requirements in Sec. 2, [2.2.] Of this chapter are applicable. However, flash point limitation on hydraulic fluids is applicable only to vessels to be assigned with CCS or UMS notations.
b. For Computer Based Equipment requirements in Sec. 5 are applicable.
c. All equipment is to be performance tested in the presence of a Surveyor in accordance with Sec. 7, Table 8.7.4 of this chapter either in the shop or after installation. All installations are to be functionally tested to the satisfaction of the surveyor on board and during sea trials, Refer Sec. 7 of this chapter.

3.2. System power supply

3.2.1. Power source

Power supply requirements provided in sec 2, [2.4.] of this chapter.

3.2.2. Power supply transfer

The two feeders should be connected to a transfer switch in the remote control station. Power supply to controls, monitoring and safety systems may be connected commonly to the transfer switch. The transfer between the power supplies might be affected by manual means at the remote control station.

3.3. Control of propulsion machinery

3.3.1. Remote control

3.3.1.1. The design of the remote control system shall be such that in case of its failure an alarm will be given. Supply failure (voltage, fluid pressure, etc.) in propulsion plant remote control is to activate an alarm at the control position. In the event of remote control system failure and unless the INTLREG considers it impracticable, the preset speed and direction of thrust are to be maintained until local control is in operation. This applies in particular in the case of loss of electric, pneumatic or hydraulic supply to the system.

3.3.1.2. Propulsion machinery orders from the navigation bridge are to be indicated in the main machinery control room and at the maneuvering platform.

3.3.1.3. The control shall be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery. Where multiple propellers are designed to operate simultaneously, they must be controlled by one control device.

3.3.1.4. Indicators shall be fitted on the navigation bridge, in the main machinery control room and at the maneuvering platform, for: propeller speed and direction of rotation in the case of fixed pitch propellers; and propeller speed and pitch position in the case of controllable pitch propellers.

3.3.2. Remote control from navigating bridge

Where a bridge control system for main propulsion machinery is to be fitted, the following requirements are to be satisfied:

a. Where propulsion machinery is to be controlled from the navigation bridge, means for control and monitoring are to be as provided in Table 8.3.1 of this section.
b. Means are to be provided to ensure satisfactory control of propulsion from the bridge in both the ahead and astern directions.
c. The following indications are to be provided on the bridge:

    i. Propeller speed;
    ii. Direction of rotation of propeller for a fixed pitch propeller or pitch position for a controllable pitch propeller.
    iii. Direction and magnitude of thrust;
    iv. Clutch position, where applicable;
    v. Shaft brake position, where applicable.

d. The propeller speed, direction of rotation and, if applicable, the propeller pitch are to be controlled from the bridge under all sea-going and maneuvering conditions.
e. Means are to be provided for local manual control so that satisfactory operation of the propulsion machinery can be exercised for lengthy periods in the event of the failure of the remote propulsion control system. For this purpose, indicators for propeller speed and direction of rotation (for fixed pitch propellers) or pitch position (for controllable pitch propellers) are to be provided at this local manual control station. It is also to be possible to control auxiliary machinery, which are essential for propulsion and safety of the vessel, at or near the machinery concerned.
f. Remote control of the propulsion machinery is to be from one control station at any one time. Main propulsion control units on the navigating bridge may be interconnected. Means are to be provided at the main machinery control station to ensure smooth transfer of control between the bridge and machinery control stations.
g. Means of control, independent of the bridge control system, are to be provided on the bridge to enable the watch-keeper to stop the propulsion machinery in an emergency.
h. Audible and visual alarms are to operate on the bridge if any power supply to the bridge control system fails. Where practicable, the preset speed and direction of thrust are to be maintained until corrective action is taken.
i. Between the bridge and the main control station in the machinery space, two means of communication are to be provided. One of these means may be the bridge control system while the other should be independent of the main electrical power supply.
j. Automation systems are to be designed in a manner such that a threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency. In particular, the systems are to control, monitor, report, alert and take

safety action to slow down or stop propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene, except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example in the case of over-speed.

k. Where it is necessary to restart the propulsion machinery in order to reverse it to go astern, means to start the propulsion machinery is to be provided on the navigation bridge. In such cases, and in other cases where propulsion machinery can be started from a remote control station, the following are to be provided:

    i. An alarm to indicate a low level starting medium energy condition, e.g., a low starting air pressure, which is to be set at a level to permit further starting operation.
    ii. A display for indicating starting medium energy level.
    iii. Where automatic starting of the propulsion machinery is fitted, the number of consecutive automatic attempts is to be limited in order to safeguard sufficient capacity for local manual starting.
    iv. Starting of the propulsion machinery is to be automatically inhibited where conditions exist which may damage the propulsion machinery. The activation of such inhibition is to be alarmed at the remote control station.

3.3.3. Remote propulsion control station other than navigation bridge

3.3.3.1. Where the remote propulsion control station is provided at a location other than the navigation bridge, such station is to comply with requirements applicable to that at the navigation bridge, with the exception of the provision of telegraph.

3.3.3.2. Remote propulsion control stations fitted in ships having the propulsion machinery space manned should be provided with the alarms, displays and controls as listed in Table 8.3.1 of this section, items A1 through C2 as a minimum. Where a remote propulsion control station is provided in or in the vicinity of the propulsion machinery space for the purpose of full remote operation of a locally manned propulsion machinery space, it is necessary that such a station is to be fitted with:

a. Remote propulsion control station.
b. Alarms, displays and controls as required in sec 2, Table 8.2.1 of this chapter.
c. Alarms and displays of table 8.2.2 through table 8.2.10 in sec 2 of this chapter as applicable.

3.3.4. Automatic control

3.3.4.1. Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shutoff arrangements in the case of failures such as lubricating oil supply failure which could lead rapidly to complete breakdown, serious damage or explosion.

3.3.4.2. The automatic control system is to be designed on a fail-safe basis, and, in the event of failure, the system is to be adjusted automatically to a predetermined safe state.

3.3.4.3. When the remote control system of the propulsion machinery includes automatic starting, the number of automatic consecutive attempts is to be limited at a preset value of the starting air pressure permitting 3 attempts, and an alarm is to be provided, on the navigation bridge and in the machinery space.

3.3.4.4. Operations following any setting of the bridge control device (including reversing from the maximum ahead service speed in case of emergency) are to take place in an automatic sequence and with acceptable time intervals, as prescribed by the manufacturer.

3.3.4.5. For steam turbines, a slow turning device is to be provided which operates automatically if the turbine is stopped longer than admissible. Discontinuation of this automatic turning from the bridge is to be possible.

3.3.4.6. When the power source actuating the automatic control of propelling units fails, an alarm is to be triggered. In such case, the preset direction of thrust is to be maintained long enough to allow the intervention of engineers. Failing this, minimum arrangements, such as stopping of the shaft line, are to be provided to prevent any unexpected reverse of the thrust. Such stopping may be automatic or ordered by the operator, following an appropriate indication.

3.3.5. Clutches

3.3.5.1. Where the clutch of a propulsion engine is operated electrically, pneumatically or hydraulically, an alarm is to be given at the control station in the event of loss of energy; as far as practicable, this alarm is to be triggered while it is still possible to operate the equipment.

3.3.5.2. When only one clutch is installed, its control is to be fail-set. Other arrangements may be considered in relation to the configuration of the propulsion machinery.

3.3.6. Brakes

Automatic or remote controlled braking is to be possible only if:

a. The turning gear is disconnected.
b. Propulsion power is shut off.
c. The shaft-line speed (r.p.m.) is below the threshold stated by the builder.

3.4. Safety system alarms

3.4.1. In all cases, automatic safety shutdowns in Sec. 2, [2.4.10.] of this chapter are to be provided. Other safety system functions, such as automatic startup of standby pump or automatic slowdown, as appropriate, may be provided.

Where the propulsion machinery can be remote control from the navigation bridge, regardless of manned or unmanned machinery space, automation systems are to be designed in a manner such that a threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency.

In particular, the systems are to control, monitor, report, alert and take safety action to slowdown or shutdown propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene (override), except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example, in the case of over speed.

3.4.2. Activation of safety system to automatic slowdown or automatic shutdown of propulsion machinery is each to be arranged with individual alarm at remote propulsion control station.

At the control station, the audible alarm may be silenced however; visual alarm is to remain activated until it is acknowledged in the machinery space.

3.4.3. Automatic slowdowns and automatic shutdowns indicated in Table 8.2.2 through Table 8.2.10 in sec 2 of this chapter may be provided with override, except that specified in sec 2, [2.10.10.] of this chapter. Overrides are to be as follows:

a. The activation of the override is to be alarmed and clearly identifiable at the remote propulsion control station and is to be designed such that it cannot be left activated.
b. Overrides fitted on the navigation bridge should be operable only when the propulsion control is from the navigation bridge.
c. The override actuator is to be arranged to preclude inadvertent operation.

3.4.4. Propulsion machinery shutdown by safety system is not to resume operation until it is reset manually.

Table 8.3.1: Instrumentation and controllers on remote propulsion control stations

System	Monitored/controlled parameter		A	D	C	Notes [A= Alarm; D= Display; C= Controller/Actuator]
Propulsion control & monitoring	A1	Propeller speed		x	x	
	A2	Propeller direction		x	x	
	A3	Propeller pitch		x	x	As applicable
	A4	Telegraph		x	x	
	A5	Emergency shutdown of propulsion engine			x	To be protected from accidental tripping
	A6	Starting of propulsion engine			x	For reversible engines only
	A7	Stored starting energy level – low	x	x		For reversible engines and engines fitted with means of starting at remote control station
	A8	Inhibition of starting of propulsion engine	x			Where remote engine starting is fitted
	A9	Automatic shutdown activated	x			
	A1	Automatic slowdown activated	x			If provided
	A1 1	Safety system override	x	x	x	If fitted (Refer [3.4.3.] of this section). To be of a design that cannot be left activated
	A1 2	Shaft turning gear engaged		x		To automatically inhibit starting of engine
	A1	Operating in barred speed range	x			
	A1 4	Threshold warning for safety system activations	x			For navigation bridge only (Refer [3.4.2.] of this section).

System monitoring	B1	Power source – fails	x	x		For non-CCS vessels, the failure alarm is applicable to main power source only. For CCS vessels, applicable to main and emergency power sources. Refer [3.2.] of this section.
	B2	Individual power supply to control, monitoring and safety systems – fails	x	x		Alarm may be common. For main power supply failure alarm for governor control
	B3	Alarm system – disconnected		x		
	B4	Integrated computer-based system: data highway abnormal conditions	x			Alarm is to be activated before critical data overload.
	B5	Integrated computer-based system: duplicated data link – failure of one link	x			
Others	C 1	Control station transfer		x	x	Display: to indicate the station in control. Control: to provide 1) Transfer switch & 2) Acknowledgment switch.
	C 2	Air conditioning system – fails	x			If necessary for equipment environment control
Additional requirements for Navigation Bridge for vessels assigned with UMS						
UMS	D 1	Summary alarms – activated by alarm conditions in Sec. 2/Table 8.2.1 through Sec. 2/Table 8.2.10 of this chapter.	x			
	D 2	High voltage rotating machine – Stationary windings temperature – high	x			
	D 3	Controllable pitch propeller hydraulic power unit run/start/stop		x	x	If standby unit is provided with automatic starting, such starting is to be alarmed.
	D 4	Steam turbine automatic shaft rollover – activated		x	x	Control: to deactivate automatic shaft rollover.
	D 5	Steam turbine shaft stopped – in excess of set period	x			
	D 6	Boiler steam pressure – low	x			For propulsion and associated electric power generating machinery

	D7	Boiler control power – failure	x			For propulsion and associated electric power generating machinery
	D8	System power source: main and emergency feeder – status and failure	x	x		
	D9	Propulsion machinery space – fire detected	x			
	D10	Start main fire pump and pressurize fire main		x	x	Sec.2, [2.8.] & [2.9.] of this chapter
	D11	Propulsion machinery space – bilge level high	x			
Display = display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered						

SECTION 4 REMOTE CONTROL MONITORING OF AUXILIARY MACHINERY AND SYSTEMS

Contents

4.1 Control and supervision of unattended machinery

4.1.1. General

4.1.1.1. Where machinery, as listed in Sec 1, [1.4.4.1.] of this chapter is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with the alarms and safety arrangements required by [4.1.2.] to [4.1.12.] of this section as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

4.1.1.2. In general, the ship is to be fitted with:

a. A remote propulsion control station on the navigation bridge specified in sec 3, [3.3.2.] of this chapter with capability to monitor the propulsion machinery space and the machinery plant.
b. A centralized control station in compliance with Sec 2, [2.13.] of this chapter, which is to be further provided with safety system functions capable of taking automated corrective actions in the event of a fault in the machinery plant; such a station may be periodically unattended.
c. A monitoring station in the engineers' quarters capable of alarming any undesirable state of the propulsion machinery space and of the machinery plant. Refer Sec. 2, [2.7.14.] of this chapter.
d. A firefighting station with means to effect rapid response to control fire in the propulsion machinery space. Refer Sec. 2, [2.8.] and [2.9.] of this chapter.

