PART 8

ELECTRICAL INSTALLATIONS

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Section 8.1 – General

8.1.1 Electrical equipment shall be designed to operate in a marine environment and the likely conditions pertaining to such an installation such as vibration, shock, temperature extremes, sea and salt spray. Equipment designed for use onshore may be used provided it meets the criteria for the onboard environment and is approved by the Surveyor.

The installation is to comply with these Standards, the current edition of the IEE Regulations for Electrical and Electronic Equipment for Ships, and the statutory requirements of the Maritime and Coastguard Agency (MCA) of the Department of Transport.

8.1.2 Electrical equipment must operate correctly under the following voltage and frequency fluctuations:-

a) Rated system AC and DC voltage, permanent, minus 10% and plus 6%. Transient +20%, -15%, recovery 1.5 seconds;

b) Rated system frequency, permanent +/-5%, transient +/-10%, recovery 5 seconds.

8.1.3 Generators' voltage regulators and governors must ensure the above are not exceeded.

8.1.4 Where electrical power is the only means for maintaining auxiliary services essential for propulsion or safety of the vessel, a main source of electrical power shall be provided comprising of at least two independent generators, one of which may be driven by the main engine. Such services shall be capable of being provided when any one of the sources of electrical power is out of operation.

8.1.5 All electrical equipment is to be designed and installed to the latest requirements to minimise interference caused by electromagnetic emissions.

8.1.6 Consideration should be given to access for maintenance/repair when positioning equipment.

8.1.7 Electrical plans and schedules showing expected sea loads, where appropriate, are to be submitted for prior approval to the Certifying Authority.

8.1.8 Vessels fitted with both AC and DC systems are to have these voltages supplied from separate panel boards. Equipment such as sockets are to be clearly marked with the voltage, and plugs of different voltage are not be interchangeable.

8.1.9 Wiring diagrams are to be included in all switchboards and distribution boards with each circuit, component and conductor identified.

8.1.10 Electrical equipment installed in compartments containing explosive gases should be ignition protected in accordance with ISO 8846.

8.1.11 Vessels fitted with LPG systems are to have ignition protected electrical equipment installed as per ISO 10239.

Section 8.2 – Cables

8.2.1 Cables rated in accordance with Tables 1-4 shown in this section, are to be used on all installations except where specifically exempted in these Standards.

8.2.2 Screens, where used, are to be of braided tinned copper wires or of metal/ polyester; in the latter, a tinned copper drain wire is to be included. The screens are to be insulated overall.

8.2.3 Conductors are to be capable of carrying the maximum rated current, taking into consideration the ambient temperature and bunching factors.

8.2.4 Conductor cross-sectional areas should be sufficient to ensure that voltage drops do not exceed 6% of nominal when carrying maximum rated current in any circuit.

8.2.5 In all cases, conductors are to be stranded copper.

8.2.6 All cables are to be of the correct voltage grade for their application.

8.2.7 Cable types as detailed in Tables 1-4 are to be used excepting that:-

a) Cables installed on deck in positions liable to damage are to be run in heavy duty galvanised conduit or pipe;

b) Cables for radio, electronic aids, alarms, communications and equipment requiring special cables are to be to the relevant Manufacturer's requirements;

c) PVC cables should not be installed in refrigeration spaces;

d) Compliance with IEC Publication 60331, Fire Characteristics of Electric Cables is required in circuits supplying systems which maintain services during a fire (e.g. CO_2 release systems);

e) In systems not exceeding 50 volts, PVC insulated, PVC sheathed cable manufactured to BS 6004, and PVC cables for vehicles manufactured to BS 6862 (Part 1 Flame Retardant) are acceptable.

8.2.8 AC wiring should be carried out, as far as is reasonably practical, in twin or multicore cables. Where it is necessary to use single-core cables in AC circuits, special precautions may be necessary.

8.2.9 The voltage rating of any cable should be not less than the nominal voltage of the circuit for which it is used.

8.2.10 The rated operating temperatures of the cables should be at least 10°C higher than the maximum ambient temperatures likely to exist, or to be produced in the space where the cable is installed.

8.2.11 Every conductor must be capable of carrying the maximum current which will normally flow through it, without exceeding the appropriate current rating. The conductor size should be calculated to take account of rating and diversity factors.

8.2.12 Cables and wiring should, so far as is practical, be routed clear of heat sources and high fire risk areas, except for supply to equipment in those spaces.

