PART 10

ELECTRICAL INSTALLATIONS

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Section 10.1 - General

Note:- The following requirements cover all likely systems that may be fitted in vessels up to 15m LOA.

10.1.1 Electrical equipment is to 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.

10.1.2 For all installations a certificate of compliance with the requirements of these standards or alternative approved marine standard utilised for the electrical installation on the vessel, is to be provided on completion by the builder or electrical installer. For electrical systems of less than 50v the certificate may be signed by the builder. For all systems greater than 50v the certificate must be signed by an electrician registered with a recognised UK regulatory body covering marine or industrial installations.

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

(i) Rated system AC and DC voltage, permanent, -10% and +6%. Transient +20%, -15%, recovery 1.5 seconds.

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

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

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

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

10.1.7 Where practicable, electrical plans and schedules showing expected sea loads, where appropriate, are to be submitted for prior approval.

10.1.8 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 to be interchangeable.

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

10.1.10 Electrical equipment installed in compartments containing explosive gases are to be ignition protected in accordance with ISO 8846.

10.1.11 Where practicable, vessels fitted with LPG systems should have ignition protected electrical equipment installed as per ISO 10239.

Section 10.2 - Cables

10.2.1 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.

10.2.2 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.

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

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

10.2.5 In all cases conductors are to be stranded copper.

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

10.2.7 Cable types, as detailed in Tables 1-4, should be used excepting that:-

(i) Cables installed on deck in positions liable to damage, are to run in heavy duty galvanised conduit or pipe.

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

(iii) PVC cables are not to be installed in refrigeration spaces.

(iv) Compliance with IEC publication 331, Fire characteristics of electric cables (or equivalent), will be required in circuits supplying systems which maintain services during a fire (e.g. CO_2 release systems).

(v) In systems not exceeding 50 volts, PVC insulated, PVC sheathed cable manufactured to BS 6004 (or equivalent), and PVC cables for vehicles manufactured to BS 6862 (Part 1 flame-retardant) (or equivalent) are acceptable.

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

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

10.2.10 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.

10.2.11 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 is to be calculated to take account of rating and diversity factors.

10.2.12 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.

10.2.13 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 (for example, 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.

10.2.14 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.

10.2.15 With the exception of cables for portable appliances, cables are to 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.

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

10.2.17 Cable clips or straps made from a material such as polyamide, PVC, etc. may be used, however, additional metal straps are to 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 500mm apart. All cable clips in engine spaces are to be of metal.

10.2.18 Cables are not to be bonded into a GRP structure, and are not to be fastened direct to oil or water pipes, fuel tanks, etc.

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

bulkhead or equipment. Cables may pass through bushed holes in non-watertight bulkheads. Where cables are exposed to sharp edges, such edges are to be bushed.

10.2.20 Cables entering electrical equipment are to be glanded. The use of flame-retarding plastic type glands is permissible provided the requirements of Paragraph 10.2.19 are maintained.

10.2.21 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 should not 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 mm^2	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 cable (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	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

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	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

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

Note for information:-

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

Section 10.3 - DC systems

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

(i) 2 wire insulated
(ii) 12 volts, 24 volts, 110 volts, 220 volts.

10.3.2 Proposals to use other voltages are to be submitted for consideration.

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

10.3.4 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 10.11.1.

10.3.5 Switchboards for systems of 110 volts or greater are to 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.

10.3.6 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.

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

10.3.8 At least one pair of spare fuses is to 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.

10.3.9 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 11.12.1. In engine spaces they are to be of fire-resistant material.

10.3.10 Fuses are to be of the high rupture capacity type. Miniature or moulded case circuit breakers may be used as circuit protection.

10.3.11 Terminations are to be of screwed or bolted types, spring-loaded types are not permissible.

10.3.12 Where combined switch fuses are used, they are to be of the “on load” type complying with BS 3185 (or equivalent).

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

10.3.14 Cables are to be sized to avoid overheating and all connections shall be vibration proof.

Section 10.4 - Batteries

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

10.4.2 The batteries are to be capable of being isolated when not in use, preferably by means of a double pole switch, however, a single pole switch may be used on the positive conductor. Where it is proposed that a changeover battery switch is to be fitted then these are to be provided with an “off” position. All switches are to be located in an accessible position.

10.4.3 Batteries should be firmly secured to avoid movement due to vessel’s motion and must be provided with stowage trays or boxes. The trays or boxes should be protected against corrosion caused by acid or alkaline. Batteries are to be capable of inclination of up to 45° without spillage of electrolyte.

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

10.4.5 Batteries in an enclosed space are to be contained in a battery box ventilated by an independent ventilating system.

10.4.6 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.

10.4.7 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.

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

10.4.9 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. All propulsion engines are to be provided with an additional starting battery, which may be the battery supplied for the domestic/navigation systems.

10.4.10 There should be arrangements for charging the batteries continuously when underway, a facility should be provided to enable a charging system to be connected to either, or both.

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

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

(i) The cables from a battery to the starter motor which are to be as short as possible and double insulated.

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

Section 10.5 - AC Systems

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

(i) 3 phase 3 wire insulated.
(ii) 3 phase 4 wire with neutral earthed at power source (generator; transformer; converter).
(iii) Single phase 2 wire.
(iv) 400 volts rms. 50 Hz.
(v) 115 volts rms. 50 Hz.
(vi) 230 volts rms. 50 Hz.

10.5.2 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.