4.1.1.3. The extent of automation, monitoring and remote control is to be such that is allows unattended propulsion machinery space operations for at least 24 hours. For duration less than 24 hours, the limitation is to be noted in the classification record.

4.1.1.4. In general, system requirements in sec. 2 of this chapter are applicable. FMEA (Refer Sec. 1, [1.3.1.14.] of this chapter) is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in the loss of propulsion control, the loss of propulsion or other undesirable consequences. The FMEA report is to be submitted for review.

4.1.1.5. System power supply is to comply with Sec. 3, [3.2.] of this chapter, except that the power supply status display and the alarm of the failure of either power source are also to be provided at the navigation bridge.

4.1.1.6. To allow for unattended operation, the centralized control station is to be provided with safety system functions specified in "Auto start", "Auto slowdown" and "Auto shutdown" columns of Sec. 2, Table 8.2.2 through Sec. 2, Table 8.2.10 of this chapter. In addition to complying with Sec. 2, [2.10.] of this chapter, the following features are also applicable in order to safeguard continued operation of machinery

a. Automatic Start and Changeover

In the event of detecting low or the loss of system pressure, as specified in Sec. 2, Table 8.2.2 through Sec. 2, Table 8.2.5 of this chapter and Sec. 2, Table 8.2.5 of this chapter (in "Auto start" column), automatic startup of and changeover to the standby pumps, which are essential to maintain the running of the propulsion machinery, are to be provided.

b. Automatic Slowdown

Automatic slowdown, where indicated in Sec. 2, Table 8.2.2 through Sec. 2, Table 8.2.4 of this chapter, is to be provided in order to maintain the continuous operation of the propulsion machinery in the event of specified alarm conditions.

c. Automatic Shutdown

Automatic shutdowns are to be provided, where indicated in Sec. 2, Table 8.2.2 through Sec. 2, Table 8.2.8 of this chapter, to protect the propulsion machinery from serious damage.

Where automatic shutdown is indicated in these tables as a requirement along with [4.1.1.6. a.] or [4.1.1.6. b.] of this section or both, the intent is that either [4.1.1.6. a.] or [4.1.1.6. b.] of this section or both is to be activated first; and if the state of the propulsion machinery does not improve, then [4.1.1.6. c.] of this section is to be activated.

4.1.1.7. Where power is automatically restored following a blackout, auxiliaries that are essential for propulsion and maneuvering are to be automatically started. In order not to overload the generator while the motors are starting, means such as sequential starting are to be provided where necessary.

Where machinery is arranged to start automatically or from a remote control station, interlocks should be provided for preventing start-up under conditions which could hazard the machinery.

4.1.1.8. Components, equipment, subsystems, etc. used in control, monitoring and safety systems of propulsion machinery, propulsion boilers and vital auxiliary pumps are to be designed and tested in accordance with the provisions of Sec. 2, [2.2.] of this chapter.

4.1.1.9. Means are to be provided to prevent leaks from high pressure oil fuel injection piping for main and auxiliary engines dripping or spraying onto hot surfaces or into machinery air inlets. Such leakage is to be collected and, where practicable, led to a collector tank(s) fitted in a safe position. An alarm is to be provided to indicate that leakage is taking place. These requirements may also be applicable to high pressure hydraulic oil piping depending upon the location.

4.1.1.10. Oil mist detection or engine bearing temperature monitors or alternative methods for crankcase protection are to be provided:

a. When arrangements are fitted to override the automatic shutdown for excessive reduction of the lubricating oil supply pressure.
b. For engines of 2250 kW and above or having cylinders of more than 300 m bore.

4.1.2. Oil engines for propulsion purposes

4.1.2.1. Alarms, displays & safety system functions for Propulsion diesel engines Refer Sec.2, Table 8.2.2 and Sec. 2, Table 8.2.3 of this chapter. For alarms and safeguards of emergency diesel engines Refer Ch 2, Sec 3, [3.6.] of this part.

4.1.2.2. Alarms should operate for the fault conditions. Where applicable, indication should be given at the relevant control stations that the speed or power of the main propulsion engine(s) is to be reduced manually or has been automatically reduced.

4.1.2.3. The following engine services should be fitted with automatic temperature controls for maintaining steady state conditions throughout the normal operating range of the propulsion engine(s):

a. Oil fuel supply: The oil fuel supply may be fitted with an automatic control for viscosity instead of the temperature control.
b. Lubricating oil supply;
c. Cylinder coolant supply, where applicable;
d. Fuel valve coolant supply, where applicable;
e. Piston coolant supply, where applicable.

4.1.2.4. At each control station, indication of the starting air pressure is to be provided from which it is possible to start the main propulsion engine(s).

4.1.2.5. The number of automatic consecutive attempts which fail to produce a start is to be limited to three. For reversible engines which are started and stopped for maneuvering purposes, means are to be provided to maintain sufficient starting air in the air receivers.

4.1.2.6. Prolonged running in a restricted speed range is to be prevented automatically or, alternatively, an indication of restricted speed ranges is to be provided at each control station.

4.1.3. Gas turbines

4.1.3.1. Alarms, displays & safety system functions in Sec. 2, Table 8.2.5 of this chapter are applicable.

4.1.3.2. Automatic control arrangements for gas turbine modules are to be provided for regulating the quantity of fuel flowing to the burners during starting, over the operating power range and when stopping the gas turbine, in a controlled manner and within the safe operating envelope of the gas turbine. The arrangement is to have provision to collect condition and transmit both primary and secondary surveillance signals to the local and remote operating locations.

4.1.3.3. The control system should be provided with control functions at the component level for allowing direct manual control of the fuel flow and engine shut down in the event of failure of the electrical power supplies or a critical failure of the engine control system.

4.1.3.4. Each gas turbine module should be provided with control unit comprising of minimum instrumentation necessary for monitoring, controlling and surveillance for safe operation both local and remote positions with facility for transfer of control authority through a suitable selector switch.

4.1.4. Main, auxiliary and other boilers

4.1.4.1. The following boiler services should be fitted with automatic controls for maintaining steady state conditions throughout the normal operating range of the boiler:

a. Oil fuel supply temperature or viscosity, heavy oil only;
b. Boiler drum water level;
c. Combustion system;

d. De-aerator water level, where applicable;
e. Superheated steam temperature, where applicable;
f. Superheated steam pressure, where applicable;
g. De-superheated steam pressure, where applicable;
h. De-superheated steam temperature, where applicable.

4.1.4.2. Safety system and overrides should be in compliance with the requirements of sec 2, [2.10.6.] of this chapter.

4.1.4.3. For propulsion boilers, alarms, displays & safety system functions in Sec. 2, Table 8.2.8 of this chapter. For auxiliary boilers, alarms, displays & safety system functions in Sec. 2, Table 8.2.9 of this chapter.

4.1.4.4. Auxiliary boilers necessary to support operation of propulsion, including ship service electric power supply, may be fitted with an alarm and display located in the centralized control and monitoring station mentioned in [4.1.4.3.] of this section, provided:

a. The boiler is fitted with automatic control.
b. The boiler is fitted with local control station and is not intended for remote control.
c. The local control station is fitted with all controls, safety provisions, alarms and displays in Sec. 2, Table 8.2.9 of this chapter (except that salinity alarm and display may be provided at the centralized control and monitoring station).
d. The centralized control and monitoring station is provided with the display for “boiler running”, and summary alarms for “boiler abnormal” and “boiler shutdown”. The “boiler abnormal” alarm is to be activated by any of the alarms listed in Sec. 2, Table 8.2.9 of this chapter.

4.1.4.5. In order to prevent a build-up of excessive propulsion boiler steam which might occur when all burners are in service and the burners are at the minimum firing rate, one of the following arrangements or equivalent is to be provided:

a. Burner sequencing which might require automatic control of one or more but not necessarily all burners in the boiler.
b. An automatic steam dump system unloading to a condenser of adequate size.
c. For long term port operation at low loads, the excess burner capacity may be secured.

4.1.4.6. Means are to be provided for preventing boiler start up in the event of unsafe firing conditions (example, low water level, forced draft failure). Such conditions are to be alarmed. Means are also to be provided for preventing start up following a shutdown, unless manually reset.

4.1.4.7. Automatically started boilers are to be provided with a programmed control. The programmed control is to be designed to cycle the boiler in accordance with a predetermined sequence and in addition to the automatic boiler purge in [4.1.4.6.] of this section is to include the following events:

a. Ignition timing (spark coming on) is to precede the opening of the fuel valve.
b. Modulated air fuel ratio: where it is necessary to cut burners in and out to handle the load on the boiler, and controls are provided to modulate the air-fuel ratio, the automatic boiler purge period is to start with the modulating control in the high-firing position (air registers in maximum opening position) and ignition is not

to be turned on until the modulating control has returned to the low-firing position (air registers in minimum opening position).

4.1.5. Thermal fluid heaters

4.1.5.1. For alarm & safeguards of thermal fluid heater Refer Table 8.4.1 of this section.

4.1.5.2. The standby pumps for oil fuel and thermal fluid circulation should start automatically when the discharge pressure from the working pump falls below a predetermined value. The standby pumps for thermal fluid circulation is also to start before the shut-offs due to low thermal fluid pressure.

4.1.5.3. The following heater services should be fitted with automatic controls for maintaining steady state conditions throughout the operating range of the heater:

a. Oil fuel supply temperature or viscosity, heavy oil only;
b. Thermal fluid temperature;
c. Combustion system.

4.1.5.4. Burner controls should have such an arrangement that light off is possible only at the minimum firing rate compatible with flame establishment. If ignition is supposed to occur at a fuel rich condition then the burner is to revert to the correct operating air/fuel ratio on establishment of a stable flame.

4.1.5.5. Arrangements should be such that burner oil fuel valve(s) do not open:

a. When the power supply to the igniter has failed, as applicable; or
b. Prior to completion of required warm up times for residual fuel oil; or
c. Until a pilot flame is established, as applicable; or
d. Prior to the completion of furnace purging.

4.1.5.6. Arrangements for flame failure detection should be provided with self-monitoring capabilities which ensures that the flame detector is not erroneously indicating the presence of a flame. In the event of failure being detected by these self-monitoring capabilities:

a. An alarm is to be activated in the event of loss of flame detection capability for a burner.
b. Oil fuel to the burner is to be shut-off automatically and
c. An alarm is to be activated.

4.1.5.7. Means are to be provided for preventing the starting of the ignition sequence following multiple flame failures until the completion of the identified lock out period.

4.1.5.8. The furnace should be purged automatically for at least the required pre purging time, following burner shutdown. The purging requires to be manually initiated in the event of a shutdown due to activation of a required safeguard.

4.1.6. Generators and Electrical Systems

4.1.6.1. For generators and electrical systems alarms and displays in Sec. 2, Table 8.2.1 of this chapter and Sec. 2, Table 8.2.10 of this chapter is applicable. The following are also to be complied with.

a. Starting of Generators

In addition to complying with Ch 2, Sec 2, [2.1.2.] of this part for automatically restoring power to equipment necessary for propulsion, steering and safety, arrangements are to be provided to enable manually starting, stopping, synchronizing, paralleling and placing in service any generator from a single location.

This location is to be at the main switchboard or may be at the centralized control console, if the main switchboard is located in the centralized control station.

b. Monitoring of Generators

Where the main switchboard is not located in the centralized control station, alarms and displays for monitoring the generators and main switchboard, as indicated in Sec 2, Table 8.2.1 of this chapter, are to be provided in the centralized control station.