8.2.13 In situations where there could be a risk of mechanical damage, cables should be enclosed in suitable metal conduits or casings, unless the cable covering (e.g. armour or sheath) provides adequate protection. Where metal conduit is used, it should be installed in such a way as to permit the drainage of water. The casings of metal conduits, trunking, etc., should be earthed and electrically continuous along its length.

8.2.14 The cable supports and accessories should be robust and constructed from corrosion-resistant material or suitably treated to resist corrosion. Low melting point metals or alloys, e.g. aluminium, should not be used.

8.2.15 With the exception of cables for portable appliances, cables should be fixed by means of clips, saddles or straps of suitable flame-retardant material and arranged so that the cables remain tight without their coverings being damaged.

8.2.16 The distance between supports is to be chosen according to the type of cable and the probability of vibration and should not exceed 400mm. For a horizontal cable run, fixings should be provided to restrain the cable movement.

8.2.17 Cable clips or straps made from a material such as polyamide, PVC, etc. may be used, however additional metal straps should be used on vertical runs and where cables are run on the underside of horizontal cable ways, such straps are to be installed a maximum of 1m apart. All cable clips in engine spaces are to be of metal.

8.2.18 Cables are not to be fastened direct to oil or water pipes, fuel tanks, etc.

8.2.19 Cables passing through watertight bulkheads, exposed decks or into watertight equipment, are to be fitted with watertight glands. Glanding or penetrations should maintain the fire and watertight integrity of the

bulkhead or equipment. Cables may pass through bushed holes in non-watertight bulkheads.

8.2.20 Cables entering electrical equipment are to be glanded. The use of flame-retarding plastic type glands is permissible.

8.2.21 Where cables are exposed to sharp edges, such edges are to be bushed.

8.2.22 Cables supplying winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless their duty is such as to require a longer time rating, cables for winch or crane motors may be half hour rated on the basis of 50% of the motors kW rating. Cables for windlasses and capstan motors are not to be less than one hour rated based on one hour kW rating of the motor. In all cases the voltage drop rating is to be within specified limits.

Recommended cables – types and ratings
Cables: continuous ratings

Table 1 – Butyl rubber insulated cable

Nominal cross-section area mm²	Current rating On average 45°C ambient		
	Single core amps	Twin core amps	3-4 core amps
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	120	98
50	165	140	115
70	215	185	150
95	260	220	180

For Notes see Table 4

Recommended cables – types and ratings
Cables: continuous ratings

Table 2 – Ethylene propylene rubber insulated cables (EPR)

Nominal cross-section area mm^2	Current rating On average 45°C ambient		
	Single core amps	Twin core amps	3-4 core amps
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	10
16	90	77	63
25	120	102	84
35	145	123	102
50	180	153	126
70	225	191	158
95	275	234	193

For Notes see Table 4

Recommended cables – types and ratings
Cables: continuous ratings

Table 3 – Silicon rubber insulated cable

Nominal cross-section area mm^2	Current rating On average 95°C ambient		
	Single core amps	Twin core amps	3-4 core amps
1	17	17	14
1.5	21	20	17
2.5	30	27	22
4	40	36	29
6	51	47	39
10	71	64	53
16	95	85	70
25	125	115	95
35	155	140	116
50	190	175	140
70	240	217	179
95	290	264	217

For Notes see Table 4

Recommended cables – types and ratings
Cables: continuous ratings

Table 4 – PVC/A insulated cable

Nominal cross-section area mm^2	Current rating On average 45°C ambient		
	Single core amps	Twin core amps	3-4 core amps
1	8	7	6
1.5	12	10	9
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

Notes:-

1) These tables assume a maximum bunching factor of 6 cables; in excess of this requires a correction factor of 0.85.

2) For non-continuous ratings the following multiplying factors may be applied:-

With metallic sheath			Without metallic sheath
Half hour ratings	factor = 1.0 factor = 1.1 factor = 1.15 factor = 1.2	1-20mm^2 20-35mm^2 50mm^2 70-95mm^2	1-70mm^2 95mm^2
One hour ratings	factor = 1.0 factor = 1.2	10-50mm^2 70-95mm^2	1-95mm^2

Detailed cable ratings and factors are contained in IEE Regulations for ships.

Section 8.3 – DC systems

8.3.1 The following forms of DC generation and distribution are acceptable:-

a) 2 wire insulated;
b) 12 volts, 24 volts, 110 volts, 220 volts.

8.3.2 Electrical systems are to be wired as insulated return systems, using two insulated conductors. The hull is not to be used as a current carrying conductor.