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

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

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

10.5.6 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.

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

10.5.8 Switchboards and distribution boards are to be of the dead front type and shall not permit access to live parts. Enclosures are to be in accordance with Paragraph 10.12.1.

10.5.9 Each alternator section of a switchboard is to 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 is to be fitted. Sub-distribution boards fitted in the wheelhouse are to have a voltmeter and mains isolator switch.

10.5.10 Free-standing switchboards are to be fitted with an insulated hand rail on the front, and an insulated mat fitted on the floor to run the length of the switchboard.

10.5.11 The requirements of Section 10.3, Paragraphs 10.3.6 and 10.3.8-10.3.14 apply to AC systems.

Section 10.6 - Earthing and bonding

10.6.1 All electrical installations and equipment are to be bonded to earth.

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

10.6.3 Earth bonding points are to be accessible.

10.6.4 Earth bonding leads are to be as short as possible and are to be identified by green with yellow stripe insulation or un-insulated. Conductors with green or green/yellow insulation are not to be used as current carrying conductors.

10.6.5 It is recommended on vessels over 10m a system of earth indicator lamps is to 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.

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

10.6.7 Exposed non-conducting metal parts of equipment are to be bonded to earth through the use of a suitable copper conductor, and in a steel vessel this may be a part of the structure in contact with the main hull. In wood and composite vessels, an unpainted copper earth plate is to be fitted which is to be outside the hull below the waterline, immersed under all sea conditions and shall have an area of at least 0.25m^2.

10.6.8 An earth bar is to be fitted in a suitable position and connected to the plate by a copper conductor of at least 64mm^2. Equipment should be connected to the earth bar by means of suitable copper conductors. Lightning protection is to be connected directly to the earth plate by means of a separate welded joint connector.

10.6.9 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.

10.6.10 Where a flexible non-conducting coupling is fitted between engine gearbox and propeller shafting, it is to be bridged by a braided copper strip across the coupling.

Section 10.7 - Motor control

10.7.1 Every electric motor is to be provided with efficient means of starting and stopping, so placed as to be easily operated by the person controlling the motor. Every motor above 0.5kW is to be provided with control apparatus.

10.7.2 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.

10.7.3 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.

10.7.4 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:-

(i) An additional means of isolation fitted adjacent to the motor.

(ii) Provision made for locking the primary means of isolation in the OFF position.

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

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

10.7.6 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 10.8 - Lighting

10.8.1 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

- 24 volt circuits 10
- 110 volt circuits 14
- 230 volt 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.

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

10.8.3 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.

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

Section 10.9 - Remote stops

10.9.1 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.

10.9.2 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, so that they may be stopped in the event of fire arising in the space in which they are located.

Section 10.10 - Emergency electrical systems

10.10.1 Where practicable, batteries shall 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 one hour:-

(i) The vessel's lights which are sited at stairways and exits, engine room, wheelhouse, boarding ladder position, and at the liferaft storage position.

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

(iii) The daylight signalling lamp if it is operated by the vessel's main source of electric power.

(iv) Other equipment as required by the Code of Safe Practice.

Section 10.11 - Testing

10.11.1 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.

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

(i) Satisfactory commutation and performance of each generator throughout a run at full rated load.

(ii) Temperatures of joints, connections, circuit breakers and fuses.

(iii) The operation of generator engine governors, synchronising devices, overspeed trips, reverse current, reverse power, over current trips and any other safety devices fitted.

(iv) Voltage regulation of every generator when full rated load is suddenly thrown off.

(v) 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.

10.11.3 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.

10.11.4 Insulation readings should be taken on all new installations, with a meter, rated and operated so as to not cause damage. On voltages 50 volts and below, such readings should be not less than 0.3 megohms, and not less than 1 megohm on voltages above 50 volts.

Section 10.12 - Enclosures

10.12.1 Switchboards, panel boards and electrical equipment are to be enclosed as follows:-

(i) Exposed to short term immersion or to heavy seas IP66

(ii)	Exposed to jets of water	IP65
(iii)	Exposed to splashing water	IP54
(iv)	Located within the vessel in a protected area	IP40

10.12.2 Sockets and plug inlets subject to conditions as shown in Paragraph 10.11.1(i), (ii) and (iii) are to be protected when in use to the same IP rating.

Section 10.13 - Shore supply

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

10.13.2 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.

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

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

10.13.5 An earth terminal is to 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.

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

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

10.13.8 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.

Section 10.14 - Reference standards

10.14.1 The following is a list of reference standards applicable. Where the reference standard requirements supersedes any of the foregoing requirements, the reference standard requirement is to be used:-

(i) *The Institution of Electrical Engineers Regulations for the Electrical and Electronic Equipment of Ships with Recommended Practice for their Implementation, (latest edition)*

(ii) *BS 6883 (1999), Specification for elastomer insulated cables for fixed wiring in vessels. (Suitable for lighting, power, control, instrumentation and propulsion circuits).*

(iii) *IEC 600 92-350, Low voltage shipboard power cables. (General construction and test requirements for shipboard cables with copper conductors intended for low voltage power systems at voltages up to and including 0.6/1kV).*

(iv) *ISO 10133, Small Craft – Electrical systems – Extra low voltage DC installations.*

(v) *ISO 13297, Small Craft – Electrical systems – Alternating current installations.*

(vi) *BS EN 28846, Small Craft – Electrical devices – Protection against ignition of surrounding flammable gases.*