4.1.6.2. For alarm & safeguards of inert gas generators Refer Table 8.4.2 of this section.

4.1.6.1. Inert gas generators should be fitted with an automatic combustion control system for maintaining steady state conditions throughout the operating range of the generator.

4.1.7. Incinerators

4.1.7.1. For alarm & safeguards of incinerators Refer Table 8.4.3 of this section.

4.1.7.2. Where arrangements are provided for introducing solid waste into the furnace, it has to be such that there is no risk of a fire hazard.

4.1.7.3. The combustion temperature is to be controlled for ensuring that all liquid and solid waste is burned efficiently without exceeding predetermined temperature limits.

4.1.8. Propulsion steam turbines

4.1.8.1. In addition to the alarms, displays & safety system functions in Sec. 2, Table 8.2.4 of this chapter and in the event of loss of lubricating oil, automatic or manual means are to be provided to allow braking steam to be applied to the turbine.

4.1.8.2. The astern guardian valve should open automatically as a result of a throttle trip or a maneuvering signal, such as the actuation of a specific switch or by movement of the throttle control in the maneuvering range. An alarm is to indicate any failure of the guardian valve to open.

4.1.8.3. If for the main condenser scoop circulation is provided, then the main circulating pump should be automatically started as required for satisfactory operation of the propulsion machinery.

4.1.8.4. In the event of low lubricating oil-pressure, there should be an automatic changeover to the standby lubricating oil-pump(s). The governor is to be arranged for shutting off the steam to the ahead turbines upon failure of the lubricating-oil system.

4.1.8.5. Audible and visual alarms are to operate and indication should be given at the relevant control stations to stop or reduce the speed of the turbine(s) for the following fault conditions:

a. Excessive axial movement of turbine rotor;
b. Excessive turbine vibration;
c. Low vacuum in main condenser;
d. High condensate level in main condenser.

4.1.8.6. The main and secondary control locations are to be provided with an alarm for indicating that the propeller shaft has been stopped too long on a standby or stop maneuver.

4.1.8.7. Reduction of speed may be effected by either manual or automatic control.

4.1.8.8. Means should be provided for preventing the risk of thermal distortion of the turbines by automatic steam spinning at a time when the shaft is stopped in the maneuvering mode. At the relevant control stations, an audible and visual alarm is to be provided when the shaft has been stopped for a predetermined time.

4.1.8.9. The following turbine services are to be fitted with automatic controls so as to maintain steady state conditions throughout the normal operating range of the propulsion turbine(s):

a. Lubricating oil supply temperature;
b. Condenser condensate level;
c. Gland steam pressure.

4.1.9. Controllable pitch propellers and transverse thrust units

4.1.9.1. For alarm & safeguards of Controllable pitch propellers and transverse thrust units Refer Table 8.4.4 of this section.

4.1.9.2. For controllable pitch propellers for main propulsion, a standby or alternative power source of actuating medium for controlling the pitch of the propelling blades is to be provided. Automatic start of the standby pump supplying hydraulic power for pitch control is to be provided.

4.1.9.3. Controllable pitch propellers for main propulsion are to be provided with indications of shaft speed, direction and magnitude of thrust and propeller pitch as a measure of the propeller blade or actuator movement at each station from which it is possible to control shaft speed or propeller pitch.

4.1.9.4. Where transverse thrust units are remotely controlled means are provided at the remote control station for stopping the propulsion unit.

4.1.9.5. Transverse thrust units should be provided with indications of direction and magnitude of thrust and propeller pitch at each station from which it is possible to control the propeller pitch.

4.1.9.6. An indication of the angular position of rotatable thrust units is to be provided at each station from which it is possible to control the direction of thrust.

4.1.10. Water-jets

4.1.10.1. For alarm & safeguards of Water-jets Refer Table 8.4.5 of this section.

4.1.10.2. For water-jets used as the only means of propulsion, a standby or alternative power source of actuating medium for the purpose of controlling the angular position and/or the reversing angle is to be provided. Automatic start of the standby pump supplying hydraulic power for the purpose of steering and reversing is also to be provided.

4.1.10.3. An indication of the angular position of water-jets is to be provided at each station from which it will be possible to control the angular position.

4.1.10.4. It is necessary to provide an indication of the bucket position at each station from which it is possible to control the reversal of thrust.

4.1.11. Miscellaneous machinery

For alarm & safeguards of miscellaneous machinery, Refer Table 8.4.6 of this section.

4.1.11.1. Dual fuel systems

Oil and gas dual fired systems for engines and boilers should be provided with indication for showing which fuel is in use.

4.1.11.2. Oil heaters

Oil fuel or lubricating oil heaters requires to be fitted with a high temperature alarm which may be incorporated in the temperature control system. An independent sensor with manual reset, in addition to the temperature control system is to be fitted which will automatically cut off the heating supply in the event of excessively high temperatures or loss of flow, except where the maximum temperature of the heating medium remains limited to a value below 220^0C.

4.1.11.3. Oil tank electric heating

Oil fuel and lubricating oil tanks that are provided with electric heating elements should be fitted with a high temperature alarm which can be incorporated in the temperature control system, a low level alarm and an additional low level sensor to cut off the power supply at a level above that at which the heating element would be exposed.

4.1.11.4. Oil fuel tanks

Low level conditions of fuel oil settling and daily service tanks are to be alarmed at the centralized control station. Where automatic filling is provided, the arrangements are to include automatic pump shutdown and start-up at predetermined high and low levels, respectively. In such cases, fuel oil high level alarm is also to be provided.

In addition, where automatic filling is provided, each of the fuel oil settling or service tanks is to be of a capacity sufficient for at least 8 hours operation at normal power.

Where automatic filling is not provided, the capacity of each of these tanks is to be sufficient for at least 24 hours operation at normal power. Otherwise, a time limitation will be noted in the classification record.

Means are to be provided for eliminating the possibility of overflow from oil fuel service tanks into the machinery space and to safeguard against overflow of oil from oil fuel service tanks through the air pipe.

Fuel oil overflow tanks and fuel oil drain tank receiving fuel oil from drip pans, spill trays and other leakage containment facilities are to be fitted with a high level alarm at the centralized control station.

4.1.12. Bilge level detection

4.1.12.1. An alarm system should be provided for warning when liquid in machinery space bilges reaches a predetermined level and should be in compliance with Sec. 2, [2.7.] of this chapter. This level should be sufficiently low for preventing liquid from overflowing from the bilges onto the tank top. The number and detectors are to be such that accumulation of liquids will be detected at all angles of heel and trim. In ships above 2000 gross tons, there should be two independent systems of bilge level detection in the machinery space, arranged such that each branch bilge is provided with a level detector.

4.1.12.2. Local or remote controls of any valve within the space serving a sea inlet, a discharge below the waterline, a bilge injection or a direct bilge system, should be so sited as to be readily accessible and to allow adequate time for operation in case of influx of water to the space, having regard to the time which could be taken to reach and operate such controls.

Where the bilge pumps are arranged to start automatically, means should be provided for indicating if the influx of liquids is greater than the pump capacity or if the pump is operating more frequently that would be expected. Special attention should be given to oil pollution prevention requirements.

Table 8.4.1: Alarms and safeguards for thermal fluid heaters

Item	Alarm	Note
Expansion tank level*	Low	Oil fuel burners to be shut-off automatically
Thermal fluid flow	Low	Oil fuel burners to be shut-off automatically, (Refer Note 5)
Thermal fluid pressure	Low	Oil fuel burners to be shut-off automatically
Thermal fluid outlet temperature*	1st stage high	—
	2nd stage high	Oil fuel burners to be shut-off automatically
Combustion air pressure*	Low	Oil fuel burners to be shut-off automatically in operation or not released during start up, Refer Note 3. Purge sequence to be inhibited.
Oil fuel pressure*	Low	—
Oil fuel temperature or viscosity*	High and Low	Heavy oil only
Oil fuel atomizing steam/air pressure	Low	—
Burner flame*	Failure	Each burner to be monitored. Oil fuel to burner to be shut-off automatically, (Refer Note 3)
Flame monitoring device(s)*	Failure	Refer [4.1.5.6.] of this section and Note 3
Igniter power supply*	Failure	Each igniter to be checked before oil fuel is supplied to burner(s), Refer [4.1.5.5.] of this section and Note 3
Forced draft fan*	Power failure	Oil fuel to burners to be shut-off automatically in operation or not released during start up, (Refer Note 3)

Air register and dampers (including those in the uptake)*	Not fully open	Purge sequence to be inhibited
Control system*	Power failure	Oil fuel to burners to be shut-off automatically. Control using alternative arrangements is to remain available, Refer Sec. 2, [2.12.7.] of this chapter.
Uptake temperature	High	To monitor for soot fires. Oil fuel to the burner is to be shut off, (Refer Notes 4and 6)

NOTES

1. Special consideration may be given to the requirements for oil-fired hot water heaters.

2. For heaters not supplying thermal oil for services essential for the safety or the operation of the ship at sea, only the items marked* are required.

3. These safeguards are to remain operative during automatic, manual and emergency operation.

4. Alarm and oil fuel shut-off only required where exhaust gas economizers/boilers are fitted.

5. For exhaust gas economizers/boilers requiring thermal fluid forced circulation, the low flow alarm is to be fitted with provision to over-ride the alarm if the exhaust gas economizer/boiler is to be operated in the dry condition.

6. Alternatively, details of an appropriate fire detection system are to be submitted for consideration.

Table 8.4.2: Alarms and safeguards for inert gas generators

Item	Alarm	Note
Inert gas outlet temperature	High	Oil fuel to burner to be shut-off automatically
Combustion air pressure	Low	Oil fuel to burner to be shut-off automatically
Oil fuel pressure	Low	—
Oil fuel temperature or viscosity	High and Low	Heavy oil only
Burner flame and ignition	Failure	Oil fuel to burner to be shut-off automatically, (Refer Note)
Cooling water pressure or flow	Low	Oil fuel to burner to be shut-off automatically
Cooling water temperature	High	—

Combustion space cooling water level (where continuous circulation is required)	High	Cooling water pump and oil fuel to burner are to be shut-off automatically
Oil fuel supply Insufficient Power supply to inert gas generator	Failure	Gas regulating valve is to be shutdown automatically
Automatic control system power supply	Failure	—
NOTE: Combustion spaces are to be purged automatically before re-ignition takes place in the event of a flame-out on all burners.		

Table 8.4.3: Alarms and safeguards for incinerators		
Item	**Alarm**	**Note**
Oil fuel temperature or viscosity	High and Low	Heavy oil and sludge
Oil fuel pressure	Low	—
Combustion air pressure	Low	Oil fuel and/or sludge to burners to be shut-off automatically
Burner flame and ignition	Failure	Oil fuel and/or sludge to burners to be shut-off automatically, (*Refer* Note)
Furnace temperature	High	Oil fuel and/or sludge to burners to be shut-off automatically
Furnace temperature	Low	If applicable
Exhaust temperature	High	—
NOTE: Combustion spaces are to be purged automatically before re-ignition takes place in the event of a flame-out on all burners.		

Table 8.4.4: Alarms and safeguards for controllable pitch propellers and transverse thrust units		
Item	**Alarm**	**Note**
Hydraulic system pressure	Low	—
Hydraulic oil supply tank level	Low	—
Hydraulic oil temperature	High	Where an oil cooler is fitted
Power supply to the control system between the remote control station and hydraulic actuator	Failure	Refer Sec. 2, [2.12.2.] of this chapter.
Propulsion motor	Overload	Refer Ch 2, Sec 4, [4.6.] of this part.