8.3.3 For voltages between poles of 110 volts DC and above, switchboards are to be of the dead front or metal clad type, in accordance with Paragraph 8.12.1.

8.3.4 Switchboards should be fitted with a voltmeter and an ammeter on each main supply. For parallel operation of generators, a voltmeter is to be fitted for each generator. Battery charging systems are to be fitted with a charge/discharge meter. Main sub-distribution boards in the wheelhouse are to be fitted with a voltmeter.

8.3.5 Insulating materials used in the construction of switchboards or mains distribution points are to be mechanically strong, flame retarding, and moisture-resistant. The surface finish should be anti-tracking.

8.3.6 Double pole switches should be used except in a final sub-circuit where the use of single pole switches is acceptable.

8.3.7 At least one pair of spare fuses should be fitted to all distribution boxes to allow for additional circuits. They should be equal in size to the largest sizes fitted in the distribution box.

8.3.8 Fuse boards in working and service areas, the wheelhouse and in alleyways are to be constructed of corrosion-protected sheet metal or other approved material and should be enclosed in accordance with Paragraph 8.12.1. In engine spaces they are to be of fire-resistant material.

8.3.9 Fuses should be of the high rupture capacity type. Miniature or moulded case circuit breakers may be used as circuit protection.

8.3.10 Terminations are to be of screwed or bolted types; spring-loaded types are not permissible.

8.3.11 Where combined switch fuses are used, they are to be of the “on load” type complying with BS 3185.

8.3.12 Attention is to be given to the layout of wiring, switchboard, batteries and control boards in order to avoid excessive cable runs.

8.3.13 In small engine spaces, accessibility of equipment is of major importance so that regular inspection and maintenance can be carried out.

8.3.14 Cables are to be sized to avoid overheating and all connections should be vibration proof.

Section 8.4 – Batteries

8.4.1 The total required battery capacity is to be calculated and adequate charging facilities provided.

8.4.2 The battery should be isolated by a double pole switch when not in use and the isolating switch is to be installed in an accessible position. (This switch is not to be used to 'open circuit' a running alternator, as high voltage surges can be created by the abrupt cut-off of current).

8.4.3 Batteries must be accessible for topping-up and the electrolyte level maintained.

8.4.4 Alkaline batteries and lead acid batteries of the vented type are not to be installed in the same battery box or container.

8.4.5 Engine starting batteries are to be located as close as practicable to the engine(s) served. Such batteries are to be installed so that adequate ventilation to outside atmosphere is ensured.

8.4.6 Battery boxes in enclosed spaces are to be ventilated by an independent ventilating system to outside atmosphere.

8.4.7 Where batteries are located in a dedicated compartment solely for battery stowage the battery box may be omitted in favour of a tray providing that the compartment has adequate ventilation.

8.4.8 Natural ventilation may be employed if a duct can be run directly from the top of the box to the open air. If natural ventilation is impracticable, mechanical ventilation is to be provided. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors for battery ventilation are to be spark-proof and are not to be located in the air stream.

8.4.9 Switches, fuses, and other electrical equipment liable to cause an arc are not to be installed in or near battery boxes.

8.4.10 Where batteries are used for starting the main engine, the capacity is to be capable of meeting 1.25 times the starting and consumer needs, or to provide at least six engine starts.

8.4.11 Batteries are to be firmly secured to avoid movement due to vessel's motion and must be provided with stowage trays or boxes. The trays or boxes are to be protected against corrosion caused by acid or alkaline.

Batteries are to be capable of inclination of up to 45° without spillage of electrolyte.

8.4.12 All circuits, except as follows, should be provided with short-circuit and overload protection. Exceptions are:-

a) The cables from a battery to the starter motor are to be as short as possible and double insulated;

b) The cables to steering gear motors are to have short-circuit protection equal to twice the rated motor current.

8.4.13 There should be arrangements for charging the batteries continuously underway. Where two batteries are required, A facility is to be provided to enable a charging system to be connected to either or both.

Section 8.5 – AC systems

8.5.1 The following forms of generation and distribution are acceptable:-

a) 3 phase 3 wire insulated;
b) 3 phase 4 wire with neutral earthed at power source (generator, transformer and converter);
c) Single phase 2 wire;
d) 400 volts rms 50 Hz;
e) 115 volts rms 50 Hz;
f) 230 volts rms 50 Hz.

8.5.2 The number and rating of generators or converters are to be sufficient to ensure that when one power source is out of action, the operation of essential services and the starting of the largest motor can be achieved by the remaining power source(s) without causing failure in any part of the system.