Table 8.4.5: Alarms and safeguards for water-jets		
Item	**Alarm**	**Note**
Hydraulic system pressure	Low	—
Hydraulic oil supply tank level	Low	—
Hydraulic oil temperature	High	Where an oil cooler is fitted
Hydraulic system flow	Low	—
Lubricating oil pressure	Low	—
Control system	Fault	—
Control system power supply	Failure	—

Table 8.4.6 : Alarms and safeguards for miscellaneous machinery		
Item	**Alarm**	**Note**
Stern tube lubricating oil tank level	Low	—
Stern tube bearing temperature (oil lubricated)	High	—
Coolant tanks level	Low	—
Oil fuel service tanks level	High and Low	Where a common overflow tank is fitted, a high level alarm in the common overflow tank may be accepted
Oil fuel service tanks temperature	High	Where heating arrangements are fitted
Oil fuel settling tanks temperature	High	Where heating arrangements are fitted
Sludge tanks level	High	—
Feed water tanks level	Low	Service tank only
Purifier water seal broken	Fault	—
Purifier oil inlet temperature	High	—
Air compressor lubricating oil	Failure	Automatic shutdown
Air compressor discharge air temperature	High	—
Hydraulic control system pressure	Low	—
Pneumatic control system pressure	Low	—
Oil heater temperature	High	—
Controlled environmental conditions	Abnormal	—

4.2 Control and monitoring of watertight bulkhead doors, shell doors and external doors

4.2.1. General

4.2.1.1. Control and monitoring of doors

a. Where doors are designed for power operation, they are to be capable of being remotely closed from the bridge and should also be operable locally from each side of the bulkhead. Each power-operated sliding door should be provided with an individual hand-operated mechanism.
b. Where designed for power operation, a single failure in the electric or hydraulic power-operated system, excluding the hydraulic actuator, is not to prevent the hand operation of any door. Where necessary for power operation of the door, means to start hydraulic unit, or equivalent arrangement, is to be provided at the navigation bridge, and at each remote control position, if provided, and local control position.
c. Displays are to be provided at control position showing whether the doors are open or closed.
d. Display and alarm systems should be self-monitoring so that any failure in the system (e.g., sensor failure, power failure etc.) can be detected and alarmed at the navigation bridge control position.
e. Effective means of testing of monitoring systems are to be provided.
f. Each power operated sliding door should be provided with an audible alarm which will sound whenever the door is closed remotely and which should sound for at least five seconds but not more than ten seconds before the door begins to move and should continue to sound until the door is completely closed. The audible alarm is to be supplemented by an intermittent visual signal at the door in passenger areas and areas where the noise level exceeds 85 dB (A).

4.2.1.2. Electrical power supply

The power circuits for power operated-doors should be separate from power supply to any other systems. Refer Ch 7, Sec 4, [4.10.1.] of this part.

4.2.1.3. Electrical equipment

a. As far as practicable, electrical equipment and components for watertight doors should be situated above the freeboard deck and outside the hazardous areas.
b. The enclosures of electrical components (such as electrical motors, door position indicators, door movement warning signals) necessarily situated below the freeboard deck are to provide suitable protection mentioned in Ch 7, Sec 4, [4.10.2.2] of this part.
c. Enclosures of other electrical components should be in accordance to Ch 2, sec 4, Table 2.4.16 of this part.

4.2.1.4. Hydraulic system

The hydraulic system should be dedicated to the operation of the doors. The system is to be so designed that the possibility of a single failure in the hydraulic piping adversely affecting the operation of more than one door is minimized.

4.2.2. Access doors/hatches normally closed at sea

4.2.2.1. Doors and hatches fitted with gaskets and dogs should be provided with means of indicating locally and on the bridge whether they are open or securely closed. All dogs are to be monitored individually for this purpose. Monitoring of a single dog is required when all dogs are linked to a single acting mechanism.

4.2.2.2. The power supply to the monitoring system should be in accordance with [4.2.1.2.] of this section and the monitoring system is to be self-monitoring in accordance with [4.2.1.1.] of this section.

4.2.3. Bow doors, inner doors, side shell doors and stern doors

4.2.3.1. Hydraulic securing devices

Where hydraulic securing devices are applied, the system should be mechanically lockable in the closed position. The securing devices are to remain locked in the event of a loss of hydraulic fluid. The hydraulic system foe securing and locking devices should be isolated from other hydraulic circuits when in the closed position.

4.2.3.2. Remote control

Doors with a clear opening area of 12 m^2 or greater are to be provided with closing devices operable from a remote control position. Where bow doors and inner doors provide access to a vehicle deck, or where side shell doors or stern doors are located partially or totally below the freeboard deck with a clear opening area greater than 6 m^2 (65 ft^2), an arrangement for remote control from a position above the freeboard deck is to be provided allowing closing and opening of the doors and associated securing and locking of every door. The operating panels for doors are to be accessible to authorized persons only. A notice plate giving instructions to the effect that all securing devices are to be closed and locked before leaving harbor is to be placed at each operating panel and is to be supplemented by warning indicator lights, as required by [4.2.3.3. d.] of this section.

4.2.3.3. Monitoring

The following requirements for displays, water leakage protection and door surveillance are required for vessels fitted with bow doors and inner doors. The requirements also apply to vessels fitted with side shell doors or stern doors in the boundary of special category spaces or ro-ro spaces through which such spaces may be flooded. The requirements are not applicable to ro-ro cargo vessels where no part of the side shell doors or stern doors is located below the uppermost waterline and the area of the door opening is not greater than 6 m^2 (65 ft^2).

a. The display system and the alarm system should be of the self-monitoring type. The alarm system is to be designed on the fail-safe principle.
b. Separate indicator lights are to be provided on the navigation bridge and on each operating panel to show that the doors are closed and that their locking devices are properly positioned.
c. The display panel on the navigation bridge should be equipped with a mode selection function, arranged in such a manner that an audible and visual alarm is given on the navigation bridge if, in the sea voyage condition, the doors are not closed or any of the securing devices are not in the correct position. Display of the open/closed position of every securing and locking device should be provided at the operating panels.

d. Indicator lights are to be designed so that they cannot be manually turned off. The display panel is to be provided with a lamp test function. Dimming facilities may be provided, but the indications are to remain clearly readable under all operating lighting conditions.
e. The power supply for the display system should be independent of the power supply for operating and closing the doors and should be provided with a back-up power supply from the emergency source of power or other secure power supply, for example, UPS.
f. Sensors are to be protected from water, ice formation and mechanical damage, Refer Ch 7, Sec 4, [4.10.4.7.] of this part.
g. *Fail Safe Principle.* The alarm/indicator system is considered designed on a fail-safe principle when the following are provided, as applicable.

1) The indicator panel is provided with:
- A power failure alarm
- An earth failure alarm
- A lamp test
- Separate indication for door closed, door locked, door not closed and door not locked.

2) Limit switches electrically closed when the door is closed (when more limit switches are provided, they may be connected in series)

3) Limit switches electrically closed when securing arrangements are in place (when more limit switches are provided, they may be connected in series)

4) Two electrical circuits (also in one multicore cable), one for the indication of door closed/not closed and the other for door locked/not locked.

5) In the case of dislocation of limit switches, indication to show: not closed/not locked/securing arrangements not in place, as appropriate

4.2.3.4. Leakage monitoring

a. Bow doors and inner doors:

In ships fitted with bow and inner doors, a water leakage detection system with audible alarm and television surveillance should be arranged for providing an indication to the navigation bridge and to the engine control room of leakage through the inner door.

b. Side shell doors and stern doors:

i. In case of passenger ships fitted with side shell or stern doors, a water leakage detection system with audible alarm and television surveillance is to be arranged for providing an indication to the engine control room as well as the navigation bridge of leakage through any of the doors.
ii. For cargo ships fitted with side shell or stern doors, a water leakage detection system with audible alarm is to be arranged for providing an indication to the navigation bridge of leakage through any of the doors.

c. Drainage:

A drainage system should be arranged in the area between the bow door and ramp or where no ramp is fitted between the bow door and inner door. The system is to be equipped with an audible alarm function to the navigation bridge being set off when the water levels in these areas exceed 0.5 m (1.6 ft) or the high water level alarm, whichever is the lesser.

4.2.3.5. Door surveillance

Between the bow door and the inner door, a television surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room. The system is to monitor the position of doors and a sufficient number of their securing devices. Special consideration is to be given for the lighting and contrasting color of objects under surveillance.

4.2.3.6. Electrical equipment
Electrical equipment should be in compliance with [4.2.1.3.] of this section.

4.2.3.7. Hydraulic system

Hydraulic system should be in compliance with [4.2.1.4.] of this section.

4.2.4. External doors/openings

4.2.4.1. External openings below damaged waterline

a. External openings should be fitted with displays on the navigation bridge indicating whether the closing appliances are open or closed securely. For the openings fitted with gaskets and dogs, all dogs should be individually monitored. When all dogs are linked to a single acting mechanism, then only the monitoring of a single dog is required.
b. The power supply to the monitoring system should be in accordance with [4.2.1.2.] of this section. The monitoring system should be self-monitoring in accordance with [4.2.1.1.] of this section.

4.2.4.2. Cargo, gangway or fueling ports

a. The ports in the side shell below the freeboard or superstructure deck should be fitted with displays on the navigation bridge indicating whether the closing appliances are open or closed securely.
b. For ports fitted with gaskets and dogs, all dogs should be monitored individually. When all dogs are linked to a single acting mechanism, the monitoring of a single dog is required only then.
c. For the compartment between the port and the second door, if provided, a water leakage detection system with audible alarm should be arranged for providing an indication to the navigation bridge of leakage through any of the doors.
d. The power supply to the monitoring system should be in accordance with [4.2.1.2.] of this section. The monitoring system is to be self-monitoring in accordance with [4.2.1.1.] of this section.

SECTION 5 PROGRAMMABLE ELECTRONIC SYSTEMS

Contents

5.1. General

5.1.1. These requirements apply to the use of programmable electronic systems providing control, alarm, monitoring or safety functions which are subject to classification.

5.1.2. The requirements given in this section do not apply to navigation and loading instruments.

5.2. Requirements applicable to programmable electronic systems

5.2.1. Programmable electronic systems are to fulfill the requirements of the system under control for all operating conditions, taking into account human safety, environmental impact and damage to vessel as well as equipment, usability of programmable electronic systems and operability of non-computer devices and systems, etc.

5.2.2. Programmable electronic equipment is to revert to a defined safe state on initial startup or re-start in the event of failure. The system's software and hardware is to be designed so that upon restoration of power supply after power failure, automatic or remote control and monitoring capabilities can immediately be available after the pre-established computer control access (sign-in) procedure has been completed.

5.2.3. The power supply is to be monitored for voltage failure and protected for short circuit. In the event of failure of any programmable electronic equipment, the system and any other system to which it is connected, is to fail to a defined safe state or maintain safe operation, as applicable.

5.2.4. Programmable electronic equipment is to be provided with self-monitoring capabilities such that hardware and functional failures will initiate an audible and visual alarm. Hardware failures are to be indicated at least at module level.

5.2.5. System configuration, programs and data are to be protected against loss or corruption in the event of failure of any power supply. To preclude the possible loss or corruption of data as a result of power disruption, programs and associated memory data considered to be essential for the operation of the specific system are to be stored in nonvolatile memory.

5.2.6. Access to system configuration, programs and data is to be restricted by physical and/or logical means providing effective security against unauthorized alteration.

5.2.7. Where date and time information is required by the equipment, this is to be provided by means of a battery powered clock with restricted access for alteration. Date and time of information is to be fully represented and utilized.

5.2.8. Displays and controls are to be protected against liquid ingress due to spillage or spraying.

5.2.9. User interfaces are to be designed in accordance with appropriate ergonomic principles to meet user needs and enable timely access to desired information or control of functions. A system overview is to be readily available. Input devices are to have clearly marked functions and, as far as practicable, are to be arranged to avoid conceivable inadvertent errors in their operations. Input devices, such as keyboard, which can be used to effect changes to equipment or processes under control, are to be provided with security arrangement, such as password, so as to limit access to authorized personnel only.

5.2.10. The keyboard is to be divided logically into functional areas. Alphanumeric, paging and specific system keys are to be grouped separately.

5.2.11. Where a function may be accessed from more than one interface, the arrangement of displays and controls is to be consistent.

5.2.12. The size, color and density of information displayed to the operator are to be such that information may be easily read from the normal operator position under all operational lighting conditions.

5.2.13. Display units are to comply with the requirements of International Electro technical Commission Standard IEC 950:1991.

5.2.14. Where a computer is used as the operator interface for displaying monitoring parameters, the centralized control station should be provided with at least two computers, including keyboards and monitors, unless other means of display capable of displaying the same information are provided.

5.2.15. Symbols used in mimic diagrams should be visually representative and needs to be consistent throughout the systems' displays.

5.2.16. Multi-function displays and controls are to be duplicated and interchangeable where used for the control or monitoring of more than one system, machinery or equipment. The number of units provided at the control location is to be sufficient for ensuring continuous safe operation in the event of failure of any one unit. At least one unit at the main control location is to be supplied from an independent uninterruptible power supply (UPS).

5.2.17. The system is to be configured such that control, alarm and safety function groups are independent. A failure of the system is not to result in the loss of more than one of these function groups. Proposals for alternative arrangements providing an equivalent level of safety will be subject to special consideration.

5.2.18. Computer-based system is to be designed such that failure of any of the system's components will not cause unsafe operation of the process or the equipment it controls. FMEA is to be used to determine that any component failure will not result in the complete loss of control, the shutdown of the process or equipment, or other undesirable consequences.

5.3. Additional requirements for programmable electronic systems used for essential services and safety critical systems

5.3.1. Common hardware in an integrated system serving many sub-systems, e.g., monitor, keyboard, micro-processor, etc., is to be duplicated or otherwise provided with a means of backup.

5.3.2. Failure of one part (individual module, equipment or subsystem) of the integrated system is not to affect the functionality of other parts, except for those functions directly dependent upon information from the defective part.

5.3.3. The design and layout of the hardware is to ensure ease of access to interchangeable parts for repairs and maintenance. Each replaceable part is to be simple to replace and is to be constructed for easy and safe handling. All replaceable parts are to be so designed that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts and their mounting location, including their means of electrical connection, are to be clearly marked.

5.3.4. Alternative means of operation are to be provided for essential services and wherever practicable, these are to be by provision of a fully independent hard wired backup system.

Where these alternative means are dependent on any programmable electronic equipment, the software is to be certified by INTLREG.

5.3.5. For essential services, the system is to be arranged to operate automatically from an alternative power supply in the event of a failure of the normal supply.

5.3.6. An audible and visual alarm is to be initiated in the event of failure of any power supply.

5.3.7. Where it is intended that the programmable electronic system implements emergency stop or safety critical functions, the software is to be certified by INTLREG.

5.3.8. Control, alarm and safety related information is to be displayed in a clear, unambiguous and timely manner and where applicable, is to be given visual prominence over other information on the display.

5.3.9. Where alarms are displayed by means of visual display unit, they are to appear in the sequence as the incoming signals are received. Alarming of the incoming fault signals is to appear on the screen, regardless of the mode the computer or the visual display unit is in. The failure of a primary color is not to prevent an alarm from being distinctly indicated.

5.3.10. Where alarms are displayed by means of graphical display unit, alarms are to be clearly distinguishable from other information and are to be visually and audibly presented with priority over other information, regardless of the mode the computer or the visual display unit is in.

Information is to be presented clearly and intelligibly, according to its functional relations. Display presentations are to be restricted to the data which is directly relevant for the user.

5.4. System categories

Programmable electronic systems are to be assigned into three system categories, as shown in Table 8.5.1 of this section, according to the possible extent of the damage caused by a single failure within the system. The extent of the damage directly caused by the failure is only to be considered and not any consequential damage. Identical redundancy will not be taken into account for the assignment of a system category.

Table 8.5.1: System categories			
Category	**Effects of failure**	**System functionality**	**Examples**
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or a threat to the environment.	Monitoring function for informational / administrative tasks	Maintenance support systems, Information and diagnostic systems
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or a threat to the environment.	• Alarm and monitoring functions • Control functions which are necessary to maintain the ship in its normal operational and habitable conditions.	Alarm and monitoring equipment, Tank capacity measuring equipment, Control systems for auxiliary machinery, Main propulsion remote control systems, Fire detection systems, Fire-extinguishing systems, Bilge systems, Governors
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or a threat to the environment.	• Control functions for maintaining the vessel's propulsion and steering • Safety functions	Machinery protection systems/equipment, Burner control systems, Electronic fuel injection for diesel engines, Control systems for propulsion and steering, Synchronizing units for switchboards

Notes:

1 Consideration is to be given to the extent of the damage directly caused by a failure, but not to any consequential damage. However, the identical redundancy for the safety system will not be taken into account for the assignment of a system category.
2 The assignment of a computer-based system to the appropriate system category is to be made according to the greatest likely extent of direct damage.
3 Where independent effective backup or other means of averting danger for the control functions is provided, the system Category III may be decreased to Category II. Regardless of the effective backup, Category II systems are not allowed to be decreased to Category I.

5.5. General requirements for integrated computer control – ICC notation

5.5.1. Integrated Computer Control class notation may be assigned where an integrated computer system provides fault tolerant control and monitoring functions for one or more of the following services:

a. Propulsion;
b. Cargo and ballast;
c. Electrical generation and distribution (power management systems).

5.5.2. A Failure Mode and Effects Analysis (FMEA) should be carried out in accordance with IEC 60812, or an equivalent and acceptable national or international standard and the report and worksheets are to be submitted for consideration. The FMEA is to demonstrate that the integrated system will ‘fail-safe’.

5.5.3. The integrated computer control system should be in compliance with the programmable electronic system requirements of [5.2.], [5.3.], [5.6.], [5.7.] of this section and the control and monitoring requirements of the Rules applicable to particular equipment, machinery or systems.

5.5.4. Alarm displays should be provided in compliance with the requirements of Sec. 2, [2.7.] of this chapter which ensures ready identification of faults in the equipment under control.

5.5.5. Alarm and indication functions are to be provided by the integrated computer control system in response to the activation of any safety function for associated machinery. Systems providing the safety functions are in general to be independent of the integrated computer system.

5.5.6. Controls are to be provided in compliance with Sec. 2, [2.12.] of this chapter for ensuring safe and effective operation of equipment and response to faults for example starting, stopping, adjustment of parameters etc. Indication of operational status and other such parameters necessary for satisfying this requirement should be provided for all equipment under control by the integrated computer control system.

5.5.7. Each operator station allowing control of equipment is to be provided with a minimum of two multi-function display and control units. The number of units should be sufficient for allowing simultaneous access to control and monitoring functions required by [5.5.4.] to [5.5.6.] of this section.

5.5.8. Each multi-function display and control unit should include a monitor, keyboard and tracker ball. Alternative arrangements will be considered where these enable each unit to be configured by the user to provide required control or monitoring functions.

5.5.9. Where the integrated computer control system is arranged in a way that control and monitoring functions may be accessed at more than one operator station, the selected mode of operation of each station (e.g. in control, standby, etc.) should be clearly indicated.

5.5.10. Means of communication should be provided between operator stations and any other stations from which the equipment may be controlled. The arrangements should be installed permanently and should remain operational in the event of failure of the main electrical power supply to the integrated control system.

5.6. Requirements for data communication links

5.6.1. These requirements are applicable to system categories II and III using shared data communication links for transferring data between distributed programmable electronic equipment/systems.

5.6.2. Means should be provided for automatically restoring data communication where a single component failure results in loss of data communication.

5.6.3. Loss of a data communication link should not affect the ability to operate essential services by alternative means.

5.6.4. Means should be provided for protecting the integrity of data and providing timely recovery of invalid or corrupted data.

5.6.5. The data communication link should be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures should initiate an alarm.

5.6.6. System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

5.6.7. The characteristics of the data communication link should be such that all necessary information is transmitted in adequate time and that overloading is prevented.

5.7. Additional requirements for wireless data links

5.7.1. These requirements are in addition to the requirements of [5.6.] of this section and apply to system category II using wireless data communication links to transfer data between distributed programmable electronic equipment/systems.

5.7.2. Category-III For system category III, the use of wireless data communication links is to be in accordance with a relevant international or national standard acceptable to the INTLREG; Refer also SOLAS Ch. II-1/F, Reg. 55.

5.7.3. Functions that are required to operate continuously to provide essential services dependent on wireless data communication links shall have an alternative means of control that can be brought into action within an acceptable period of time.

5.7.4. Wireless data communication is to employ recognized international wireless communication system protocols that incorporate the following:

a. Message integrity:

Fault prevention, detection, diagnosis and correction so that the received message is not corrupted or altered when compared to the transmitted message.

b. Configuration and device authentication:

It is only to permit connection of devices that are included in the system design.

c. Message encryption:

Protection of the confidentiality and / or criticality of the data content.

d. Security management:

Protection of network assets and prevention of un-authorized access to network assets.

5.7.5. The wireless system is to comply with the radio frequency and power level requirements of International Telecommunications Union and flag State requirements.

5.8. Protection against modification

5.8.1. Computer-based systems should be protected against unintentional or unauthorized modification of software.

5.8.2. Programmable electronic systems of category II and III are to be protected against program modification by the user. Any significant modification to the software or hardware for system category II and III is to be submitted for approval.

5.8.3. For systems of Category III modifications of parameters by the manufacturer are to be approved by INTLREG.

5.9. Documents to be submitted

5.9.1. Documents according to IEC 60092-504 are to be submitted for the evaluation of programmable electronic systems of category II and III.

5.9.2. When an alternative design or arrangement is intended to be used, it is required to submit an engineering analysis in addition.

5.9.3. For all tests required in accordance with the system category, it is necessary to submit a test plan and the tests are to be documented.

5.9.4. For systems of category III, additional documentation might be required. The documentation should include a description of the methods of test and test results.

5.9.5. The following additional information is to be submitted for wireless data communication equipment:

a. Details of Manufacturer's recommended installation and maintenance practices;
b. Specification of wireless communication system protocols and management functions;
c. Network plan with arrangement and type of antennas and identification of location;
d. Evidence of type testing in accordance with;
e. On-board test schedule;
f. Details of radio frequency and power levels.

5.9.6. Upon request, necessary documents for the evaluation of programmable electronic systems of Category-I are to be submitted.

5.9.7. The following software and hardware descriptions are to be submitted:

a. Software description

   i. Description of application software (not program listings);
   ii. Description of the basic and communication software installed in each hardware unit;
   iii. Description of functions, performance, constraints and dependencies between modules or other components.

b. Hardware description

   i. Connection diagrams;
   ii. System block diagram, showing the arrangement, input and output devices and interconnections;
   iii. Details of power supplies;
   iv. Details of input and output devices.

5.9.8. Following user interface descriptions are to be submitted:

a. A description of individual screen views (schematics, color photos, etc.).
b. A description of the functions allocated to each operator interface (keyboard/screen or equivalent).
c. An operator manual providing necessary information for installation and use.
d. A description of how menus are operated (tree presentation).

5.9.9. Modifications to approved systems are to be notified in advance. The manufacturer has to document the modifications. Subsequent significant modifications to the hardware and software for system categories II and III are to be submitted for approval.

5.9.10. Following evidence of quality system are to be submitted:

a. A plan for software lifecycle activities should be produced which defines relevant procedures, responsibilities and system documentation, including configuration management generally in accordance with ISO standard 90003 “Guidelines for the Application of ISO 9001:2000 to the Computer Software or Equivalent”.
b. Inspection of components (only Hardware) from sub-suppliers Proof that components and/or sub-assemblies conform to specification.
c. Evidence of quality assurance measures on production.
d. Reports from testing of the finished product and documentation of the test results.
e. Modification of program contents and data, as well as change of version have to be carried out in accordance with a procedure and are to be documented.

5.9.11. The documentation to be submitted should demonstrate the reliability of the system by means of appropriate analysis such as, a failure mode analysis describing the effects due to failures leading to the destruction of the automation system.

Additionally, this documentation should also point out the consequences on other systems, if any. This analysis is appraised in accordance with the IEC Publication 60812, or a recognized standard.

a. MTBF calculation (Mean Time Between Failure);
b. Test Report/Life Test;
c. Any other documentation demonstrating the reliability of the system.

5.10. Tests and evidence

5.10.1. The purpose of failure analysis for safety related function is to demonstrate that in case of single failures, systems will fail to safety and that systems in operation will neither be lost nor degraded beyond acceptable performance criteria when specified by INTLREG. The analysis should be carried out with the use of appropriate means: for example:

a. Risk analysis;
b. Fault tree analysis;
c. FMEA or FMECA.

5.10.2. Tests are to be carried out, and the evidence of quality assurance is to be maintained in accordance with Table 8.5.2 of this section.

5.10.3. For evidence of software testing procedures for verification and validation activities are to be established, example:-

a. Methods of testing;
b. Test programs producing;
c. Stimulation.