8.5.3 Power sources are to be capable of continuous full rated output duty at maximum specified cooling air and water temperatures for an unlimited period.

8.5.4 Non self-regulating alternators are to be provided with automatic voltage regulation.

8.5.5 Alternators may be run in parallel provided synchronising and power sharing devices are fitted; reverse power protection shall be fitted in such a system.

8.5.6 The primary windings of transformers are to be protected against short-circuits by circuit-breakers or fuses. Such protective devices are to be capable of withstanding current surges.

8.5.7 Transformers arranged to operate in parallel are to be provided with secondary isolation.

8.5.8 Switchboards and distribution boards should be of the dead front type and should not permit access to live parts. Enclosures are to be in accordance with Section 8.12, Paragraph 8.12.1.

8.5.9 Each alternator section of a switchboard should have a voltmeter, a frequency meter, and an ammeter with a switch to enable the current to be read in each phase. Above 50kW a wattmeter should be fitted. Sub-distribution boards fitted in the wheelhouse should have a voltmeter and mains isolator switch.

8.5.10 Freestanding switchboards are to be fitted with an insulated hand rail on the front, and an insulated mat is to be fitted on the floor to run the length of the switchboard.

8.5.11 The requirements of Section 8.3, Paragraphs 8.3.5 and 8.3.7-8.3.14 apply to AC systems.

Section 8.6 – Earthing and bonding

8.6.1 All electrical installations and equipment is to be bonded to earth to comply with these Standards and the IEE Regulations for Ships.

8.6.2 The basic requirement of earth bonding is to provide a low impedance path from the unit to the earth.

8.6.3 Earth bonding points should be accessible.

8.6.4 Earth bonding leads should be as short as possible and are to be identified by green with yellow stripe insulation or shall be uninsulated. Conductors with green or green/yellow insulation are not to be used as current carrying conductors.

8.6.5 A system of earth indicator lamps should be fitted. Such lamps are to be of the metal filament type not exceeding 30 watts of clear glass and sited not more than 150mm apart. The lamps should not be powered except for ‘testing’ or in the event of an earth fault. To prevent corrosion damage, earth faults should be immediately located and cleared.

8.6.6 An earthing point used for radio, radar and other navigational equipment, is not to be used for other electrical equipment and should be as short as possible.

8.6.7 Exposed non-conducting metal parts of equipment are to be bonded to earth through the use of a suitable copper conductor, which may be a part of the structure in contact with the main hull.

8.6.8 Equipment need not be earthed where it is of the double insulated type, or at a voltage not exceeding 55 volts DC or 55 volts rms between conductors (auto transformer supplied voltages are excluded), or from a safety transformer rated not more than 230 volts and supplying one consumer device only.

8.6.9 Where a flexible non-conducting coupling is fitted between engine gearbox and propeller shafting, it should be bridged by a braided copper strip across the coupling or other suitable method to the approval of the surveyor.

Section 8.7 – Motor control

8.7.1 Every electric motor is to be provided with efficient means of starting and stopping, positioned to enable easy operation by the person controlling the motor. Every motor above 0.5kW is to be provided with control apparatus.

8.7.2 Means to prevent undesired restarting after a stoppage due to low volts or complete loss of volts are to be provided. This does not apply to motors where a dangerous condition might result from the failure to restart automatically, e.g. steering gear motor.

8.7.3 Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus, including any automatic circuit breaker.

8.7.4 Where the primary means of isolation (that provided at the switchboard, section board or distribution board) is remote from a motor, one of the following is to be provided:-

a) An additional means of isolation fitted adjacent to the motor;

b) Provision made for locking the primary means of isolation in the OFF position;

c) Provision made so that the fuses in each line can be readily removed and retained by authorised personnel.

8.7.5 Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided.

8.7.6 When motor control gear is being selected, the maximum current of a motor is to be taken as the full load rated current of the motor.

Section 8.8 – Lighting

8.8.1 A final sub-circuit of rating exceeding 16A is not to supply more than one point. The number of lighting points supplied by a final sub-circuit of rating 16A or less is not to exceed the following

24v circuits	10
110v circuits	14
230v circuits	18

except that in final sub-circuits where lampholders are closely grouped, the number of points supplied is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10A.

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

8.8.3 Lighting for machinery spaces, control stations and work spaces should be supplied from at least two final sub-circuits in such a way that failure of any one of the circuits does not leave the space in darkness.