Analysis regarding existence and fulfillment of programming procedures for safety related.

Functions Specific assurance methods are to be planned for verification and validation of satisfaction of requirements, e.g.

a. Diverse programs;
b. Program analysis and testing to detect formal errors and discrepancies of the description.
c. Simple structure.

5.10.4. Hardware tests according to Sec 7 of this chapter will normally be a type approval test.

5.10.5. Following software tests are to be carried out:

a. Module test

   Software module tests should provide evidence that each module performs its intended function and not unintended functions.

b. Subsystem tests

   Sub-systems testing should verify that modules interact correctly for performing the intended functions and do not perform unintended functions.

c. System test

   System testing should verify that subsystems interact correctly for performing the functions in accordance with specified requirements and do not perform unintended functions.

5.10.6. Following performance tests are to be carried out:

a. Integration tests

   Programmable electronic system integration testing is to be carried out using satisfactorily tested system software and as far as practicable intended system components.

b. Fault simulation

   Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

c. Factory acceptance test (FAT)

Factory acceptance testing is to be carried out in accordance with a test program accepted by INTLREG. Testing is to be based on demonstrating that the system fulfils the requirements specified by INTLREG.

5.10.7. Following on-board tests are to be carried out:

a. Complete system test

Testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program.

b. Integration tests

On board testing is to verify that correct functionality has been achieved with all systems integrated. For wireless data communication equipment, tests during harbor and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not it-self fail as a result of electromagnetic interference during expected operating conditions.

c. Wireless Data Communication Tests

Tests during harbor and sea trials are to be conducted to demonstrate that radio-frequency transmission from wireless data communication equipment does not cause failure of any equipment and does not cause the wireless data communication equipment itself to fail as a result of electromagnetic interference during expected operating conditions

5.10.8. Where the Surveyor's witness is required in accordance with [5.10.4.] and [5.10.6.] of this section, the test procedure for hardware test and performance test for computer-based system of Category II and III is to be submitted for review. For these computer-based systems, the test procedure is to include the tests in Sec. 7, Table 8.7.4 of this chapter and the required functions in Sec. 5 of this chapter for verification.

Table 8.5.2: Tests and evidence of quality assurance

ItemNo.	Tests and evidence	System		
		I	II	III
1.	**Evidence of quality system**			
1.1	Quality plan for software		M	M
1.2	Inspection of components (only Hardware) from sub-suppliers		M	M
1.3	Quality control in production		M	M
1.4	Final test reports	M	M	S
1.5	Traceability of software	M	M	S
2.	**Hardware and software description**			
2.1	Software description		M	S
2.2	Hardware description		M	S
2.3	Failure analysis for safety related functions only			S

3.	**Evidence of software testing**			
3.1	Evidence of software testing according to quality plan		M	S
3.2	Analysis regarding existence and fulfillment of programming procedures for safety related functions			S
4.	**Hardware tests**			
4.1	Type tests according to Sec. 7, Table-8.7.3 of this chapter		W	W
5.	**Software tests**			
5.1	Module tests		M	S
5.2	Subsystem tests		M	S
5.3	System test		M	S
6.	**Performance tests**			
6.1	Integration test		M	W
6.2	Fault simulation		W	W
6.3	Factory Acceptance Test	M	W	W
7.	**On-board test**			
7.1	Complete system test	M	W	W
7.2	Integration test		W	W
7.3	Wireless Data Communication Test	W	W	W
8.	**Modifications**			
8.1	Tests after modifications	M	S/W	S/W

Notes:

1. M = Evidence kept by manufacturer and upon request checked by INTLREG.
2. S = Evidence to be checked by INTLREG.
3. W = To be witnessed by the Surveyor.
4. All evidence may be subject to review and therefore, upon request, is to be submitted for review.
5. System categories are defined in Table 8.5.1 of this section.

Definitions Relating to this Table:

1. Quality Plan for Software
   A plan for software lifecycle activities are to be produced which defines relevant procedures, responsibilities and system documentation, including configuration management.
2. Inspection of Components (Only Hardware) from Sub-suppliers
   Proof that components and/or sub-assemblies conform to specification.
3. Quality Control in Production
   Evidence of quality assurance measures on production.
4. Final Test Reports
   Reports from testing of the finished product and documentation of the test results.
5. Traceability of Software
   Modification of program contents and data, as well as change of version, have to be carried out in accordance with a procedure and are to be documented.

SECTION 6 INSTALLATION REQUIREMENTS

Contents

6.1. General

6.1.1. Automation systems are to be installed taking into account:

a. The maintenance requirements (test and replacement of systems or components).
b. The influence of EMI (Electromagnetic interference). The IEC 60533 standard is to be taken as guidance.
c. The environmental conditions corresponding to the location in accordance with Table 1.2.2 to Table 1.2.5 in Ch 1, Sec 2 of this part.

Control equipment and instrumentation are to be so placed or protected as to minimize the likelihood of sustaining damage from the accumulation of dust, oil vapors, steam or dripping liquids, or from activities around their location.

6.1.2. Control stations are to be arranged for the convenience of the operator.

6.1.3. The installation of equipment in areas of unusual electromagnetic sources should be avoided.

6.1.4. Automation components should be properly fitted. Where necessary, screws and nuts are to be locked.

6.1.5. Mechanical resonances with amplification more than 10 shall not occur.

6.1.6. Electric cables and components require to be separated effectively from all equipment, which, in case of leakage has chances of damaging the electrical equipment. In desks, consoles and switchboards, which contain electrical equipment, pipes and equipment conveying oil, water or other fluids or steam under pressure shall be built into a separate section with drainage.

6.1.7. Installation of equipment in locations where ambient temperature fluctuations might lead to accumulation of moisture condensation inside equipment enclosure is to be avoided unless means are provided for preventing moisture (condensation) accumulating inside the equipment during operation and at the time when the plant is shut down.

6.1.8. Differential pressure elements (DP-cells) shall be able to sustain a pressure differential at least equal to the highest pressure for the EUC (equipment under control).

6.1.9. Thermometer wells shall be used when measuring temperature in fluids, steam or gases under pressure.

6.1.10. Clamps used in securing capillary tubes are to be made of a material that should be softer than the tubing.

6.1.11. All control, actuating, monitoring and alarm devices are to be able to operate successfully when inclined at an angle of 30° in any direction from the vertical and when subjected to vibratory frequencies of 2 to 80 Hz, in conjunction with peak to peak amplitudes of 2 mm for frequencies 2 to 13.2 Hz and an acceleration of 0.7 g for frequencies of 13.2 to 80 Hz. Care is to be taken to ensure that mounting arrangements for the components will not amplify shipboard vibrations.

6.2. Installation of sensors and components

6.2.1. The location and selection of the sensor is to be done so as to measure the actual value of the parameter. Temperature, vibration and EMI levels are to be taken into account. When this is not possible, the sensor is to be designed to withstand the local environment.

The enclosure of the sensor and the cable entry should be appropriate to the space in which they are located.

6.2.2. Means are to be provided for testing, calibration and replacement of automation components. Such means are to be designed, as far as practicable for avoiding perturbation of the normal operation of the system.

6.2.3. A tag number is to be there for identifying automation components and should be clearly marked and attached to the component. These tag numbers are to be collected on the instrument list mentioned in Sec 1, Table 8.1.1 of this chapter.

6.2.4. Electrical connections should be arranged for easy replacement and testing of sensors and components. They are to be clearly marked.

6.2.5. It is better to avoid low level signal sensors. When installed, they should be located as close as possible to amplifiers in order to avoid external influences. Failing this, the wiring is to be provided with suitable EMI protection and temperature correction.

6.2.6. Temperature sensors, thermostats or thermometers should be installed in a thermo well of suitable material for permitting easy replacement and functional testing. The thermo well should not significantly modify the response time of the whole element.

6.2.7. Three-way valves or other suitable arrangements are to be installed for permitting functional testing of pressure elements such as pressure switches or pressure gauges, pressure sensors, without stopping the installation.

6.2.8. In specific applications, where there are chances of high pulsations of pressure occurring, a damping element, such as a capillary tube or equivalent, is to be installed.

6.2.9. Level switches fitted to flammable oil tanks or similar installations are to be installed for reducing the risk of fire.

6.3. Installation of cables

6.3.1. Cables should be installed according to the requirements in Ch 6, Sec 4 of this part.

6.3.2. Suitable installation features like screening and/or twisted pairs and/or separation between signal and other cables should be provided for avoiding possible interference on control and instrumentation cables.

To avoid electromagnetic noise caused by circulating currents, the conductive shield and cable armor is to be grounded only at one end of the cable.

6.3.3. Specific transmission cables (twisted pairs, coaxial cables. etc.) should be routed in specific cable-ways and mechanically protecting for avoiding loss of any crucial transmitted data. The cables are to be protected with pipes or equivalent in cases there is a high risk of mechanical damage.

6.3.4. The cable bend radius should be in accordance with the requirements of Ch 6, Sec 4, Table 6.4.1 of this part.

6.3.5. Special precautions are to be taken according to the manufacturer's instructions for mineral insulated cables, fiber optic cables or coaxial cables whose characteristics may be modified.

6.3.6. The conductive shield and cable armor should be grounded only at one end of the cable for avoiding electromagnetic noise caused by circulating currents.

6.3.7. Cable terminations are to be arranged according to the requirements in Chapter 6 of this part. Particular attention is to be paid to the connections of cable shields. Shields are to be connected only at the sensor end when the sensor is earthed and only at the processor end when the sensor is floating.

6.3.8. Cable terminations are to be able to withstand the identified environmental conditions (shocks, vibrations, salt mist, humidity, etc.).

6.3.9. Terminations of all special cables such as mineral insulated cables, coaxial cables or fiber optic cables are to be arranged according to the manufacturer's instructions.

6.4. Installation of pipes

6.4.1. As far as practicable, piping containing liquids is not to be installed in or adjacent to electrical enclosures.

6.4.2. Hydraulic and pneumatic piping for automation systems is to be marked to indicate its function.

6.5. Installation of automation consoles

6.5.1. Consoles or control panels are to be located so as to enable a good view of the process under control, as far as practicable. Instruments are to be clearly readable in the ambient lighting.

6.5.2. The location should be such that it allows easy access for maintenance operations.

SECTION 7 TESTS & TRIALS

Contents

7.1. General

7.1.1. Automation systems are to be tested for type approval, acceptance or commissioning, when required. Tests should be carried out under the supervision of a Surveyor of INTLREG.

7.1.2. The manufacturers of control systems should certify that the mechanical, electrical and solid state components utilized have been satisfactorily tested individually or by acceptable lot sampling to establish their suitability for the intended service including their exposure to the following conditions:

a. Ship motion and vibration;
b. Shipboard ambient conditions;
c. Temperature range;
d. Voltage and frequency tolerances;
e. Pressure tests as per [7.1.3.] and [7.1.4.] of this section.

7.1.3. Hydraulic and pneumatic piping should be subjected to pressure tests at 1.5 times the relief device settings using the service fluid in hydraulic systems and dry air or dry inert gas for pneumatic systems as the testing media. Means are to be provided for removing the moisture automatically from the piping before delivery to the pneumatic control system.

7.1.4. It is mandatory to check all electrical control and monitoring circuits and prove them free of unintentional grounds and short circuits, defective electrical or electronic elements.

7.2. Type approval test

7.2.1. Hardware type approval

7.2.1.1 These tests are to demonstrate the ability of the equipment to function as intended under the specified testing conditions. The extent of the testing, i.e. the selection and sequence of tests and the number of pieces to be tested is to be determined upon examination and evaluation of the equipment or component subject to testing giving due regard to its intended use. Equipment is to be tested in its normal position unless otherwise specified in the test specification. The relevant tests are listed in Table 8.7.3 of this section.

7.2.1.2 Depending on particular manufacturing or operational conditions, the following additional tests may be required:

a. Temperature shock test (e.g. 12 shocks on exhaust gas temperature sensors from 20°c ± 5°c to maximum temperature of the range).
b. Mechanical endurance test;
c. Oil resistance test;
d. Immersion test;
e. Shock test.

7.2.2. Software type approval

7.2.2.1. Software type approval consists of evaluation of the development quality and verification of test results. Documents in accordance with Sec 1, Table 8.1.2 of this chapter are required to demonstrate the development quality. Repetition of unit tests, integration tests or validation tests is required to verify the consistency of test results. Certificate may be issued at the request of the manufacturer when approval is granted.

7.2.2.2. The software type approval applies only to basic software of the programmable electronic system. The basic software approval is carried out in the following phases:

a. Examination of the documents as required in Sec 5, [5.9.7. a.] of this chapter.
b. Verification that all the development work has been carried out according to the quality procedure. The complementary documents required in Table 8.7.1 of this section prove the quality of the development work.

7.2.2.3. The application software is to be approved on a case by case basis, according to [7.3.2.2.] of this section.

Table 8.7.1: Basic software development documents

No.	**I/A (Refer 2)**	**Document**
1	I	Follow-up of developed software: identification, safeguard, storage
2	I	Document showing the capability and training of the development team
3	I	Production of a specification file
4	I	Production of a preliminary design file
5	I	Production of a detailed design file
6	I	Production of a coding file
7	I	Production of a unit testing file (Refer 1)
8	I	Production of an integration test file (Refer 1)
9	I	Production of a validation test file (Refer 1)
10	I	Production of a maintenance facility file
11	I	Production of a quality plan
12	I	Follow-up of the quality plan: checks, audits, inspections, reviews

(1) Complementary test carried out, at random, at the request of the Surveyor.

(2) A: to be submitted for approval; I: to be submitted for information.

7.2.3. Navigational and radio equipment

The test conditions as specified in IEC 60945 (marine navigational and radio communication equipment and systems -general requirements, methods of testing and required test results) are to be applied for the above-mentioned equipment.

7.2.4. Loading instruments

Loading instrument approval consists of:

a. Approval of hardware according to [7.2.1.] of this section, unless two computers are available on board for loading calculations only.
b. Approval of basic software according to [7.2.2.] of this section;
c. Approval of application software;
d. Installation testing.

7.2.5. Equipment Tests

7.2.5.1. Prototype Environmental Testing

The following tests are to be carried out as a prototype testing in the presence of the Surveyor:

a. Power supply variation test (item 1 in Table 8.7.3 of this section)
b. Vibration test (item 5 in Table 8.7.3 of this section)
c. Inclination test (item 6 in Table 8.7.3 of this section)

Other prototype environmental tests specified in Table 8.7.3 of this section are to be conducted by the manufacturers; acceptance will be based on review of manufacturer's certified test reports by INTLREG. Omission of certain tests may be considered, taking into consideration the location of installation, functionality, contained devices, etc. of the equipment.

In general, field sensors (e.g., pressure transmitters) and field devices (e.g., solenoid valves), circuit breakers and cables may be exempted from tests specified in Table 8.7.3 of this section.

For computer-based systems, the equipment to be tested includes microprocessors, storage devices, power supply units, signal conditioners, analog/digital converters; computer monitors (visual display units), keyboards, etc. but may exclude printer, data recording or logging device not required in this section.

7.2.5.2. Production Unit Certification

After assembled to a complete assembly unit or subassembly unit, each production unit of equipment used in control, monitoring and safety systems is to be tested at the manufacturer's shop in the presence of the Surveyor to verify the tests in Table 8.7.4 of this section.

7.2.5.3. Type Approval Program

At the request of the manufacturer, equipment, subassemblies, or complete assemblies of control, monitoring and safety systems may be considered for Type Approval, in accordance with the Table 8.7.3 of this section.

7.3. Acceptance testing

Acceptance tests are generally to be carried out at the manufacturer's facilities before the shipment of the equipment.

7.3.1. Hardware testing

7.3.1.1. Hardware acceptance tests include, where applicable:

a. Visual inspection;
b. Operational tests and in particular:

i. Tests of all alarm and safety functions.
ii. Verification of the required performance (range, calibration, repeatability, etc.) for analogue sensors.
iii. Verification of the required performance (range, set points, etc.) for on/off sensors.
iv. Verification of the required performance (range, response time, etc.) for actuators.
v. Verification of the required performance (full scale, etc.) for indicating instruments.

- Hydrostatic tests;
- High voltage test.

Additional tests may be required by INTLREG.

7.3.1.2. Final acceptance will be granted subject to:

a. The results of the tests listed in [7.3.1.1.] of this section.
b. The type test report or type approval certificate.

7.3.2. Software testing

7.3.2.1. Software acceptance tests of programmable electronic systems are to be carried out to verify their adaptation to their use on board, and concern mainly the application software.

7.3.2.2. The software modules of the application software are to be tested individually and subsequently subjected to an integration test. The test results are to be documented and to be part of the final file. It is to be checked that:

a. The development work has been carried out in accordance with the plan;
b. The documentation includes the proposed tests, the acceptance criteria and the result.

Repetition tests may be required for verifying the consistency of test results.

7.3.2.3. Software acceptance will be granted subject to:

a. A functional test of the whole system;
b. Examination of the available documentation.

INTLREG might ask for additional tests of systems which is part of safety systems or which integrate several functions.

7.4. Commissioning test

Commissioning tests are to be carried out on automation systems associated with essential services to verify their compliance with the Rules, by means of visual inspection and the performance and functionality according to Table 8.7.2 of this section. When completed, automation systems are to be such that a single failure, for example loss of power supplies, is not to result in a major degradation of the propulsion or steering of the ship. In addition, a blackout test is to be carried out to show that automation systems are continuously supplied. Upon completion of commissioning tests, test reports are to be made available to the Surveyor.

Table 8.7.2: Commissioning tests

Equipment	Nature of tests
Electronic equipment	Main hardware functionality
Analogue sensors	Signal calibration, trip set point adjustment
On/off sensors	Simulation of parameter to verify and record the set points
Actuators	Checking of operation in whole range and performance (response time, pumping)
Reading instruments	Checking of calibration, full scale and standard reference value

7.5. Shop testing

Upon completion of the control consoles or sections or component assemblies of such consoles, the manufacturer is to carry out tests in the presence of the Surveyor to demonstrate the satisfactory performance of all controls, instruments and alarms. The tests are to simulate all control and alarm functions given in the operational manual as far as practicable. The tests are to demonstrate satisfactory performance under the following conditions:

7.5.1. Tests should be carried out at rated power supply at prevailing ambient air conditions.

7.5.2. Loss of power to be stimulated.

7.5.3. The voltage of the electrical supply to be varied ± 10% and where alternating current is used, the frequency is to be varied simultaneously to ± 5%. The controls are to function satisfactorily during these variations without faults. Where the components selected have been tested individually and are certified to function satisfactorily during these power variations, retesting of final assemblies will not be required.

7.5.4. All electrical circuits supplying power to servo-motors and actuators rated over 100 volts are to be subjected to dielectric-strength tests.

7.5.5. Vibration tests required by sec 6, [6.1.11.] of this chapter may be conducted in shops other than the plant of manufacture. When equipment is not energized during the test it is to perform satisfactorily after the vibration test.

7.5.6. Variation of hydraulic or pneumatic system pressure ± 20% of normal operating pressure, except that relief valve pressure need not be exceeded. The system is to operate satisfactorily at the relief valve pressure setting.

7.6. On board testing

7.6.1. The tests shall include:

a. During installation the correct function of individual equipment packages, together with establishment of correct parameters for alarm, control and protective safety (set points, time constants etc.).
b. During installation and sea trials, the correct function of systems and integration of systems, including the ability of the control systems to keep any EUC within the specified tolerances.
c. The correct protection and capacity of power supplies.
d. Back-up and emergency control functions for essential ships systems.

7.6.2. The tests are to demonstrate that the primary functions of the ship are operable on the available back-up means of control as required in the relevant application rules and in a situation where the primary control system is disabled as far as practical.

7.6.3. The remote control system shall, in case fitted, should be tested at sea for demonstrating stable control and operation of the propulsion system with its necessary auxiliaries over the full operating range and regardless of the type of propulsion. It shall be demonstrated that necessary ramping/controller functions are implemented for ensuring that any operation of the maneuvering levers do not cause shutdown, instability or damage to the propulsion machinery or power generating units.

7.7. Trials

7.7.1. Upon completion of the installation, complete performance tests of all systems are to be carried out during dock trials and sea trials to demonstrate that the system will perform successfully during standby, maneuvering, steady conditions, and during transfer of controls.

7.7.2. Independent manual local control of the propulsion machinery & boiler are to be demonstrated during trials. This is to include demonstration of independent manual control through the full maneuvering range and transfer from automatic control.

7.7.3. A copy of the record of the trials is to be submitted for information. It is recommended that a copy of the record of the trials be kept on board for reference purposes for future adjustments/testing etc. The record should include details of all adjustments, calibrations, method of simulating failures and expected results due to these simulations. The record should be kept up to date at all times.

7.7.4. During sea trial, the following tests, as appropriate should be carried out to the satisfaction of the Surveyor.

7.7.4.1. For Propulsion remote control:

a. Control functions:

The ability to effectively control the propulsion from the remote propulsion control station is to be demonstrated during sea trials or at dockside. These trials should include:

i. Propulsion starting;
ii. Propulsion control transfer;
iii. Verification of propulsion control responses;

iv. Response to propulsion control power failure;
v. Automatic propulsion shutdown;
vi. Automatic propulsion slowdown;
vii. Actuation of propulsion emergency stop devices;
viii. For turbine-driven ship, actuation of the shaft turning device.

b. Throttle response:

Response of propulsion machinery to throttle control demands should be tested at the time of sea trials for demonstrating that no part of the plant or engine is jeopardized by the rate at which the throttle is moved from one extreme position to the other.

7.7.4.2. In addition to the tests required in [7.7.4.1.] of this section ships with a centralized control station should be tested, as follows, during sea trial or during the dock trial as appropriate.

After the propulsion machinery has been running for at least two hours, the machinery is to be operated over its full range of power for demonstrating the adequacy of all control systems. The propulsion machinery is to be run for at least an additional four hours, for a total minimum of six hours duration. The following tests are to be included:

a. All alarm points and displays;
b. Operations of automatic controlled machinery;
c. Transfer of standby auxiliary;
d. Remote control of auxiliary machinery;
e. Fire detection system;
f. Bilge alarm.

7.7.4.3. In addition to the tests required in [7.7.4.1.] & [7.7.4.2.] of this section, ships intended to be operated with periodically unattended machinery space are to be tested, as follows:

a. Loss of generator tests:

The loss of electric power is to be simulated with the main engine running and simulated loss of generator to test:

i. Automatic restoration of electric power by standby generator(s);
ii. Automatic starting of vital auxiliaries; and
iii. Starting and restoration of control of propulsion prime mover from the centralized control station or the navigation bridge, as appropriate.

b. Firefighting control function tests:

All controls provided at the firefighting station are to be functionally tested.

c. Full functional test:

After the propulsion machinery has been running for at least two hours, the machinery is to be operated over its full range of power to demonstrate the adequacy of all control systems. The propulsion machinery is to be run for at least four more hours; in total a minimum duration of six hours. During this period, the ability to control the machinery functions correctly for all loads and engine maneuvers without any manual intervention in the propulsion machinery space for four hours is to be demonstrated.