8.8.4 The stroboscopic effect of fluorescent lighting shall be avoided.

8.8.5 Lighting of unattended spaces such as fish rooms and net stores is to be controlled by a switch situated outside the space.

8.8.6 Emergency lighting is to be fitted in accordance with Paragraph 8.10.1.

Section 8.9 – Remote stops

8.9.1 Means of stopping all electric ventilation fans are to be provided outside the spaces being served at positions which will not readily be cut off in the event of a fire. The provisions for machinery spaces are to be independent of those for other spaces.

8.9.2 Electric fans, independently driven pumps delivering oil to main propulsion machinery for lubrication, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned, thus enabling them to be stopped in the event of fire arising in the space in which they are located.

Section 8.10 – Emergency electrical systems

8.10.1 An emergency electrical power source should be located outside of the engine room and should be positioned so as not to short-circuit if their compartment is flooded up to the load waterline, and be capable of operating the following services simultaneously for a period of at least three hours:-

a) The vessel's emergency lights, which are to be sited at stairways and exits, engine room, wheelhouse, and at the liferaft storage position;

b) Emergency communications, navigation lights and signal equipment if they are operated from the vessel's main source of power;

c) The daylight signalling lamp if it is operated by the vessel's main source of electric power;

d) Other equipment as required by the statutory Regulations.

Section 8.11 – Testing

8.11.1 A certificate of compliance of conformity with the requirements of the foregoing Standards or alternative Standards utilised for the electrical installation on the vessel, is to be provided on completion.

8.11.2 It is to be demonstrated that the Standards have been complied with in respect of the following:-

a) Satisfactory commutation and performance of each generator throughout a run at full rated load;

b) Temperatures of joints, connections, circuit-breakers and fuses;

c) The operation of generator engine governors, synchronising devices, overspeed trips, reverse current, reverse power, over-current trips and any other safety devices fitted;

d) Voltage regulation of every generator when full rated load is suddenly thrown off;

e) For alternating current and direct current generators, satisfactory parallel operation and kW load sharing of all generators capable of being operated in parallel at all loads up to normal working load. For alternating current generators, satisfactory parallel operation and electrical load sharing of all generators capable of being operated in parallel at all loads up to normal working load.

8.11.3 All essential motors 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 satisfactory performance.

8.11.4 Insulation readings shall be taken on all new installations, with a meter, rated and operated so as not to cause damage. On voltages 50V and below, such readings shall be not less than 0.3 megohms, and not less than 1.0 megohm on voltages above 50V.

Section 8.12 – Enclosures

8.12.1 Switchboards, panel boards and electrical equipment shall be enclosed as follows:-

a)	Exposed to short term immersion or to heavy seas	IP66;
b)	Exposed to jets of water	IP65;
c)	Exposed to splashing water	IP54;
d)	Located within the vessel in a protected area	IP40.

8.12.2 Sockets and plug inlets subject to conditions as shown in Paragraph 8.12.1 a), b) and c) shall be protected when in use to the same IP rating.

Section 8.13 – Shore supply

8.13.1 Vessels arranged to have a supply from a shore or other external supply should be fitted with a suitable connection box having an inlet socket or terminals suitably rated for the supply.

8.13.2 The connection box is to be fitted in a position as close as possible to the source of supply to minimise the length of flexible supply cable. The flexible cable should not be run into the main switchboard, unless the board is the nearest point, in which case it is to be connected via a suitable isolating device and be incapable of being paralleled with the vessel's own supply.

8.13.3 A permanent cable shall be run from the connection box to the main switchboard and connected via a suitable isolating device.

8.13.4 On three phase AC systems, a meter or lamps should be fitted at the shore inlet termination point to indicate the correct phase sequence and, on a DC system, the correct polarity.

8.13.5 An earth terminal should be fitted to connect the vessel's hull (or in the case of non-metallic hull, the main earth plate) to permit interconnection to the incoming supply earth.

8.13.6 An indicator should be fitted at the main switchboard to show when the shore supply is live.

8.13.7 Shore connection boxes are to be fitted with a label detailing the supply requirement of the vessel and the method of connection.

8.13.8 Shore supply connections are to be capable of powering all emergency systems including but not limited to; Smoke Alarms, Fire Alarms, Bilge Alarms, Emergency lighting, Source of Radio communication and Fire suppression systems where fitted. The vessel is also to be fitted with a power dropout alarm in case of shore power disruption.

8.13.9 In addition to 8.13.8, for crews living on board a source of heating and facilities for cooking are also to be provided.