Table 8.7.3: Type tests for control, monitoring and safety equipment

No	Test	Procedure according to: [Refer Note	Test parameters			Other information
1.	Electric Power supply variations	–	AC Supply			
			Combination	Voltage variation permanent (%)	Frequency variation permanent (%)	
			1	+ 6	+5	
			2	+ 6	-5	
			3	- 10	-5	
			4	- 10	+5	
			Combination	Voltage transient 1.5 s (%)	Frequency transient 5 s (%)	
			5	+ 20	+ 10	
			6	- 20	-10	
			DC Supply			
			Voltage tolerance continuous		± 10%	
			Voltage cyclic variation		5 %	
			Voltage ripple		10%	

			Electric battery supply: +30% to –25% for equipment connected to charging battery or as determined by the charging / discharging characteristics, including ripple voltage from the charging device; +20% to –25% for equipment not connected to the battery during charging	
2	Pneumatic and hydraulic Power	–	Pressure: ± 20% Duration: 15 minutes	
3.	Dry heat	IEC Publication 60068-2-2	Temperature: 55°C (131°F) ± 2°C (3.6°F) Duration: 16 hours Or Temperature: 70°C (158°F) ± 2°C (3.6°F) Duration: 16 hours [Refer Note 1]	Equipment operating during conditioning and testing; functional test during the last hour at the test temperature; For equipment specified for increased temperature the dry heat test is to be conducted at the agreed

4	Damp heat	IEC Publication 60068-2-30 – Test Db	Temperature: 55°C (131°F) Humidity: 95% Duration: 2 cycles 2 x (12 + 12 hours)	Measurement of insulation resistance before test; The test shall start with 25°C ± 3°C and at least 95% humidity; Equipment operating during the complete first cycle and switched off during second cycle, except for functional test; Functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature; Duration of the second cycle can be extended due to more convenient handling of the functional test. Recovery at

5	Vibration	IEC Publication 60068-2-6, Test Fc	2.0 (+3/-0) Hz to 13.2 Hz – amplitude ±1 mm (0.039 in.) 13.2 Hz to 100 Hz – acceleration ±0.7 g For severe vibration conditions, e.g., on diesel engines, air compressors, etc.: 2.0 Hz to 25 Hz – amplitude ±1.6 mm (0.063 in.) 25.0 Hz to 100 Hz – acceleration ±4.0 g Note: More severe conditions may exist for example on exhaust manifolds or fuel oil systems of diesel engines especially for medium and high speed engines.*For equipment specified for increased vibration levels, the vibration test is to be conducted at the agreed vibration level, frequency range and duration* Values may be required to be in these cases 40 Hz to 2000 Hz – acceleration ± 10.0g at 600 ºC duration 90 min.	Duration: 90 minutes at 30 Hz in case of no resonance conditions; Duration: 90 minutes for each resonance frequency at which Q ≥ 2 is recorded; During the vibration test, functional tests are to be carried out; Tests to be carried out in three mutually perpendicular planes; It is recommended as guidance that Q does not exceed 5; Where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies are detected close to each other duration of the test is to be 120 min. Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate. Note: Critical frequency is a frequency at which the equipment being tested may exhibit: • malfunction and/or performance deterioration • *mechanical resonances and/or other response effects occur, for example, chatter*

6.	Inclination	IEC Publication 60092-504	Static 22.5°	a) Inclined at an angle of at least 22.5° to the vertical; b) Inclined to at an angle of at least 22.5° on the other side of the vertical and in the same plane as in (a); c) Inclined to at an angle of at least 22.5° to the vertical and in plane at right angles to that used in (a); d) Inclined to at an angle of at least 22.5° on the other side of the vertical and in the same plane as in (c) ***Note:*** *The duration of testing in each position should be sufficient to fully evaluate the behavior of the equipment.*

<table>
<tr><td></td><td></td><td></td><td colspan="4">Dynamic 22.5°</td><td>Using the directions defined in a)

to d) above, the equipment is to

be rolled to an angle of 22.5° each side of the vertical with a period of 10 seconds.

The test in each direction is to be carried out for not less than 15 minutes

Note: These inclination tests are normally not required for equipment with no</td></tr>
<tr><td rowspan="4">7.</td><td rowspan="4">Insulation resistance</td><td rowspan="4">–</td><td rowspan="2">Rated supply voltage (V)</td><td rowspan="2">Test voltage (V)

(DC voltage)</td><td colspan="2">Min. Insulation
Resistance</td><td rowspan="4">Insulation resistance test is to be carried out before and after: damp heat test, cold test, salt mist test, and high voltage test;

• between all phases and earth;

• and where appropriate, between the phases.

Un is the rated (nominal) voltage.

Note: Certain components e.g., for</td></tr>
<tr><td>Before test

(MΩ)</td><td>After

test</td></tr>
<tr><td>Un ≤ 65</td><td>2 × Un

(min. 24 V)</td><td>10</td><td>1.0</td></tr>
<tr><td>Un > 65</td><td>500</td><td>100</td><td>10</td></tr>
<tr><td rowspan="4">8.</td><td rowspan="4">High voltage</td><td rowspan="4">-
-
-</td><td colspan="2">Rated voltage Un (V)</td><td colspan="2">Test voltage

[A.C. voltage 50 or 60 Hz] (V)</td><td rowspan="4">Separate circuits are to be tested against each other and all circuits connected with each other tested against earth;

Printed circuits with</td></tr>
<tr><td colspan="2">Up to 65</td><td colspan="2">2 × Un + 500</td></tr>
<tr><td colspan="2">66 to 250</td><td colspan="2">1500</td></tr>
<tr><td colspan="2">251 to 500</td><td colspan="2">2000</td></tr>
</table>

			501 to 690	2500	electronic components may be removed during the test; Period of application of the test voltage: 1 minute
9.	Cold	IEC Publication 60068-2-1	Temperature: +5°C (41°F) ± 3°C (5.4°F) Duration: 2 hours Or Temperature: -25°C (-13°F) ± 3°C (5.4°F) Duration: 2 hours [Refer Note 2]		Initial measurement of insulation resistance; Equipment not operating during conditioning and testing, except for functional test; Functional test during the last hour at the test temperature; Insulation resistance measurement and the functional test after recovery.

10.	Salt mist	IEC Publication 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each.	Initial measurement of insulation resistance and initial functional test; Equipment not operating during conditioning of the test specimen; Functional test on the 7^{th} day of each storage period; Insulation resistance measurement and performance test: 4 to 6 hours after recovery [Refer Note 3] On completion of exposure, the equipment shall be examined to verify
11.	Electrostatic discharge	IEC Publication 61000-4-2	Contact discharge: 6 kV Air discharge:2 kv,4 kV, 8 kV Interval between single discharges: 1 sec. Number of pulses: 10 per polarity According to test level 3 severity standard	To simulate electrostatic discharge as may occur when persons touch the appliance; The test is to be confined to the points and surfaces that can normally be reached by the operator; Performance Criterion B [Refer Note 4].

12.	Electro-magnetic field	IEC Publication 61000-4-3	Frequency range: 80 MHz to 2 GHz Modulation*: 80% AM at 1000 Hz Field strength: 10 V/m Frequency sweep rate: ≤ 1.5×10^{-3} decades/s (or 1% / 3 sec) According to test level 3 severity standard.	To simulate electromagnetic fields radiated by different transmitters; The test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation. Performance criterion A [Refer Note 5] * *If for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation* *frequency of 400 Hz may be chosen.*
13	Conducted Low Frequency		**AC:** Frequency range: rated frequency to 200th harmonic; Test voltage (r.m.s.): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, minimum 3 V (r.m.s.), maximum 2 W **DC:**Frequency range: 50 Hz – 10 kHz; Test voltage (rms): 10% of supply, maximum 2 W	To simulate distortions in the power supply system generated for instance, by electronic consumers and coupled in as harmonics; Performance criterion A [Refer Note 5] For keeping max. 2W, the voltage of the test signal may be lower

14.	Conducted Radio Frequency	IEC Publication 61000-4-6	**AC, DC, I/O ports and signal/control lines:** Frequency range: 150 kHz – 80 MHz Amplitude: 3 V r.m.s. [Refer Note 6] Modulation ** : 80% AM at 1000 Hz Frequency sweep range: ≤ 1.5 × 10^{-3} decades/sec. (or 1% / 3 sec.) According to level 2 severity standard	Equipment design and the choice of materials are to simulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. Performance criterion A [Refer Note 5]. ** *If for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz should be chosen.*
15.	Electrical Fast Transients Burst Transients	IEC Publication 61000-4-4	Single pulse time: 5ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2 kV line on power supply port/earth; 1kV on I/O data control and communication ports (coupling clamp); Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to test level 3 severity standard.	Arcs generated when actuating electrical contacts; Interface effect occurring on the power supply, as well as at the external wiring of the test specimen; Performance criterion B [Refer Note 4].
16.	Surge Voltage	IEC Publication 61000-4-5	Test applicable to AC and DC power ports Open-circuit voltage Pulse rise time: 1.2 μVs (front time) Pulse width: 50 μVs (50% value) Amplitude (peak): 1 kV line/earth; 0.5 kV line/line Short-circuit current: Pulse rise time: 8 μs (front time) Pulse width: 20 μs (time to half value) Repetition rate: ≥ 1 pulse/min .Number of pulses: 5 per polarity Application: continuous according to test level 2	Interference generated for instance, by switching "ON" or "OFF" high power inductive consumers; Test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical; Performance criterion B [Refer Note 4].

17.	Radiated Emission	CISPR 16-2-3	**For equipment installed in the bridge and deck zone:** Frequency range:Quasi peak Limits: 0.15 – 0.3 MHz 80 – 52 dBμV/m 0.3 – 30 MHz ~~50~~ 52 – 34 dBμV/m 30 – 2000 MHz 54 dBμV/m except for: 156 – 165 MHz 24 dBμV/m **For equipment installed in the general power distribution zone:** Frequency range: Limits: 0.15 – 30 MHz 80 – 50 dBμV/m	Procedure in accordance with the standard but distance 3 m (10 ft) between equipment and antenna Alternatively, the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 30 dB micro-V/m peak.
18.	Conducted Emission	CISPR , 16-2-1	**For equipment installed in the bridge and deck zone:** Frequency range: Limits: 10 – 150kHz 96 – 50 dBμV 150 – 350 kHz 60 – 50 dBμV 350 kHz – 30 MHz 50 dBμV	

19.	Flame retardant	IEC Publication 60092-101 or IEC Publication 60695-11-5	Flame application: 5 times 15 sec each. Interval between each application: 15 sec. or 1 time 30 sec. Test criteria based upon application. The test is performed with the Equipment Under Test (EUT) or housing of the EUT applying needle-flame test method.	The burnt out or damaged part of the specimen by not more than 60 mm long. No flame, no incandescence or in the event of a flame or incandescence being present, it shall extinguish itself within 30 sec. of the removal of the needle flame without full combustion of the test specimen. Any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.

Notes:

1. Equipment to be mounted in consoles, housing, etc. together with other equipment is to be tested with 70°C (158°F).
2. For equipment installed in non-weather protected locations or cold locations, test is to be carried out at -25°C (-13°F).
3. Salt mist test is to be carried out for equipment installed in weather exposed areas.
4. Performance criterion B (for transient phenomena): The equipment under test is to continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self- recoverable is, however, allowed but no change of actual operating state or stored data is allowed.
5. Performance criterion A (for continuous phenomena): The equipment under test is to continue to operate as intended during and after test. No degradation of performance or loss is allowed as defined in relevant equipment standard and the technical specification published by the manufacturer.
6. For equipment installed on the bridge and deck zone, the test levels are to be increased to10 V r.m.s. for spot frequencies, in accordance with IEC 60945 at 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.
7. As used in this document, and in contrast to a complete performance test, a functional test is a simplified test sufficient to verify that the EUT has not suffered any deterioration caused by the individual environmental tests.

Alternative equivalent testing procedures may be accepted, provided the requirements in the other columns are complied with.

TABLE 8.7.4: Tests for Unit Certification of Control, Monitoring and Safety Equipment

No	TEST	PROCEDURE ACCORDING. TO:[Refer Note]	TEST PARAMETERS	OTHER INFORMATION
1.	Visual inspection	-	-	Conformance to drawings, design data Quality of workmanship and construction
2.	Performance test	Manufacturer’s performance test program based upon specification and relevant Rule requirements When the EUT is required to comply with an international performance standard (e.g., protection relays), verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing where required by 8.7.3	Standard atmosphere conditions Temperature: 25°C (77°F) ± 10°C (18°F) Relative humidity: 60% ± 30% Air pressure: 96 kPa (0.98 kgf/cm2, 13.92 psi) ± 10 kPa (0.10 kgf/cm^2, 1.45 psi)	Confirmation that operation is in accordance with the requirements specified for particular system or equipment; Checking of self-monitoring features; Checking of specified protection against an access to the memory; Checking against effect of Un-erroneous use of control elements in the case of computer systems.
3.	External Power supply failure	-	3 interruptions during 5 minutes; switching-off time 30 s each case	The time of 5 minutes may be exceed if the equipment under test (EUT) needs a longer time for startup, for example, booting sequence. For equipment which requires booting, one additional power supply interruption during booting is to be performed. Verification of: the specified action of equipment upon loss and restoration of supply; possible corruption of program or data held in programmable electronic systems, where applicable.

Note: Alternative equivalent testing procedures may be accepted, provided the requirements in the other columns are complied with.